New Scientist

WEEKLY July 9 - 15, 2022

YOUR INNER VOICE
How you can take control of it to beat stress

TIME LOOPS
Mind-bending paradoxes might just be possible

COVID REINFECTION
The serious health risks from catching it twice

The UNIVERSE AS WE'VE NEVER SEEN IT BEFORE

What the world's most powerful space telescope is about to reveal

PLUS ALIEN WORM INVASION / **BIGGEST-EVER WATER LILY** / **BRAIN IMPLANTS EASE DEPRESSION** / AI PREDICTS CRIME

Science and technology news **www.newscientist.com**

No3394 US$6.99 CAN$9.99

WE'RE LOOKING FOR THE *best ideas in the world* ON BEHALF OF OLDER PEOPLE

The Ryman Prize is an international award aimed at encouraging the best and brightest thinkers in the world to focus on ways to improve the health of older people.

The world's ageing population means that in some parts of the globe – including much of the Western world – the population aged 75+ is set to almost triple in the next 30 years.

Older people face not only the acute threat of COVID-19, but also the burden of chronic diseases including Alzheimers and diabetes.

At the same time the health of older people is one of the most underfunded and poorly resourced areas of research.

To stimulate fresh efforts to tackle the problems of old age, we're offering a NZ$250,000 (£130,000) annual prize for the world's best discovery, development, advance or achievement that enhances quality of life for older people.

The Ryman Prize is awarded each year by the Prime Minister of New Zealand. It was first awarded in 2015 to Gabi Hollows, co-founder of the Hollows Foundation, for her tireless work to restore sight for millions of older people in the developing world.

Since then world-leading researchers Professor Henry Brodaty, Professor Peter St George-Hyslop, Professor Takanori Shibata, Dr Michael Fehlings and Professor Miia Kivipelto have all won the prize for their outstanding work.

In 2021 Professor Kenneth Rockwood, a Canadian geriatrician, academic and anti-ageism campaigner whose research into frailty has had a huge impact, was awarded the prize by the Right Honourable, Jacinda Ardern, Prime Minister of New Zealand.

If you have a great idea or have achieved something remarkable like Kenneth and our six other prize winners, we would love to hear from you.

Entries for the 2022 Ryman Prize close at 5pm on Friday, July 15, 2022 (New Zealand time).

Go to **rymanprize.com** for more information.

This week's issue

On the cover

38 The universe as we've never seen it before
What the world's most powerful space telescope is about to reveal

Vol 255 No 3394
Cover image: Andy Gilmore

46 Your inner voice
How you can take control of it to beat stress

9 Time loops
Mind-bending paradoxes might just be possible

21 Covid reinfection
The serious health risks from catching it twice

15 Alien worm invasion
14 Biggest-ever water lily
12 Brain implant eases depression
18 AI predicts crime

38 Features

"There are going to be discoveries that nobody anticipates, and those are often the most fun"

News

8 US climate setback
Supreme Court ruling could hamper US carbon-free goals

10 'Fair' AI tackles bias
An artificial intelligence aims to redress racial discrimination in financial aid to homebuyers

12 Molecular computer
A new design based on biology is energy efficient

Views

27 Comment
Restoring seagrass would be a huge conservation win, says Sophie Pavelle

28 The columnist
Chanda-Prescod Weinstein on space-time

30 Aperture
Dazzling photos from an astronomy photo competition

32 Letters
More on the mystery of time

34 Culture
A vivid window into Chernobyl's exclusion zone

CARLOS MAGDALENA, RBG KEW

14 Giant water lily Newly identified species is the largest of its kind

Features

38 A new cosmic dawn
Seven big questions the James Webb Space Telescope could soon answer

44 Future-proofing
Sophie Howe on how to bring long-term thinking into politics

46 Internal chatter
Why getting to know your inner voice could have a dramatic impact on your daily life

The back pages

51 Cooking
Making cold-brew coffee at home

53 Puzzles
Try our crossword, quick quiz and logic puzzle

54 *Almost* the last word
What shape would a candle's flame be in zero gravity?

56 Feedback
Doop Snogg enters the world of ton-nungible fokens

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

Elsewhere on New Scientist

Tour

Renaissance astronomy in Prague, Czech Republic

Explore the legacy of Renaissance astronomers in Prague, the city of a hundred spires, where maths, music and art connect. Astronomer Martin Griffiths will guide you through Prague's medieval marvels, including one of the world's oldest astronomical clocks, Prague Castle and the Klementinum astronomical tower. Plus enjoy stargazing at the Štefánik Observatory. This six-day trip starts on 10 September and costs £1968.

newscientist.com/tours

Event

Origin of the universe

One of the most famous ideas in science is that the universe began in a big bang. But this leaves many questions unanswered, like why the universe is so big and so old, and why it has its particular structure. In this talk, physicist Will Kinney delves into the theory of inflation, which may hold some answers. Join us online at 6pm BST/1pm EST on 14 July.

newscientist.com/events

Podcast

Weekly

The team examine the ethics surrounding the world's first genetically modified children, who are now toddlers. They also chat about "super-poopers" who are helping treat people with irritable bowel syndrome. Plus there is monkeypox, rogue planets and a singing whale.

newscientist.com/nspod

KLEIN & HUBERT/NATUREPL.COM

Hedgehog friendly How to make your garden more welcoming

OLGA GAVRILOVA/GETTY IMAGES

Tick tock Check out one of the world's oldest astronomical clocks

Video

All in the mind

A man who is partially paralysed has been able to feed himself dessert using only his thoughts and some smart robot hands. Researchers at Johns Hopkins University Applied Physics Laboratory in Maryland decoded the man's brain signals associated with the thought of moving, using them to control two robotic limbs holding a knife and fork.

youtube.com/newscientist

Newsletter

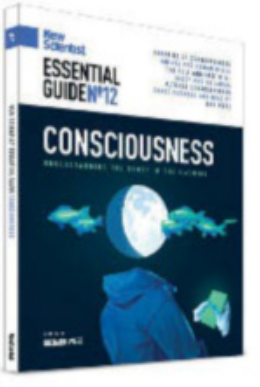
Wild Wild Life

News and digital director Penny Sarchet has been hunting around her garden in search of the West European hedgehog, an animal in decline in the UK. She finds out how to make your garden hedgehog-friendly, plus there is a new species of toad, a deep dive into coral reefs and some surprising news about chickens.

newscientist.com/sign-up

Newsletter

"Gardens are vital for connecting habitats – hedgehogs travel up to 3 kilometres a night"



Essential guide

Consciousness is the ghost in our machine – our feeling of being and our relationship with the world. But what does it consist of and why do we have it? Delve into the greatest mystery of the mind with the latest *New Scientist Essential Guide*.

shop.newscientist.com

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.

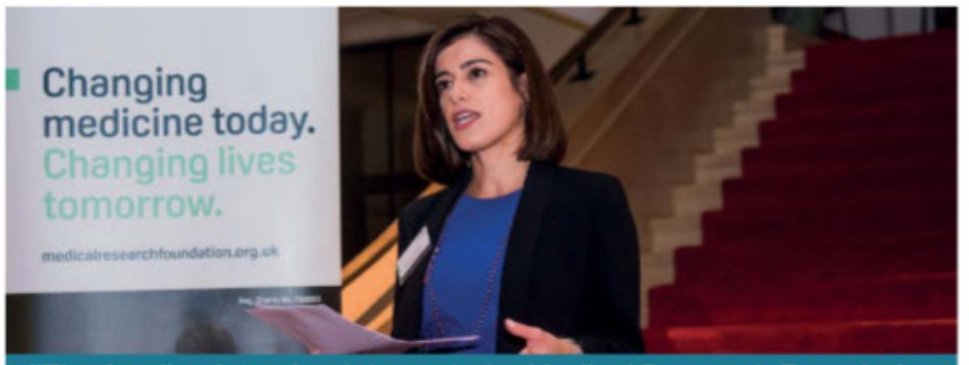
Right now, the Foundation is funding research to tackle antimicrobial resistance, and investing in researchers like Dr Myrsini Kaforou – who will make the fight against antimicrobial resistance her life's work.

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**

You don't need a stamp **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

0222PBN

Award-winning Children's Magazine

ORDER NOW
While stocks last!

In this issue: History of Time Machines; Delia Derbyshire's electronic music; Tracking time in space; Mathematical paradoxes; Twisted timelines and a leap into the future. PLUS! Extra Summer – fun activity pages.

AQUILA Magazine is a seriously intelligent publication that's written with a playful sense of humour. Every month there's a *beautifully illustrated* educational topic with first class *Science, Arts & General Knowledge* – and although AQUILA is perfectly designed for curious children of 8 –12 years, many adults love reading it too!

Coming up next...
In September join AQUILA's visit to *Pompeii* the day before the AD79 eruption. Peer into October's *Spooky issue* if you dare, then in November – we step out *On the Stage*...

"it informs, it educates, it entertains..."
The British Society of Magazine Editors 2021 – Winner Youth Category

AQUILA.CO.UK
01323 431313

A new dawn for astronomy

Seeing the first images from our new space telescope will be a moment to cherish

FINALLY, we are about to see further back in time than ever before – and all in glorious high resolution. On 12 July, NASA will release the first full-colour images captured by the James Webb Space Telescope (JWST), which promises to transform our understanding of how the universe was made.

It is a moment to savour. These first snapshots are the culmination of a decades-long engineering effort, not to mention a suspenseful launch and commissioning phase in which the telescope's origami-style sunshield had to unfold without a hitch and the 18 hexagonal segments of its mirror align with astonishing precision. Last month, there was another scare as the $10-billion telescope was struck by a small space rock.

Not to worry. The JWST is working perfectly, and it sounds like those first images will be worth the wait.

NASA has said that next week's release will include a deep-field image, revealing a patch of the universe as it looked a few hundred million years after the big bang,

"The space telescope is set to reveal the properties of other potentially habitable planets"

and the spectrum of an atmosphere around an exoplanet. That is a fitting curtain-raiser for a telescope designed to reveal the universe's early history – the first stars, the invisible matter that brought them into being and the gargantuan black holes that sculpted galaxies – and the properties of potentially habitable planets orbiting other stars.

And so the science begins. Precisely what scientists granted precious time with the JWST during its first observation cycle will look at, and how they will address some of the cosmos's biggest mysteries, is the subject of our cover story on page 38.

This is just the start: all being well, the telescope will be gathering data and images for the next 20 years. It will leave a stunning legacy. However, there is also the question of whether this might be the last of the scientific megaprojects, given that nothing remotely comparable in ambition or expense is currently funded. Let's hope not, because you don't have to be a scientist to be moved by what we are about to see. ▮

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
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
Production executive Isabella Springbett

New Scientist Discovery Tours
Director Kevin Currie

Marketing & Data
Marketing director Jo Adams
Director of performance marketing and audience development Jeffrey Baker
Head of campaign marketing James Nicholson
Head of customer experience Emma Robinson
Head of audience data Rachael Dunderdale
Data and analytics manager Ebun Rotimi
Senior email marketing executive Natalie Valls
Email marketing executive Ffion Evans
Digital marketing manager Jonathan Schnaider
Senior customer experience marketing manager Esha Bhabuta
Senior marketing executive Sahad Ahmed
Marketing assistant Charlotte Weeks

Digital Products
Digital product development director Laurence Taylor
Head of learning experience Finola Lang

Technology
Chief operations officer International Debora Brooksbank-Taylor
Technology director Tom McQuillan
Maria Moreno Garrido, Dan Pudsey, Amardeep Sian, Ben Townsend, Piotr Walków
Front end developer Damilola Aigoro
Junior front end developer Matthew Staines

NewScientist

Chief executive Nina Wright
Executive assistant Lorraine Lodge
Team administrator Olivia Abbott

Finance & operations
Chief financial officer Amee Dixon
Financial controller Taryn Skorjenko
Commercial finance manager Charlotte Thabit
Commercial finance manager Anna Labuz
Management accountant Charlie Robinson

Human resources
Human resources director Shirley Spencer
HR business partner Katy Le Poidevin

CONTACT US

newscientist.com/contact

General & media enquiries
US PO Box 80247, Portland, OR 97280
UK **Tel** +44 (0)203 615 6500
Northcliffe House, 2 Derry Street, London, W8 5TT
Australia 58 Gipps Street, Collingwood, Victoria 3066

US Newsstand **Tel** +1 973 909 5819
Distributed by Time Inc. Retail, a division of Meredith Corporation, 6 Upper Pond Road, Parsippany, NJ 07054

Syndication Tribune Content Agency
Tel 1-800-346-8798 **Email** tca-articlesales@tribpub.com

Subscriptions **newscientist.com/subscribe**
Tel 1 888 822 3242
Email subscriptions.us@newscientist.com
Post New Scientist, PO Box 3806, Chesterfield MO 63006-9953

New Scientist ISSN 0262 4079 is published weekly except for the last week in December by New Scientist Ltd, England. New Scientist (Online) ISSN 2059 5387. New Scientist Limited, 387 Park Avenue South, New York, NY 10016

Periodicals postage paid at New York, NY and other mailing offices. Postmaster: Send address changes to New Scientist, PO Box 3806, Chesterfield, MO 63006-9953, USA. Registered at the Post Office as a newspaper and printed in USA by Fry Communications Inc, Mechanicsburg, PA 17055

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) Michael Le Page, Matthew Sparkes, Adam Vaughan, Clare Wilson, (Aus) Alice Klein
Trainees Jason Arunn Murugesu, Alex Wilkins
Intern Carissa Wong

Digital
Audience editor Alexander McNamara
Podcast editor Rowan Hooper
Web team Emily Bates, Matt Hambly, Chen Ly, David Stock

Features
Deputy head of features Daniel Cossins, Helen Thomson
Editors Abigail Beall, Anna Demming, Kate Douglas, Alison George, Joshua Howgego
Feature writer Graham Lawton

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

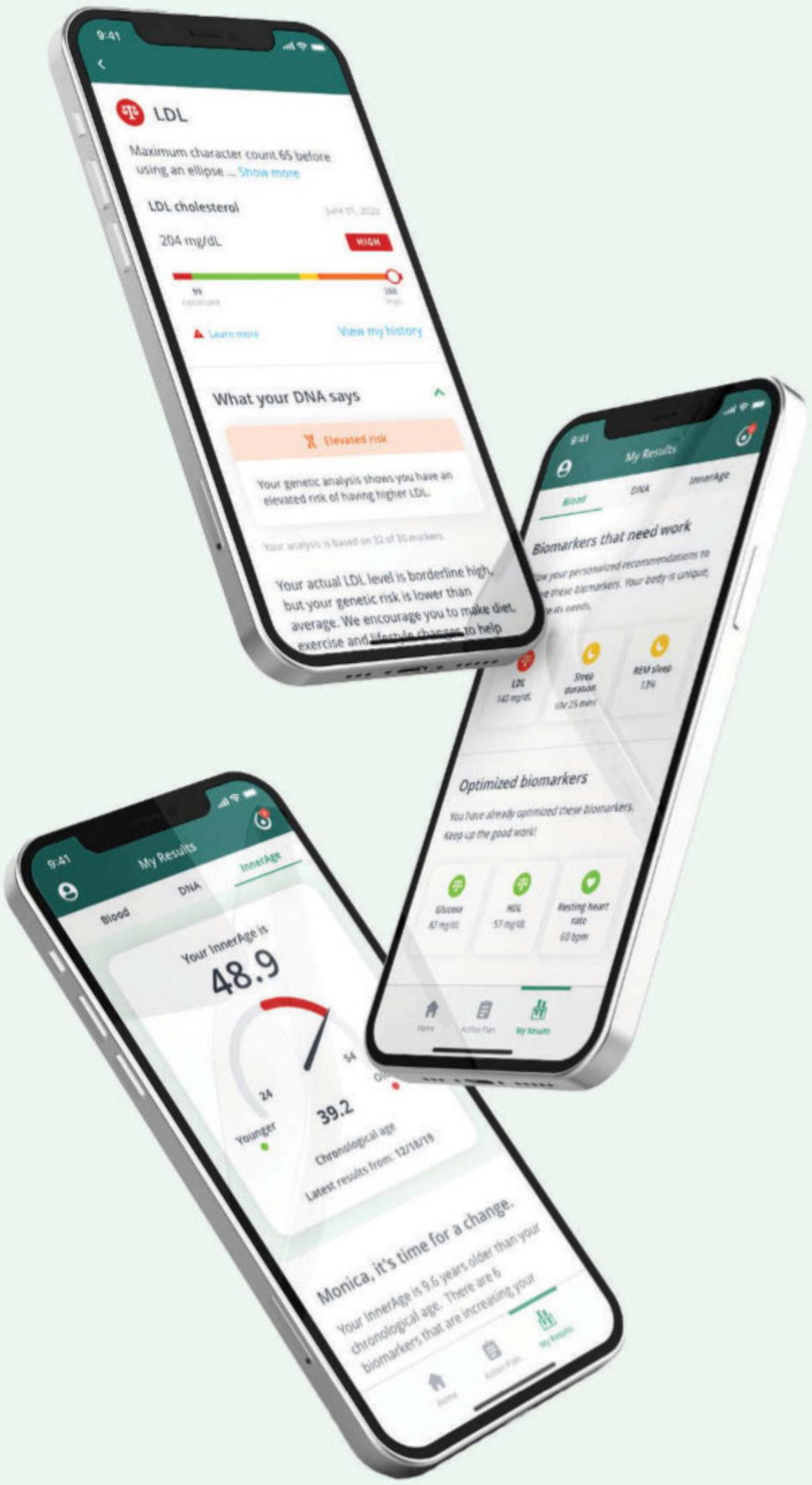
Subeditors
Chief subeditor Eleanor Parsons
Bethan Ackerley, Tom Campbell, Jon White
Trainee Tom Leslie

Design
Art editor Julia Lee
Joe Hetzel, Ryan Wills

Picture desk
Picture editor Helen Benians
Tim Boddy

Production
Production manager Joanne Keogh
Robin Burton
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



Powered by A.I.

Our advanced, algorithmic engine uses information from your blood, DNA, and lifestyle habits—plus vast amounts of biometric and scientific data—to build your personalized Action Plan.

Validated by science

Our nutrition, fitness, and lifestyle recommendations are backed by the latest, peer-reviewed research in nutrition, genetics, and aging. Your Action Plan evolves with your body and continually updates based on the latest available science.

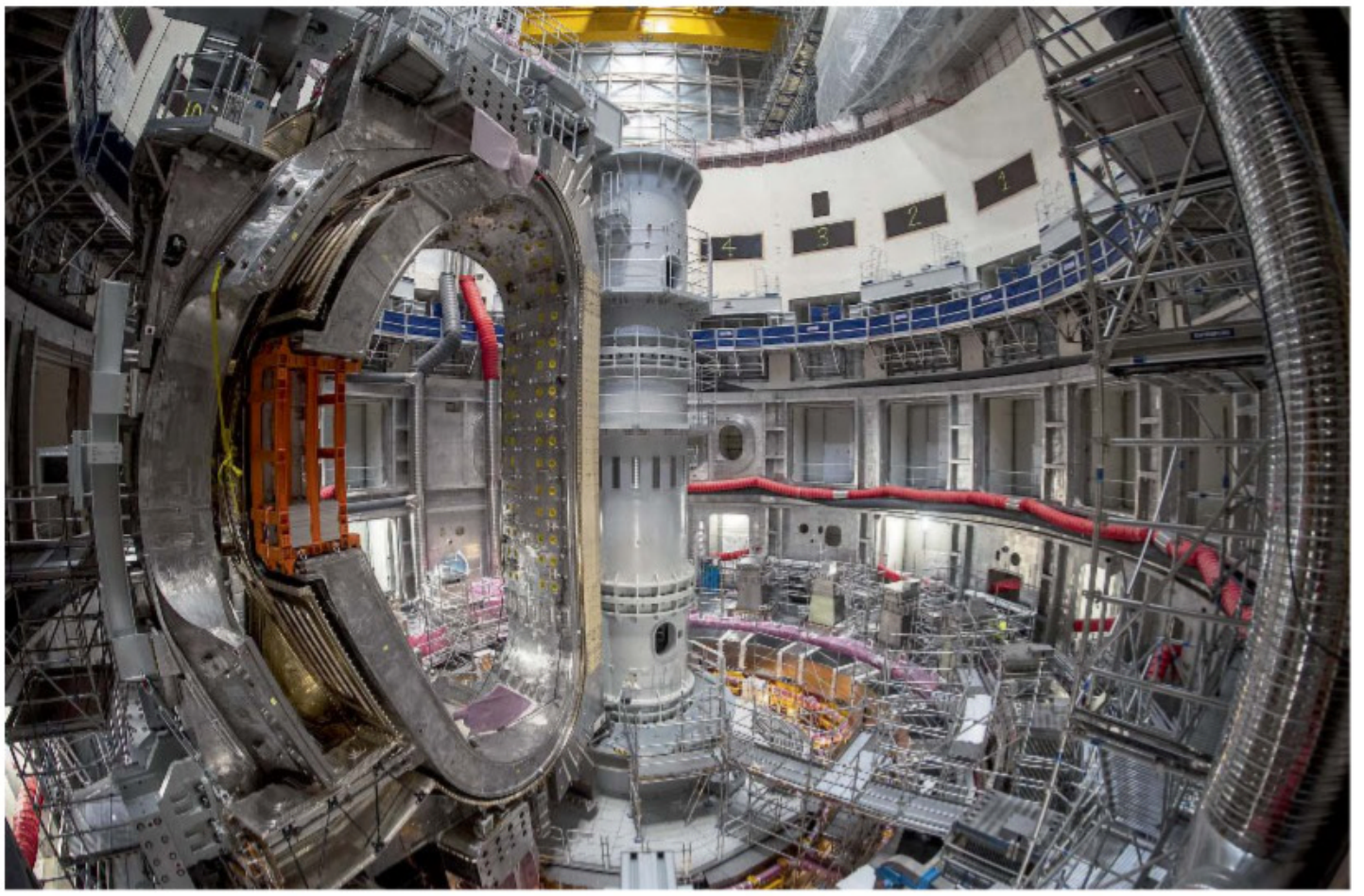
Driven by your data

InsideTracker does what one-size-fits-all nutrition plans can't: it uses your body's unique biomarkers to deliver truly personalized guidance that specifically addresses your individual health goals.

InsideTracker

InsideTracker is a truly personalized nutrition and performance system, created by leading scientists and researchers to help you live healthier, longer.

News



ITER ORGANIZATION, HTTP://WWW.ITER.ORG

ITER, being built in France, will inform commercial fusion

Technology

Fusion plans announced

A European consortium is beginning to design a commercial nuclear fusion power plant to be built by 2054, reports **Adam Vaughan**

NUCLEAR fusion engineers are starting to design a power station they hope will mimic how the sun works to provide a clean, almost unlimited source of energy.

This week marks the beginning of a five-year "conceptual design" phase to flesh out key technology decisions for the DEMOnstration power plant (DEMO), a project backed by a European consortium, EuroFusion, to take fusion power from the concept stage to a commercial reality. The group plans for the 300 to 500 megawatt reactor to be generating low-carbon energy by 2054.

There has been plenty of experimental work on nuclear fusion, largely with machines known as tokamaks. These use powerful magnets to confine and control hot matter – or plasma – usually in the shape of a doughnut. The plasma is typically produced from two hydrogen isotopes: deuterium and tritium.

Much of the research has focused on tweaking the materials and magnets in the walls of tokamaks, and better modelling how experiments with plasmas will play out, with the ultimate aim of getting more energy out of a fusion reaction than goes in.

That major milestone of "net gain" has yet to be achieved, but there is progress: a global energy record was set last year. More may occur when an €18 billion research tokamak in France, known as ITER, is switched on. It is scheduled for completion in 2025 and due to achieve full power in 2035.

The DEMO power station will need to control and maintain the plasma for much longer than experiments to date. DEMO will also need to collect the heat from the reaction and turn it into

"DEMO will need to collect heat from the reaction and turn it into electricity, for 24 hours a day"

electricity, all while working 24 hours a day. "It's hard. But that's why we need to start – that's exactly the point," says Ambrogio Fasoli, chair of the EuroFusion General Assembly, the decision-making body for the consortium, which is funded by EU member states and Switzerland.

There are problems to overcome, such as generating tritium. Supplies of the isotope are limited and expensive because it decays quickly. Research projects have so far used only grams, but a power station will need kilograms. This will require design choices about how to create more tritium by allowing neutrons to escape the plasma and interact with lithium in the tokamak's walls.

Other design choices include the materials to use in the tokamak walls, which will be exposed to a huge influx of neutrons from the fusion reaction. "The dose [of neutrons] that the structure absorbs is much, much bigger than we ever had to do. It's really orders of magnitude larger," says Fasoli.

He says work on DEMO can't wait for the completion of ITER, but must happen in parallel. "[Otherwise] there will be a big gap of decades and then nobody will have an interest in fusion," says Fasoli. Nonetheless, he says DEMO must learn from ITER.

Where the power plant will be built remains to be seen. Juan Matthews at the University of Manchester, UK, is betting on Germany, given it has no fusion device and France and the UK have won competitions to host previous ones.

Whatever DEMO's conceptual design looks like when it is finished in 2027, the plant is unlikely to be the world's first fusion power station. Several private fusion start-ups have claimed they will have one operating by the early 2030s, while the UK government has said its "STEP" fusion power plant will be running by 2040. China has said it will have one complete in 2035. ▮

Briefing Climate change

US ruling may harm climate efforts

A decision by the US Supreme Court clarifies a long-running row about the role of the Environmental Protection Agency, says **James Dinneen**

ON 30 June, the US Supreme Court issued a ruling that could set back efforts to reduce greenhouse gas emissions and more widely limit the work of the Environmental Protection Agency (EPA).

What was the ruling about?

The ruling looked at a case between the state of West Virginia and the EPA with roots in a complex legal fight over who has authority to regulate greenhouse gas emissions from power plants.

In the 1960s, Congress passed the Clean Air Act, giving the EPA authority to enforce regulations to improve air quality. In 2015, the Obama administration's Clean Power Plan set guidelines for states around carbon dioxide emissions from power plants.

Some states objected to the plan, setting up a political and legal back and forth across the Trump and Biden administrations that culminated in coal companies and coal-producing states, led by West Virginia, petitioning the Supreme Court to rule on the powers granted to the EPA by the Clean Air Act.

ALI MAJDFAR/GETTY IMAGES

A coal power plant in Avon Lake, Ohio, which was closed this year

How did the Supreme Court rule?

In the 6-3 opinion, chief justice John Roberts wrote that the Clean Air Act doesn't give the EPA clear congressional authority to regulate greenhouse gas emissions at power plants by making sweeping changes to entire grids, as opposed to requiring individual emitters to make reductions.

In her dissenting opinion, Elena Kagan, citing the dire assessments by the Intergovernmental Panel on Climate Change on the impacts of climate change, wrote that the ruling "deprives EPA of the power needed – and the power granted – to curb the emission of greenhouse gases".

How will this affect efforts to combat climate change?

In short, it could have a big impact, but not as big as some had feared.

The ruling is likely to stymie the Biden administration's plans to make US electricity generation carbon-free by 2035. However, it falls far short of limiting the EPA's discretion to regulate on all issues. That said, it could be a "canary in the coal mine" for how this court will interpret various agencies' authority to use their expertise, says Dena Adler at New York University School of Law.

While the ruling limits the EPA's authority, Congress could still pass legislation on greenhouse gas emissions or other environmental issues, or grant the agency that authority. But given current congressional gridlock, that is unlikely to happen any time soon.

"The ruling curtails EPA's authority to regulate pollutants on the basis of protection of the Earth's climate and will result in unconscionable delays, given that Congress is not poised to address this issue," says Lynn Goldman at George Washington University in Washington DC.

Conservative lawyers point out that the EPA has other avenues to control greenhouse gas emissions, for instance through standards for exhaust emissions or by setting rules for individual power plants.

"There are many, many other steps the EPA already has the statutory authority to take to reduce emissions," says Joseph Bingham, an attorney at Mountain States Legal Foundation. The agency can still regulate CO_2 as it would any other pollutant, he says.

It is also worth pointing out that reductions are possible without regulations. The emissions targets set in the Clean Power Plan, for instance, were met a decade ahead of schedule even though the plan never came into effect. ▮

Technology

Firms plan to clean up construction with net-zero concrete

CONCRETE is one of the most important construction materials, but it is associated with high carbon emissions. Now, an alliance of construction and property giants is hoping to kickstart development of greener concrete.

The group of 17 companies, including Willmott Dixon, Laing O'Rourke and Skanska, have formed a coalition pledging that one-third of the concrete they use by 2025 will be a low-emission version, rising to one-half by 2030. They also intend to use only net-zero concrete by 2050.

"Concrete is a huge part of global emissions. What we are aiming to do is put a really big collective demand signal there, which gives confidence to innovators, to investors," says Helen Clarkson at Climate Group, the non-profit organisation that has organised the campaign.

The problem with decarbonising concrete is there are currently no solutions on a large-enough scale.

The chemical process of making cement is inherently carbon-intensive and usually requires plenty of fossil fuel-powered heat.

However, researchers and companies are making progress, such as electrifying the production of cement and strengthening the material by adding graphene so less concrete is needed to build a given structure. There are also efforts to develop technology to capture and store the carbon released when limestone is heated and crushed to make cement.

"We are aiming to put a big collective demand signal there, which gives confidence to innovators"

Paul Dipino at property developer Joseph Homes, one of the initiative's founders, says in the short term people are looking to cut concrete emissions by using fly ash, a by-product of coal power stations, as a replacement for some of the cement in the concrete.

"It's going to cost more in the short term," he says of buying low-carbon concrete, but he thinks some of that extra cost could be offset by design choices that use less of the material. ▮

Adam Vaughan

Technology

Self-cooling quantum computer made of diamonds

Karmela Padavic-Callaghan

QUANTUM computers made from imperfect diamonds could stop themselves from overheating just by running an algorithm. Most quantum machines must be kept at low temperatures, but "algorithmic cooling" might allow quantum computers to perform well at room temperature in the future.

Conventional computers slow down as they warm up, and quantum computers can even stop working if they get too hot. While classical computers are typically cooled by fans, quantum computers generally require much greater cooling than fans could provide.

Eric Lutz and his colleagues at the University of Stuttgart in Germany built a small, diamond-based quantum computer that can cool itself by performing a sequence of mathematical operations.

Their device consists of three qubits, or quantum bits, in a diamond that is missing two carbon atoms. They replaced one of these with a nitrogen atom and left an empty space, known as a vacancy, where the other one had been.

To manipulate each qubit, the researchers blasted them with microwaves. This changed the spin of either the nitrogen atom's nucleus or the nuclei of two carbon atoms close to the vacancy. These manipulations act as logic gates, the basic building blocks of calculations the computer performs, and alter the quantum state of a qubit. Each quantum state has a specific amount of energy, so a sequence of gates can be used to change the computer's energy and cool it.

The team found that algorithmic cooling was exceedingly close to the theoretical limit of maximum cooling efficiency (arxiv.org/abs/2109.14056). "We tested and evaluated the performance of an algorithm, but by the performance standards of a refrigerator," says team member Rodolfo Soldati. ▮

Physics

Time loops may be easier to achieve than we thought

A CAUSAL loop is a classic time travel conundrum. If you send information to the past – say, you give Albert Einstein the formula $E=mc^2$ before he theorises it himself, then he publishes it and you go on to find it in a textbook – you would create a situation in which the information has no true origin.

A new analysis shows that this type of causal loop is possible in more theoretical universes than had previously been expected.

In most science-fiction scenarios, sending messages back in time requires information to move faster than the speed of light. But in theoretical universes where causal loops are allowed, such law-breaking physics isn't required, though it is unclear if these loops would be possible in our universe.

Venkatesh Vilasini at ETH Zurich in Switzerland and Roger Colbeck at the University of York, UK, mathematically modelled a set of theoretical universes where all that is known is that there are people who can discern information and act on it, but who can't communicate faster than light.

The researchers didn't require the universes to obey any specific physical laws, such as how gravity works. They found that causal loops could be mathematically possible in universes that they didn't theorise as being particularly odd or exotic from the start (arxiv.org/abs/2206.12887).

"Sending messages back in time would require information to move faster than light"

Such causal loops would disturb reality by removing the origin of some information, but they seem to be possible in universes with one spatial dimension (arxiv.org/abs/2109.12128).

Vilasini explains that causality can be defined in two ways. The first incorporates how two agents are related to each other in space-time, the distance between them and whether they are in each other's future or past. The second involves analysing the flow of some information passing between the two agents.

"Typically, we say that correlation does not imply causation. We now focused on the converse, where causation does not imply correlation, or the ability of two agents to send signals to each other," says Vilasini.

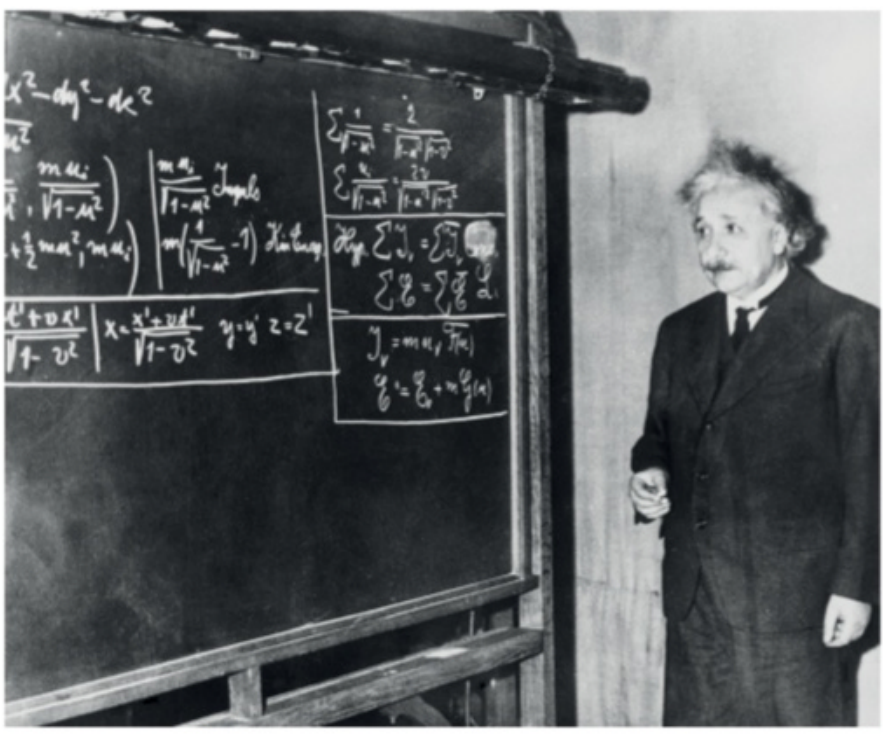
Somewhat mind-bogglingly, this case is like being able to cause Einstein to discover his famous equation based on information from his future without ever directly communicating with him.

Vilasini says that the causal loops examined don't necessarily lead to dramatic paradoxes, but they do show that past and future can be correlated in counter-intuitive ways. Whether causal loops can happen in our universe is still an open question, she says.

Our universe, with space-time structured the way it is and where nothing can move faster than light, is similar to the universes examined in the new analysis. But the three spatial dimensions in our universe may change the mathematics of causal loops just enough to make them impossible. Vilasini and Colbeck are still studying these dimensional effects.

Ravishankar Ramanathan at the University of Hong Kong says that while the analysis provides a general framework for examining causal loops, the exact details of the physical mechanisms that would bear them out are the biggest question still to answer. ▮ **KP-C**

A causal loop would let you give Albert Einstein a leg up



DAILY HERALD ARCHIVE/GETTY IMAGES

Technology

‘Fair’ AI looks at racial bias

Black homebuyers in the US could get a boost from AI decision-making

Jeremy Hsu

AN ARTIFICIAL intelligence could improve the effectiveness of reparations programmes created to redress decades of US housing discrimination against Black homebuyers. Using data from the first US housing reparations programme, an AI was able to suggest how large the monetary support might actually need to be to improve Black people’s chances of getting a favourable loan to buy a home.

“If, for some reason, you are excluded from the housing market, you are excluded from one of the primary ways to generate wealth for your family in this country,” says Anette Hosoi at the Massachusetts Institute of Technology (MIT).

A long history of government-sanctioned redlining – in which services are withheld from people in certain areas – reinforced by bias in mortgage-approval algorithms has affected millions of Black borrowers trying to buy homes.

This has caused a huge wealth gap. In 2015, the Federal Reserve Bank of Boston found that, in the Boston area, white households had an estimated median net worth of $247,500, but it was just $8 for Black households.

A growing number of cities and states are considering or implementing policies to redress this imbalance. In 2019, city council members in Evanston, Illinois, voted to set up the first US reparations programme, providing grants of up to $25,000, so that recipients could buy or repair homes, or get mortgage assistance.

Inspired by the Evanston example, Hosoi and her colleagues have trained an AI model on mortgage-lending data to evaluate the impact of the $25,000 grant for Black residents in Evanston’s Cook County.

SHUTTERSTOCK/JAY YUAN

Boston has a large wealth gap between white and Black people

“What we are really interested in is enabling the people from the municipal level, like the city council, to use this kind of tool to actually budget the housing reparations scenario,” says team member Wonyoung So, also at MIT.

The AI estimated that just 27 per cent of Black people who were denied a conventional mortgage in Cook County would now be accepted by using the $25,000 to boost their deposit. On average, the AI found that a Black person who applied for a conventional mortgage but was denied it would have needed a $33,289 down payment and $173 monthly support to be approved.

$8

Median net worth of Black households in the Boston area

Such findings suggest that the effectiveness of the reparations programme in Evanston could be boosted by increasing the amount of financial assistance, along with encouraging local lenders to lower the debt-to-income ratio used in lending decisions, say the researchers.

That estimate should be considered a general guide rather than being accurate, because the algorithm wasn’t able to train on credit score data, which is also used in evaluating lending risk, says So. Evanston officials didn’t respond to requests for comment.

It is a good example of how to develop a “fair algorithm” to account for historical factors such as discrimination, says Vinhcent Le at the Greenlining Institute, a non-profit group based in Oakland, California.

“I think it’s important that we supplement the moral reasons that we need to address this with data, because there are some people who aren’t going to be convinced by those moral reasons,” says Le.

The team presented the findings at the ACM Conference on Fairness, Accountability, and Transparency in June (FAccT ’22, doi.org/h34k). Next, the group plans to develop AI-powered tools that policy-makers can use to examine different housing reparations scenarios. ▮

Nutrition

Intermittent fasting linked to improved gut function in mice

Grace Wade

LIMITING meals to an 8-hour time frame each day leads to better organ function in mice.

In a study, around 200 young male mice were placed into two groups, one restricted to eating in an 8-hour window, the other able to feed freely. Both groups were fed a high-fat, high-sugar diet with the same total number of calories.

After four weeks, Satchidananda Panda at the Salk Institute for Biological Studies in California and his colleagues collected fat tissue and samples from the gut, brain, liver and other organs, and analysed gene expression in each to measure organ function.

Compared with mice that could eat whenever they wanted, those restricted to the 8-hour window had significant improvements in gene activation: 70 per cent of the genes in at least one organ changed their expression in a way that reflected improved functioning. The biggest improvements were in fat and digestive tissues.

It isn’t about which genes are good or bad, says Panda. “It’s about what time they come on.” That is because each organ follows its own internal clock that determines when to switch between functions.

In the gut, during the day, a set of genes turns on to digest food, but at night, a separate set activates to repair the gut’s lining. Both sets can’t be active at once because the gut can’t perform these functions simultaneously, says Panda. The same is true for genes in the heart, liver and other organs, he says.

“What we find is time-restricted feeding helps robustly regulate our circadian rhythm,” he says.

Panda believes the study suggests a potential mechanism for how intermittent fasting may benefit humans too. The research was presented at the online American Society for Nutrition conference in June. ▮

New Scientist Podcast

The New Scientist Weekly podcast

Our weekly podcast has become the must-listen science show, bringing you the most important, surprising or just plain weird events and discoveries of the week. Hosted by *New Scientist*'s Rowan Hooper, new episodes are out each Friday.

Follow us on Twitter **@newscientistpod**

THE PUBLISHER PODCAST AWARDS
★
2021 WINNER
PODCAST OF THE YEAR

Listen on Apple Podcasts · Listen on Spotify · Listen on Google Podcasts · Listen on Stitcher

Biotechnology

Molecular computer is extremely energy efficient

Karmela Padavic-Callaghan

A COMPUTER that uses molecules to solve problems needs 10,000 times less energy than a conventional computer. If made larger, these biocomputers could efficiently solve complex logistics problems that normally require a lot of time and energy.

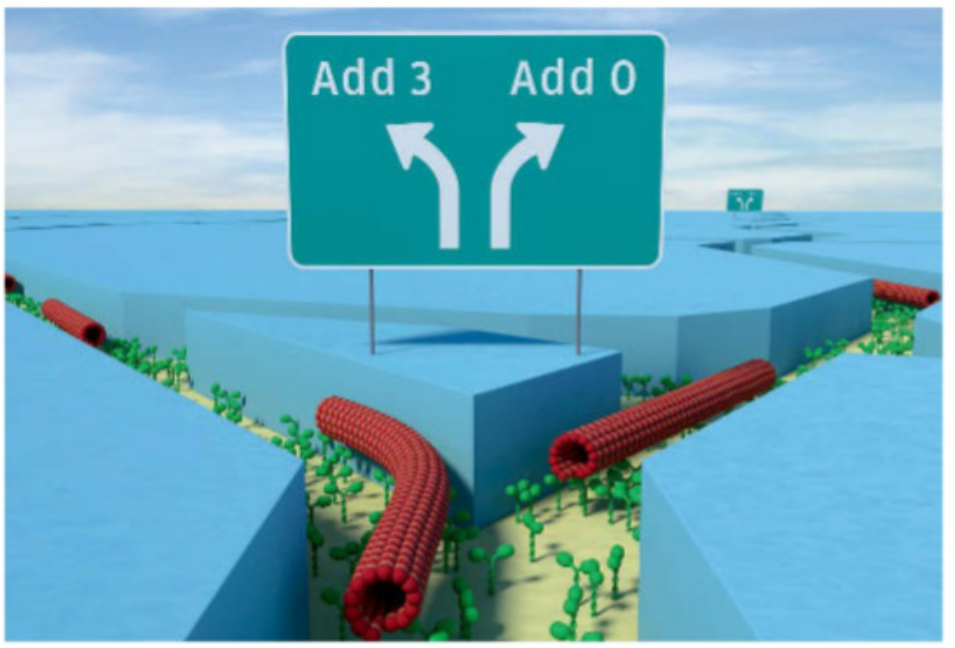
For most of computing history, as chips have decreased in size, they have also required less energy to run. But this relationship broke around 15 years ago, meaning that computers that perform large computations aren't as energy-efficient as we might have once hoped.

One way to make future computers use less energy may be to ditch electronics altogether and turn to biology instead. Till Korten at Dresden University of Technology in Germany and his colleagues have built a chip-based biocomputer that uses molecules travelling through channels to solve problems.

The chip is made of glass and etched in such a way that it encodes a problem for the computer to solve. To perform the computation, the researchers flood the chip with a fluid containing molecules called kinesins and microscopic tubes called microtubules.

Microtubules form part of the inner scaffolding of cells, and kinesins move along them to transport other molecules. The biocomputer design turns this upside down. The microtubules

Molecules can travel through channels to perform calculations



TILL KORTEN/DRESDEN UNIVERSITY OF TECHNOLOGY

effectively "crowd-surf" on kinesins through the chip's channels, says Korten. All the microtubules move at once, meaning many calculations can be performed simultaneously.

The microtubules move through the channels and each path one takes corresponds to the computer trying out a solution. The researchers then take an image to read the biocomputer's output and determine the most successful solution.

Korten says the biocomputer can solve intensive combinatorial problems, similar to the calculations used to figure out the optimal route for an airplane that has to make stops in multiple cities.

His team's machine solved one such problem that required 128 times more computations than what had previously been considered the state of the art for biocomputers that use the same computational mechanism (*ACS Nanoscience Au*, doi.org/h3vb).

Henry Hess at Columbia University in New York says that this is significant progress compared with the first biocomputers made a decade ago.

Surfing molecules also perform each step of computation using 10,000 times less energy than electrons in a traditional computer. "One way to understand it is that these [molecular] motors have been optimised by a billion years of evolution," says Korten. The new device is the most powerful of its kind yet, but it still isn't advanced enough to be practical. ▮

Mental health

Brain electrodes may be long-lasting aid for depression

ELECTRODES implanted deep inside the brain may provide considerable relief for just under half of people with the most severe depression for up to nine years, a trial has found.

"They've taken the sickest of the sick and made almost half of them better, which is quite remarkable," says Philip Mosley at the University of Queensland, Australia, who wasn't involved in the study.

The 25 participants had tried antidepressants, psychotherapies and electroconvulsive therapy for their condition, without success.

As part of the trial, they had tiny electrodes implanted into a brain circuit linked to severe depression.

Implanted between 2010 and 2014, the electrodes released impulses that it was hoped would improve connections within this circuit. "It's like adding noise to a telephone cable: participants with severe depression have too much communication between certain brain areas, but adding this noise normalises this communication," says Isidoor Bergfeld, who led the trial at Amsterdam UMC, a medical centre in the Netherlands.

The participants were monitored for six to nine years until 2019. At this point, 44 per cent had significantly benefited from the treatment, defined as their depression score reducing by at least 50 per cent from baseline.

Another 28 per cent had partial benefits, with their depression score decreasing by 25 to 50 per cent.

"They've taken the sickest of the sick and made almost half of them better, which is quite remarkable"

To check this wasn't a placebo effect, the trial included a 12-week period in which the electrodes were switched off for half the time, without the participants knowing when. Their depression scores then worsened, on average, suggesting the treatment effects are genuine (*Brain Stimulation*, doi.org/h34x).

Bergfeld and his colleagues are now running a second trial. "If we manage to show an effect in more patients, then the ambition is to make this a standard treatment that's more widely available to more patients," he says. ▮

Alice Klein

University of Salford MANCHESTER

SEE THE FUTURE

Rising to the challenge of a changing world, our multi-disciplinary courses, research centres and industry collaborations are designed to shape the next generation of scientists, engineers, urbanists and industry leaders.

- / ARCHITECTURE
- / ACOUSTICS
- / BUILT ENVIRONMENT
- / BIOSCIENCES
- / COMPUTER SCIENCE
- / ENGINEERING
- / ROBOTICS
- / WILDLIFE AND ENVIRONMENT

DISCOVER MORE

Discover more about how the University of Salford is shaping the future of science, engineering and the environment: **www.salford.ac.uk/SEE**

SCHOOL OF
SCIENCE, ENGINEERING
& ENVIRONMENT

Botany

Largest of the water lilies

Victoria boliviana is the third known giant water lily – and the biggest

Carissa Wong

WITH lily pads up to 3.2 metres wide and flowers that are each larger than a human head, a newly identified species of giant water lily is the world's largest.

In 2016, Bolivian institutions Santa Cruz de La Sierra Botanic Garden and La Rinconada Gardens donated giant water lily seeds to Kew Gardens in the UK. As Carlos Magdalena – a horticulturalist at Kew – grew them, he could see from the way they developed that they were different from the two known species of giant water lily. In 2019, he visited Bolivia to see the water lilies growing in the wild (pictured).

A research team at Kew has named the new species *Victoria boliviana* (*Frontiers in Plant Science*, doi.org/gqfvrd).

Genetic analysis shows it has a large genome. Natalia Przelomska at Kew would like to find out why. "A larger plant wouldn't necessarily have a larger genome," she says. ▮

CESAR DAVID SALAZAR

Technology

Floating buoy uses waves to power itself

A SELF-CHARGING buoy that uses nanogenerators to harness power from the movement of waves could be used as part of an early flood warning system or to help monitor water quality over time.

Many sensing systems used in water have a problem: they rely on batteries that are often made from unsustainable materials and that will need replacing at some point.

Looking for a cleaner, long-lasting alternative, Zhong Lin Wang at the Chinese Academy of Sciences, Beijing, and his colleagues have created a self-charging buoy. The device uses nanogenerators that harness the triboelectric effect, in which electricity is produced when materials become charged as they rub together.

The buoy consists of an acrylic ball about 10 centimetres across, containing four nanogenerators, which are made from polyester film and copper twisted into a spiral. As water moves back and forth through the nanogenerators, they produce around 24.5 milliwatts of power, enough to send a radio signal to a mobile phone 25 metres away (*Advanced Functional Materials*, doi.org/h3qf).

The researchers suggest that such buoys could be used for checking water levels to warn of floods. However, there are already many effective and cheap alternatives for this, says Wouter Buytaert at Imperial College London.

Non-contact methods, such as lidar, are probably more suitable for sensing water levels, he says.

If used in rivers, there is also a high chance the buoys would be damaged by rising or turbulent water, especially if they are installed upstream of a settlement at risk of flooding as an early warning system, says Liz Stephens at the University of Reading, UK.

"For measuring water quality, self-powering buoys like this could be very, very promising"

"In these environments, there is often a high sediment load in the river during a flood and so any sensor actually in the river is likely to get destroyed," she says.

The novel power generation method could prove useful for situations in which non-contact methods aren't viable, though, says Buytaert, such as water quality sensing.

"There have been developments of using buoys very similar to the one described here to measure water quality variables. For applications like that, combined with the type of power harvesting they show here, it could be very, very promising," he says. ▮

Alex Wilkins

Fertility

We may know why some IVF embryos stop developing

Clare Wilson

ABOUT two-thirds of embryos created during in vitro fertilisation inexplicably stop growing – and we are starting to understand why.

In IVF, eggs are placed in a dish with sperm and checked to see which get fertilised. Some then develop into a blastocyst, a ball of about 100 cells, and can be transferred into someone's uterus. However, about 6 in 10 never reach this stage.

To better understand why, Andrew Hutchins at the Southern University of Science and Technology in China and his colleagues looked at 17 so-called arrested embryos by sequencing their RNA, strands of genetic material that show which genes are active. The team also examined their chromosomes.

The researchers combined this with data on six other arrested embryos from a previous study, before comparing the set with RNA sequencing work on embryos that seemed to be developing normally.

They discovered that arrested embryos could be divided into three groups. In type 1, the arrested embryo makes proteins from RNA that had been in the egg, but fails to make proteins from its own genetic material.

Type 2 and 3 arrested embryos fail to make a crucial transition in how they obtain energy. Healthy embryos shift from a metabolism that is dependent on oxygen to one that requires little oxygen.

In type 2 arrested embryos, their oxygen-dependent metabolism continues, while in type 3, it falls to low levels (*PLoS Biology*, doi.org/gqfjsz).

The findings are early stage, but could help doctors reduce the number of arrested embryos, says Virginia Bolton at King's College London. "That could increase the number of embryos a couple would have available to them for pregnancy," she says. ▮

Ecology

Alien earthworms have invaded nearly all of North America

Michael Le Page

AS NORTH Americans have busied themselves about their various concerns, unseen invaders have slowly been amassing beneath their feet. There are now more alien species than native species of earthworms in most places on the continent, a study has discovered.

"Our results reveal that the entire continent is being invaded by non-native earthworms through a variety of pathways," Jérôme Mathieu at the Sorbonne University in Paris, France, and his colleagues write. "These

77%

Proportion of earthworm species seen in Canada that are invasive

aliens... represent a major threat to native ecosystems."

Although invading worms are a problem all over the world, this is especially the case in North America, where many northerly areas had been free of earthworms after the last glacial period ended about 12,000 years ago.

The study reveals just how massive the problem is. The team drew together more than 68,000 records running from 1850 to 2021 to create a comprehensive overall picture of this silent invasion.

Alien worms are now found in 97 per cent of the areas for which there are records, whereas native species are located in just 72 per cent.

In terms of the proportion of non-native to native species, earthworms are the most invasive type of animal, the study says. Of the 308 species of earthworm recorded in North America, 23 per cent are non-native. In Canada, invasive earthworms make up 77 per cent of worm species.

The alien species also have much bigger ranges than most of the native ones. "A startling twelve of the thirteen topmost widespread earthworm species are alien," the researchers write (bioRxiv, doi.org/h34w).

We didn't have a detailed picture of which non-native species of earthworms were where before this study, says Malte Jochum at the German Centre for Integrative Biodiversity Research in Leipzig. "This is very important work," he says. "It's very impressive."

Non-native worms not only alter underground ecosystems, he says, they also transform those above the soil. Earlier this year, Jochum's team reported that the numbers, biomass and diversity of insects and spiders in a forest in Canada decline as non-native worms arrive. Other studies have shown that invasive worms can cause declines in some plants and even kill trees such as sugar maples (*Acer saccharum*).

"These below-ground invaders also have impacts on above-ground communities," says Jochum. "Just because we don't see them does not mean they don't have a huge impact."

The spread of non-native worms in northern regions of the continent is being worsened by global warming, says Jochum. "With thawing permafrost and other changes, the problem will only increase, and maybe quite dramatically," he says.

BLICKWINKEL/ALAMY

***Eisenia fetida* worms are invasive to North America**

Slow spread

The impacts aren't all bad. Earthworms can dramatically increase crop productivity, according to Mathieu's study, while earthworm collecting for fishing bait, say, is a sizeable business in Canada.

There is little that can be done in areas where the worms have already arrived. "It is virtually impossible to remove established populations of alien earthworms," write Mathieu and his colleagues.

However, the worms naturally spread slowly, by just 10 or so metres a year. It is human activities, such as carrying soil or plants around, that enable them to disperse much faster. So measures like cleaning hiking boots and car tyres, and not discarding unused bait worms, would help keep the non-native worms out of places they haven't reached.

The problem is that there is little knowledge of the problem, says Jochum. "Many people I have met in Canada aren't aware that the earthworms don't belong," he says.

Mathieu declined to discuss the study's findings ahead of its publication in a journal. ▮

Climate change

UK set to miss carbon goals due to failure to insulate homes

Adam Vaughan

A "SHOCKING" failure to insulate homes is one of the key reasons the UK government's independent climate advisers have warned the country is set to miss its net-zero target.

In a 600-page report to the UK parliament on 29 June, the Climate Change Committee (CCC) said that while there had been progress on carbon-cutting policies in the past year, the government was taking a "high-wire approach to net zero" due to a lack of credible plans across the economy.

The group was scathing about government efforts to upgrade the energy efficiency of UK homes – some of the oldest and draughtiest in Europe.

"It's a complete tale of woe," says Chris Stark at the CCC, and the approach has been "frankly shocking".

Government plans to reduce agriculture's emissions are also highlighted as falling short of what is needed.

The report came as fears grow that the UK government is considering rowing back on its green agenda in the wake of concerns over energy security and the cost of living.

The UK prime minister, Boris Johnson, also recently hinted that the government will give the green light to the UK's first coal mine in 30 years.

John Gummer, chair of the CCC, says approval of the mine would be indefensible. "We do not need this coal mine," he says, and most of the coking coal it produces will be exported.

However, Stark isn't worried about the government's plan to postpone the closure of three coal power stations this winter to address energy security fears, because the emissions will be "very, very tiny", he says.

STURTI/GETTY IMAGES

Not enough loft insulation is being installed in the UK

The progress report finds that almost two-fifths of the emissions reductions needed for the UK to meet its legally binding carbon target for the mid-2030s are endangered by a "policy gap" or "significant risks" to the policies that exist. The target is to slash emissions by 78 per cent by 2035 compared with 1990 levels. "Overall, the programme is not sufficient to get to the targets," says Stark.

The government is also criticised for over-reliance on tech fixes and not doing enough to encourage behaviour change, such as pushing people to fly less or eat less meat and dairy.

"Overall, the emission-cutting programme is not sufficient to get to the net-zero target"

Only 39 per cent of the required emissions cuts for the mid-2030s are considered to be backed by credible policies, mostly ones to spur electric car use and renewable electricity generation. Support for electric cars is judged to be a bright spot, with the CCC finding that sales are outpacing its projections.

The report says the UK is about halfway – a 47 per cent reduction on the level of emissions in 1990 – to its legal goal of getting to net zero by 2050. Despite emissions rising in 2021, they are still 10 per cent below pre-pandemic levels. Aviation emissions last year were down 8 per cent, but total road and rail transport emissions were up 10 per cent.

A UK government spokesperson said: "We should all be proud that over the past three decades, the UK has driven down emissions faster than any other G7 country, and that we have clear plans to go further."

The report wasn't hampered by a lack of transparency on the government's net-zero plans, says Stark. But, he adds: "They are not producing line-by-line, policy-by-policy assessments, even though we know they have that kind of information. So I think there is still more that could be done." ▮

Evolution

Dinosaurs' ability to survive cold helped them rule the planet

Luke Taylor

SOME dinosaurs may have evolved traits that allowed them to endure freezing winters during the Late Triassic and Early Jurassic period. It could explain how they came to dominate the planet for the next 135 million years.

Analysis of rock sediment in Junggar basin in north-west China, where dinosaur footprints have previously been found, adds to evidence that these animals didn't just inhabit green, tropical landscapes, but also icy forests.

Paul Olsen at Columbia University in New York and his colleagues have found signs that the region regularly froze over when it was inhabited by the prehistoric reptiles. The sediment contains unusually large particles that are typical of lakes that freeze each year (*Science Advances*, doi.org/gqfn27).

Dinosaur fossils have been found near the poles, but models suggesting that temperatures there dropped below freezing between 237 million years and 174.1 million years ago are disputed, so no one knew if the reptiles actually lived in cold conditions.

Fossil dating shows that most medium and large continental reptiles disappeared at the end of the Triassic, when temperatures plunged. But medium-large dinosaurs rapidly appeared again almost everywhere after this extinction event, says Olsen, and the adaptation of the polar dinosaurs to the cold probably explains why.

When temperatures plummeted in the end-Triassic period, these dinosaurs were prepared, having survived by eating polar vegetation and with feathers that served as insulation, says Olsen. They then expanded across the world throughout the Jurassic.

"Our view of the dinosaurian world is basically all wrong," says Olsen. "Dinosaurs are fundamentally cold-adapted animals." ▮

New Scientist
Subscriptions

Try *4 weeks* of our world-leading science journalism for *free*

Whether it's sentient trees, human health or the mysteries of the universe – *New Scientist* provides the answers to the biggest questions surrounding the most fascinating topics.

Find out for yourself and try 4 weeks for free, including unlimited access to all our news and in-depth articles in print, in our app and on newscientist.com.

Scan me to sign up

Sign up today and try 4 weeks for free at newscientist.com/18336
or call: +1 888 822 3242, quoting 18336

Offer available on 'web', 'digital' and 'digital + print packages'. This is an auto renewing subscription. After your free 4-week trial period is over, your subscription will step up to the full monthly or annual rate. You can cancel anytime in your trial period and no charges will be made. Other offers available. Once payment has been taken, in the unlikely event that you wish to cancel your subscription, we offer a 14-day cooling off period after initial payment is made. Offer ends 13 July 2022.

Technology

AI predicts crime a week in advance

The location of crimes could be accurately predicted, but bias concerns persist

Matthew Sparkes

AN ARTIFICIAL intelligence can now predict the location and rate of crime across a city a week in advance with up to 90 per cent accuracy. Similar systems have been shown to perpetuate racist bias in policing, and the same could be true in this case, but the researchers who created this AI claim that it can also be used to expose those biases.

Ishanu Chattopadhyay at the University of Chicago and his colleagues created an AI model that analysed historical crime data from Chicago between 2014 and the end of 2016, then predicted crime levels for the weeks that followed this training period.

The model predicted the likelihood of certain crimes occurring across the city, which was divided into squares about 300 metres across, a week in advance with up to 90 per cent accuracy. It was also trained and tested on data for seven other major US cities, with a similar level of performance.

Previous efforts to use AIs to predict crime have been controversial because they can perpetuate racial bias. In recent years, Chicago Police Department has trialled an algorithm that created a list of people deemed most at risk of being involved in a shooting, either as a victim or as a perpetrator. Details of the algorithm and the list were initially kept secret, but when the list was released, it turned out that 56 per cent of Black men in the city aged between 20 to 29 featured on it.

Chicago, where an AI has been trained to predict crimes

MAYTIKKA/SHUTTERSTOCK

Chattopadhyay concedes that the data used by his model will also be biased, but says that efforts have been taken to reduce the effect of bias and that the AI doesn't identify suspects, only potential sites of crime. "It's not *Minority Report*," he says.

"Law enforcement resources are not infinite. So you do want to use that optimally. It would be great if you could know where homicides are going to happen," he says.

Chattopadhyay says the AI's predictions could be better used to inform policy at a high level, rather than being used to allocate police resources. He has released the study's data and algorithm publicly so that other researchers can investigate the results.

Chattopadhyay and his team also used the data to look at human bias in policing by analysing the number of arrests following crimes in neighbourhoods in Chicago with different socio-economic levels. This showed that crimes in wealthier areas resulted in more arrests than they did in poorer areas, suggesting bias in the police response (*Nature Human Behaviour*, doi.org/h3s8).

Lawrence Sherman at the Cambridge Centre for Evidence-Based Policing, UK, says he is concerned about the inclusion of reactive and proactive policing data in the study, or crimes that tend to be recorded because people report them and crimes that tend to be recorded because police officers go out looking for them. The latter type of data is very susceptible to bias, he says. "It could be reflecting intentional discrimination by police in certain areas," says Sherman. ▮

Medicine

Implantable device blocks pain by chilling nerves

PUTTING ice on an injury can ease the pain – and we may be able to get the same effect with an implant that cools down nerve fibres inside the body.

The device can chill nerves to 10°C, reducing pain signals sent to the brain, according to a study that tested a prototype in rats. Made from biodegradable materials, it is designed to be implanted after surgery and then be absorbed by the body as the pain eases.

John Rogers at Northwestern University in Illinois and his colleagues developed a thin, flexible strip of material that contains small channels for chemicals to flow through. One end can be wrapped around a nerve fibre like a cuff. The other end emerges from the skin and is connected to a small pump.

Nitrogen gas and a harmless liquid called perfluoropentane (PFP) are pumped in through separate channels in the strip. The chemicals mix at the far end of the strip, which causes the PFP to evaporate, providing a cooling effect.

To test the device, it was implanted around the sciatic nerve in the legs of three rats, and their paws were injured so they became more sensitive. Three weeks later, when each paw was pressed using a sensitive measuring device, it required seven times more force to make the animals retract their leg when the cooling was turned on.

After six months, the device had been absorbed into the body and no nerve damage was observed (*Science*, doi.org/gqfjsx).

"The device is designed to be implanted after surgery and then be absorbed by the body as pain eases"

The team now needs to continue testing the implant in animals to understand how much nerves can be chilled – and for how long – without causing harm, says Rogers.

Many previous pain-relieving approaches that worked in rats haven't succeeded in people, but it is well established that cooling nerves blocks their function, says Francis McGlone at Liverpool John Moores University in the UK. "This is basic biophysics," he says. "The underlying principle is secure." ▮

Clare Wilson

Molecular biology

Alternative CRISPR tool may be better way to edit genes

Carissa Wong

A NEW form of the genome-editing technique CRISPR could offer a more accurate way to edit mutations that cause genetic conditions.

CRISPR usually works with a protein called Cas9, which acts like molecular scissors to cut through the two strands of a DNA molecule at the site of a targeted sequence. This can allow new DNA sequences to be inserted between the cuts to replace the mutated gene.

However, this insertion usually works for less than 10 per cent of cells and insertions can occur in incorrect, or off-target, regions of the genome.

Now, Annabel Guichard at the University of California, San Diego, and her colleagues have developed a new form of CRISPR that uses a variant of the Cas9 enzyme called a nickase, which only cuts one strand of the DNA double helix.

The researchers tested the approach in fruit flies that had a mutation on one chromosome that turned their eyes white instead of red. They found that the nickase system edited the eye colour mutation in up to 65 per cent of cells, giving the flies red eyes. Standard CRISPR using Cas9 edited the mutation in up to 30 per cent of cells, causing each eye to have a small patch of red (*Science Advances*, doi.org/gqfn28).

"It was a truly incredible moment. We knew we had found something absolutely amazing when we saw that right away," says Guichard.

The team didn't introduce any extra pieces of DNA as a template for each cell to correct the mutation on the chromosome, so the molecular machinery must have used the equivalent chromosome – inherited from the other parent – as a template. This generally wasn't thought to be possible, but recent findings suggest it can occasionally occur under some circumstances that have yet to be identified. ▮

Climate change

The 'human climate niche' may shrink drastically this century

James Dinneen

AS MANY as a billion people could be living outside the optimal climate for humans by the end of the century if we hit 2.7°C of global warming. At 1.5°C of warming, half as many people would be affected.

Among the many ways to quantify the effects of climate change is to consider how a warmer world might change the climate in places humans have historically lived. Tim Lenton at the University of Exeter, UK, and his colleagues previously found that over the past 8000 years, people have congregated within temperature ranges where domesticated crops grow best. Human populations are densest in places with an average annual temperature of around 13°C, with another cluster at 27°C.

While people have found ways to make homes in places from Siberia to the Sahara, this "human climate niche" represents a kind of optimum for human flourishing, says Lenton. Climate change could shrink the niche.

Lenton and his team quantified how many people would be left outside this niche given different scenarios. With 2.7°C of warming by the end of the century, between 21 and 42 per cent of people would live in areas where the average annual temperature exceeds 29°C. Assuming a future population of 9.5 billion, that would leave as many as 4 billion people outside the niche, with the greatest number in India at 600 million, followed by 300 million people in Nigeria and 100 million in Indonesia (bioRxiv, doi.org/gqbn8w).

4 billion

Number of people who may live at temperatures above 29°C by 2100

However, every bit of warming avoided this century leads to hugely different outcomes, says Lenton. With 1.5°C of warming – a target that may already be out of reach – the study found a sixfold decrease in the number of people in India who would end up outside the niche, a sevenfold drop in Nigeria and a 20-fold fall in Indonesia compared with the 2.7°C scenario. "My god, there's a lot to play for," says Lenton.

In 1980, the year the study used as a baseline for population density, just 0.3 per cent of people, or about 12 million people, were exposed to average annual temperatures over 29°C. In 2015, due to both climate and demographic change, that number had increased to 12 per cent of people.

"These are the sort of numbers we should have been listening to for years," says Steve Keen at University College London.

Elisabeth Gilmore at Carleton University, Canada, says the study helps frame the magnitude of the climate problem, though it might falsely imply that migration and conflict are inevitable outcomes of rising temperatures, rather than things people and governments can affect.

People can and do live outside the niche, but Lenton says many aspects of life are generally more difficult, from growing food and staying healthy to keeping the peace. "We don't live in a world where everyone is rich enough to try and isolate themselves from the climate," he says. What's more, the analysis doesn't account for rising seas, extreme weather or other cascading effects. ▮

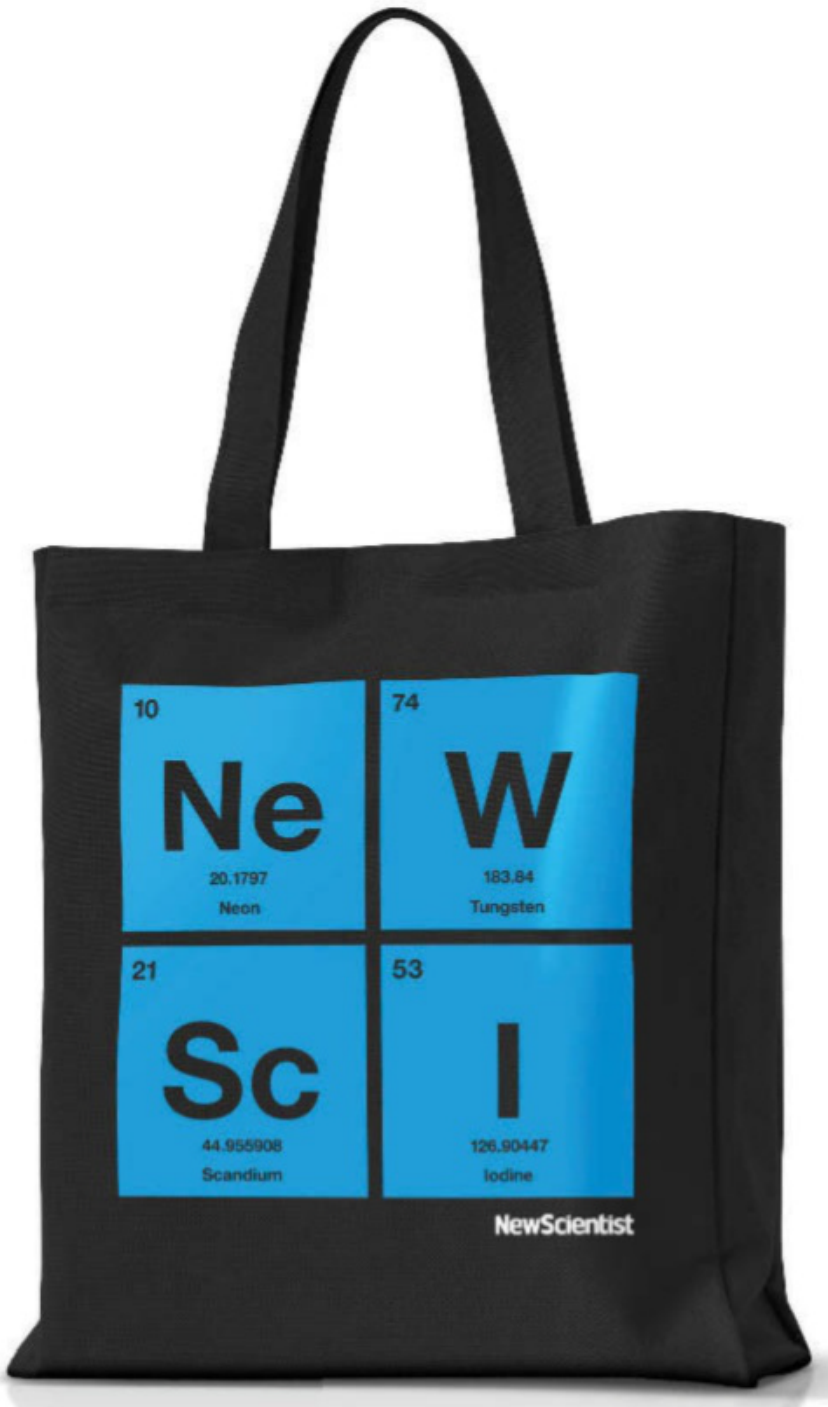
DAVID MCNEW/GETTY IMAGES

The range of areas with optimal temperatures for us to live may shrink

New Scientist
Shop

EXCLUSIVE *NEW SCIENTIST* TOTE BAG

Our reusable tote-style shopper bag is perfect for taking everything you need on the go. They are lightweight with double handles to make them strong for carrying all your essential items.



Also available in the *New Scientist* shop

shop.newscientist.com

worldwide shipping available

Coronavirus

The risks from covid-19 reinfection

A study has found that people who catch the coronavirus two or three times go on to have higher rates of everything from heart disease to kidney disorders, reports **Michael Le Page**

YOU have been vaccinated and recently had covid-19, so you don't have to worry about any serious problems if you get it again, right? Wrong. A large study suggests that every time a person is reinfected, they have extra health risks.

"Every reinfection is like rolling the dice again," says Ziyad Al-Aly at VA St. Louis Health Care System in Missouri. "A second infection is still bad for you."

The omicron subvariants BA.4 and BA.5, which are driving the latest wave of cases in much of the world, are even better at evading prior immunity than their BA.1 and BA.2 predecessors. In the UK alone, up to 1 in 20 people were thought to have covid-19 in the middle of June, according to the Office for National Statistics. This is despite an estimated 97 per cent of adults having antibodies at a level that should at least provide some protection against the delta variant at the end of May.

Al-Aly and his colleagues' study gained a lot of attention online when it was released as a preprint on 17 June. It found that people who had two or more covid-19 infections were twice as likely to die of any cause and three times as likely to be hospitalised in the six months after catching the coronavirus, compared with people who caught it just once.

This was widely misinterpreted as reinfections being worse than first infections. That absolutely isn't the case, says Al-Aly.

The risk of serious outcomes is probably smaller after reinfections than after the first infection, he says. We can't be certain, however, as the study compared people who had been infected at least twice with those who had been infected just once, rather than comparing first and second infections in the same individuals. It is possible that those who were infected twice had one covid-19 infection and 40,000 had two or more.

SPENCER PLATT/GETTY IMAGES

Another covid-19 wave has hit the US, the UK and other parts of the world

1 in 20
The upper estimate of people with covid-19 in the UK in mid-June

97%
Proportion of adults in the UK with antibodies against the delta variant at least

x2
The elevated risk of death by any cause in the six months after a covid-19 reinfection

Across the study, the average age of the people was 60, but many were as young as 20, says Al-Aly, who doesn't think the results apply only to older people.

One criticism of the study is that it defined reinfections as a positive test 30 days or more after a previous positive test, which could be a persistent initial infection rather than a reinfection. That criticism is entirely fair, says Al-Aly. The team has since reanalysed the data looking only at positive tests that occurred at least 90 days after the first, and the results are essentially the same, he says.

Overall, these findings shouldn't be a big surprise given what we know about the risk of reinfection with other viruses. For instance, flu reinfections occasionally cause serious complications, from heart inflammation to multi-organ failure, especially in older people.

It wouldn't be surprising if covid-19's disease burden is even higher than flu's, due to more reinfections and possibly greater risks with each reinfection.

So what should we do? Given there is a reduced will to wear masks and limit social contact in most parts of the world, Al-Aly says we should be giving more people preventative treatments, such as Pfizer's Paxlovid (made up of the generic drugs nirmatrelvir and ritonavir), while also prioritising the development of more effective vaccines, like nasal ones.

"There is simply no excuse for why these vaccines are not being hyper-aggressively pursued," Eric Topol at the Scripps Research Translational Institute in California wrote in a commentary on the study. "The lack of priority and resource allocation stems from the illusion that the pandemic is behind us." ▮

New Scientist Newsletter

Daily Newsletter

Get the best of science delivered straight to your inbox

The *New Scientist* Daily newsletter is your daily dose of all that's hot in science and technology, delivered straight to where you are.

Plus, whether it's the latest in health, space exploration, fundamental physics, our human story or the environment you're interested in, we have a wealth of weekly and monthly newsletters to suit your tastes too.

Find out more at
newscientist.com/sign-up

Scan me to sign up

Our family of newsletters

newscientist.com/newsletter

The Weekly	The Daily	Fix The Planet	Health Check	Launchpad	Lost in Space-time	Our Human Story	Wild Wild Life
NS							

Evolution

Dogs related to two groups of wolves

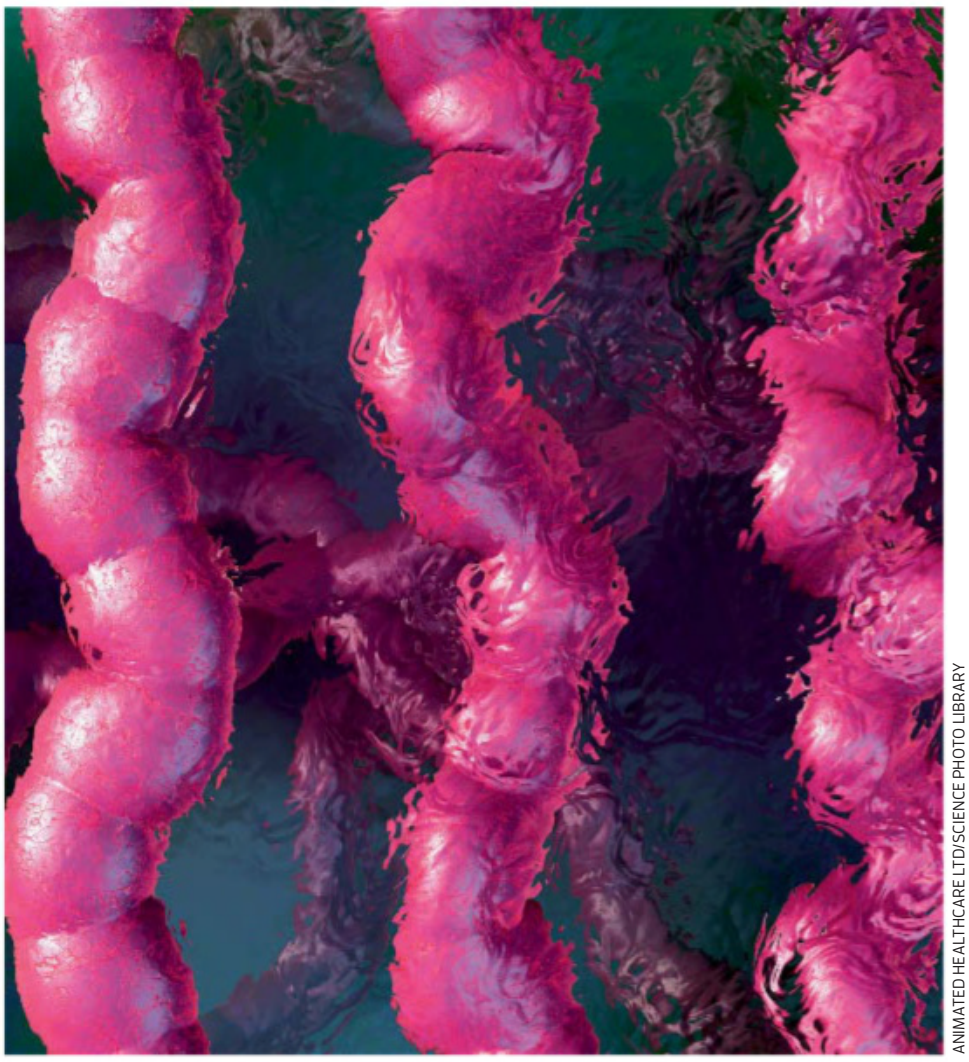
MODERN domestic dogs are closely related to two populations of ancient wolves, one from Asia and one from Europe, according to a study looking at ancient DNA.

Dogs are thought to be descended from Eurasian grey wolves (*Canis lupus lupus*), but the story of when and where they were domesticated is still a mystery.

Anders Bergstrom at the Francis Crick Institute in London and his colleagues analysed the DNA of 72 ancient wolves from skeletal remains up to 100,000 years old found in Europe, Siberia and North America.

They compared the genome of modern-day dogs with the sequenced wolf DNA and found links to populations of ancient wolves in Europe and Asia (*Nature*, doi.org/gqfkwm).

Jason Arunn Murugesu



ANIMATED HEALTHCARE LTD/SCIENCE PHOTO LIBRARY

Technology

Structures take shape in mid-air

SOUND waves have been used to levitate components and tiny droplets of quick-setting glue to build complex structures piece by piece in mid-air. The approach may have practical engineering and medical applications.

Asier Marzo at the Public University of Navarre, Spain, and his colleagues have developed a system called LeviPrint, which uses a robot arm that can create very specific sound waves. The arm's movement and acoustic levitation abilities mean that it can carry components to assemble an object from them without touching any parts (*SIGGRAPH '22 Conference Proceedings*, DOI: 10.1145/3528233.3530752).

This has advantages over 3D printing, says the team, including the ability to handle liquids, powders and hot or hazardous substances. **Matthew Sparkes**

Health

Faecal swap offers hope of lasting relief from IBS pain

IRRITABLE bowel syndrome can be eased for at least three years by faecal transplants, according to the longest-running clinical trial so far.

About 10 per cent of the global population have IBS, typically with symptoms including chronic gut pain, fatigue, bloating, constipation and diarrhoea. Some medications can reduce the symptoms, but don't address the root cause.

Studies have found that people with IBS often have an imbalance of "good" and "bad" gut microbes in their digestive tract (illustrated above), hinting that it may be possible to treat them by recolonising their guts with a healthier mix of microbes.

To test this idea, Magdy El-Salhy at Stord Hospital in Norway and his colleagues collected faeces from a 36-year-old man judged to have an optimum mix of gut microbes.

They transferred samples of his stool into the small intestines of 87 people with moderate-to-severe IBS in order to introduce his mix of gut microbes. Another 38 people had samples of their own faeces transferred as a placebo. None of the participants knew which kind of faeces they had been given.

Three years later, at least 64 per cent of the people who received the healthy stool transplant had fewer gut symptoms, less fatigue and better quality of life. In contrast, only 27 per cent of the placebo group reported improvements (*Gastroenterology*, doi.org/h3tz).

At the moment, it isn't feasible to offer faecal transplants to all people with IBS because of the cost, but, in future, we may be able to isolate "good" microbes and administer them in tablet form, says Stuart Brierley at Flinders University in Adelaide, Australia. Alice Klein

Really brief

KARRASTOCK/GETTY IMAGES

AI could improve chicken welfare

An AI has been trained to recognise the distress calls of chickens, which could help flag up welfare issues in crowded poultry barns on farms. Spotting the calls is difficult without AI because 25,000 birds or more can be housed together (*Journal of the Royal Society Interface*, doi.org/gqfc7f).

Zika raises chances of mosquito bites

Humans and mice infected with the Zika or dengue virus secrete a chemical that makes them more appetising to mosquitoes. This means they are more likely to be bitten and transmit the viruses. But isotretinoin, an acne medication, suppresses production of the chemical (*Cell*, doi.org/h3tv).

Gut viruses also live in salivary glands

Norovirus and two other gut viruses can also survive in salivary glands of mice, which suggests they might not spread simply through the faecal-oral route. The viruses also grow in human salivary gland cells, which might offer a way to grow the viruses in the lab and develop treatments (*Nature*, doi.org/gqfdz7).

THE WORLD'S GREATEST FESTIVAL OF IDEAS & DISCOVERIES

New Scientist Live

7–9 OCTOBER 2022 | EXCEL LONDON AND ONLINE

FEATURE PARTNERS

SCHOOLS' DAY SPONSOR

MEDIA PARTNER

CHARITY PARTNER

We've got some of the best-loved names in science, alongside up-and-coming researchers who are tackling some of humanity's greatest challenges. You can hear about everything from the biggest number in the world to the smallest particles in the universe from experts at the forefront of scientific discovery.
Meet our latest speakers:

HELEN CZERSKI

Associate Professor, UCL

AN OCEAN OF SALT

Join physicist and presenter Helen Czerski as she reveals how understanding salt is vital to understanding how our ocean shapes life, climate and human civilisation

EUGENIA CHENG

Scientist in Residence, Art Institute of Chicago

THE JOY OF ABSTRACTION

Maths isn't just about numbers, equations and getting the right answer. Mathematician and author Eugenia Cheng will show how even high-level abstract maths can be accessible, open-ended and joyful.

CHRISTOPHER JACKSON

Geoscientist, Jacobs

THE GEOLOGICAL RECORD OF CLIMATE CHANGE

Geologist Chris Jackson will explain how, by understanding the changes in Earth's climate over the past 4 billion years, we can better understand its present and future.

ADAM RUTHERFORD

Scientist, writer and broadcaster

THE DARK HISTORY AND TROUBLING PRESENT OF EUGENICS

Adam Rutherford will tell the story of attempts by the powerful throughout history to dictate reproduction and regulate its interface with society.

Super early bird tickets are selling out fast. Book today to get the best offer.

newscientist.com/ns0710

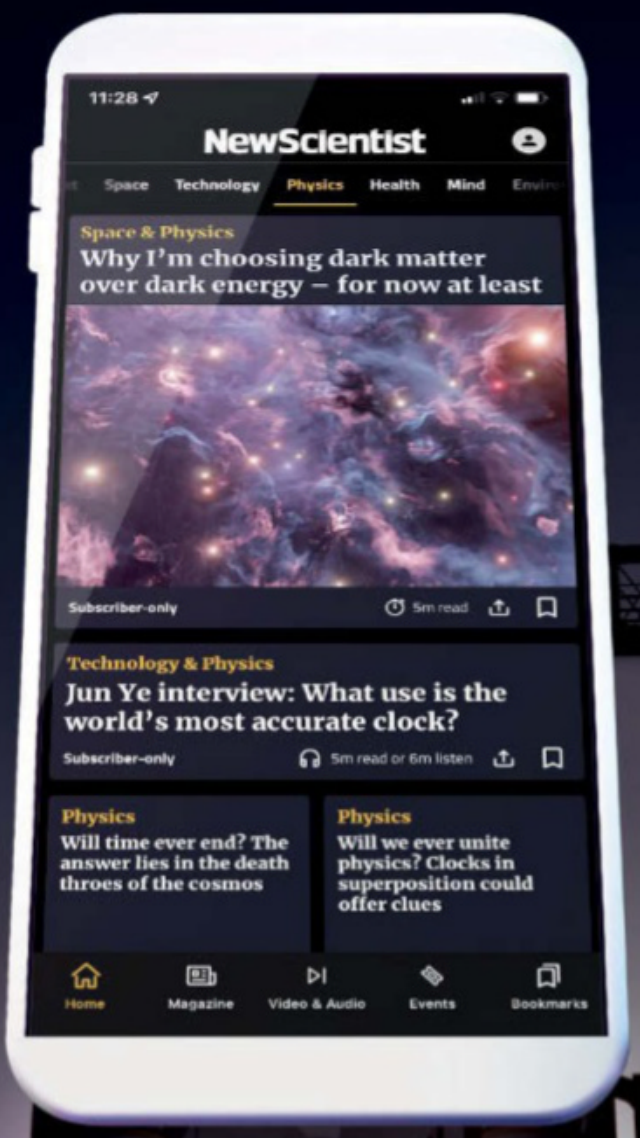
New Scientist App

NOW WITH DARK MODE

Interested in dark matter? Read about it in dark mode

Enjoy the benefits of our improved app, available on iOS and Android smartphone or tablet devices

- → Live feed of the latest news
- → Latest issue available to download every Thursday
- → Curate a playlist of articles to listen offline
- → Play videos at the touch of a button
- → Browse and book our series of events
- → Enable notifications for breaking news stories
- → Take advantage of dark mode



Download now

Download on the App Store

GET IT ON Google Play

Need help? Contact us

subscriptions.us@newscientist.com

1 888 822 3242
(Mon-Fri 7.30-7pm CST)

Views

Comment

A grassroots movement

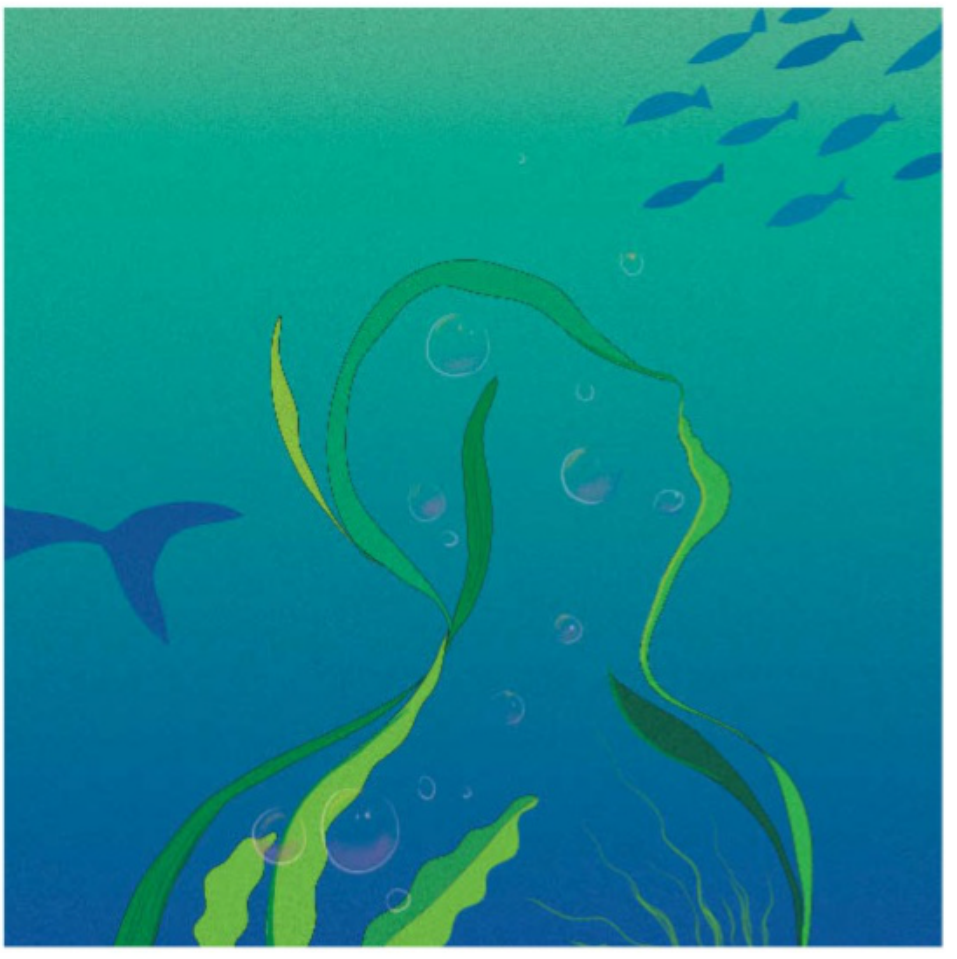
Seagrass meadows are vanishing at a rate of 7 per cent a year. Restoring them would be a huge conservation win, says **Sophie Pavelle**

SEAGRASS has been hailed both as conservation's "wonder plant" and its "ugly duckling". Since 1980, the world has been losing this flowering marine plant to pollution, disease and human disturbance at a rate of around 14,000 square metres per hour; in the UK, there has been a decline of nearly 92 per cent in the past century. But seagrass is a habitat that buries carbon up to 35 times faster than tropical rainforest. If silver bullets exist in conservation, could seagrass claim that title?

Though it covers just 0.1 per cent of the ocean floor, seagrass flanks coastlines across every continent except Antarctica. Its beds hold at least 10 per cent of the carbon buried in Earth's seabed, and it has evolved into around 72 species. It appears unassuming, yet a cross-section of a meadow would reveal an architectural masterpiece of horizontal roots and "rhizomes", which form often-ancient highways of nutrition throughout the seabed.

Carbon deposits within these rhizomes in Spain's Portlligat Bay have amassed into a layer over 10 metres thick and 6000 years old. Earlier this June, a single specimen of seagrass was discovered off the coast of Australia's Shark Bay that is estimated to be around 4500 years old and spans about 180 square kilometres.

The subterranean root system can stabilise coastlines in the face of storm surges and floods, both of which are more frequent in a warmer world. Carbon stockpiles latticed below meadows are also thought to elevate the seabed. Studies have found how increased sediment levels can reduce water currents and wave energy, softening the impact of climate-induced sea level rise.



MICHELLE D'URBANO

Seagrass can also help with ocean acidification. Since the industrial revolution, seawater acidity has increased by 30 per cent, due to dissolved carbon dioxide becoming carbonic acid. This lethal chemical imbalance dissolves the calcareous shells of vital corals, bivalves and molluscs. But a healthy seagrass bed can help neutralise acidic seawater. A compelling six-year experiment in California found seagrass reduced local acidity by up to 30 per cent.

Oceanic plastic waste is set to triple by 2040, yet seagrass could provide an answer here too. Recent research found established meadows can trap, sort and sieve microplastics into "Neptune balls". Up to 900 million plastic items are thought to be collected in these fibrous bundles every year.

The UN Environment Programme states that restoring seagrass meadows will contribute to reaching 10 of its sustainable development goals. Members of the public are helping re-seed meadows. The UK's Seagrass Ocean Rescue was inspired by a citizen science project in Chesapeake Bay, which restored the largest area of seagrass in the world. And the UK charity Ocean Conservation Trust recently allowed the Blue Meadows project to build the country's largest seagrass nursery, in a 400-square-metre plot.

So, have we found our elixir? Hailing anything as a single remedy risks dismissing conservation efforts as simple, achievable solutions. Amid the climate and biodiversity crises, a false sense of security is deadly, not least as it would place faith in a habitat that is disappearing at a global rate of 7 per cent per year. Seagrass needs to be safeguarded alongside coral reefs and mangroves: just 26 per cent of its recorded meadows fall within Marine Protected Areas, compared with 40 per cent of coral reels and 43 per cent of mangroves.

But the implications of restoring seagrass can't be ignored. With its rate of carbon burial and its ability to stabilise and elevate the seabed and halt marine plastic in its tracks, there is danger in delay. And what better approach to habitat restoration and climate change mitigation than a grassroots one? ▮

Sophie Pavelle is author of *Forget Me Not: Finding the forgotten species of climate-change Britain*

Field notes from space-time

Space for intuition

When it comes to the complexities of space-time, intuition comes in different ways, depending on the level of science you have access to, says **Chanda Prescod-Weinstein**

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

Chanda's week

What I'm reading
Elite Capture: How the powerful took over identity politics (and everything else) *by Olúfẹ́mi O. Táíwò is a really useful intervention.*

What I'm watching
I'm really excited to see some fellow queer people on 90 Day Fiancé: Love in Paradise*!*

What I'm working on
I've worked on this column simultaneously to a statement from scientists against the rollback of civil rights here in the US.

This column appears monthly.

THE origin story we tell about the universe goes roughly like this: there may have been a big bang (we aren't sure), then space-time expanded extremely rapidly (we think) and has continued to expand ever since, even picking up the pace in relatively recent times (we are fairly certain). It is a nice story, and one I largely believe is true. But what does it mean when we say that space-time expanded?

In presentations to broad audiences, I explain by asking people to imagine an unfilled balloon with special dots on it. Imagine that as the balloon fills with air, the dots stay the same size, but, as one would expect, the distance between the dots expands. Pretend those dots are galaxies and, roughly speaking, this is what is happening to space-time.

The expansion of space-time means the space-time between galaxies grows, making the distance between galaxies larger as time goes on. There are exceptions to this. Galaxies that are gravitationally bound to each other won't be pulled apart; for example, the Milky Way and Andromeda are on course to eventually collide and merge. The Milky Way also has many satellite galaxies in its orbit or otherwise gravitationally bound to it.

Other than ties through gravity, galaxies are generally "moving" away from each other because space-time continues to grow between them. The balloon analogy helps us understand this with some intuition, without needing to take several years of courses in order to fully understand general relativity as a technical subject. However, it also introduces problems that one can avoid if the subject is only looked at in mathematical terms.

As a scientist with deep knowledge of general relativity – the first advanced physics subject I trained in – I don't necessarily need to spend a lot of time interpreting the equations to suit my intuition. Rather, part of my job is to develop new intuition based on the latest results from mathematical derivations, lab experiments and astronomical observations. The way I lead my life as a scientist involves a foundational commitment to looking at the world as it is and revising my understanding as I gather new information.

In the case of expanding space-time, I have to think carefully about what I mean by "space-time". General relativity teaches me to think about space-time as a phenomenon that is described by the ruler we use to measure distances, an equation we call the metric. Therefore, expanding space-time means that the metric changes with time in such a way that spatial distances get larger as time goes on. This is something of an idealisation: we know this isn't happening on the scales of everyday life here on Earth.

"The universe is always more queer and fantastical than we think, and space-time is an example of this"

I am lucky because I can work through the equations and get a feeling for how this works mathematically, which makes it intuitive in a language that has more words than everyday English. This raises the question of translation from my technical, mathematical vocabulary into phrases that are comprehensible to broader audiences.

So we return to the balloon, which, yes, gives some good intuition, but can also get a reader thinking. Specifically, I know at least one person who is a regular reader of this column (thank you!) started to wonder where the space-time is expanding into. Certainly that is a limit of the balloon analogy. When we are blowing up a balloon, the balloon is expanding into the room we are in. Another way of putting it is that the balloon exists in a background, where the room is that background.

I introduce this way of thinking because it is one we scientists use when we describe general relativity, which we call a "background independent theory". Relativity is described in this way because it doesn't matter how we map out the coordinates in this theory, the physical reality it describes stays the same. There is a lot more to unpack here and not enough space (or time!), so let me just point out that this implies the space-time of general relativity doesn't have a room. In other words, space-time is expanding, but into nothing in particular. The expansion is simply a growth in distances. It isn't a material either, so it isn't coming from somewhere. The distances just grow and grow.

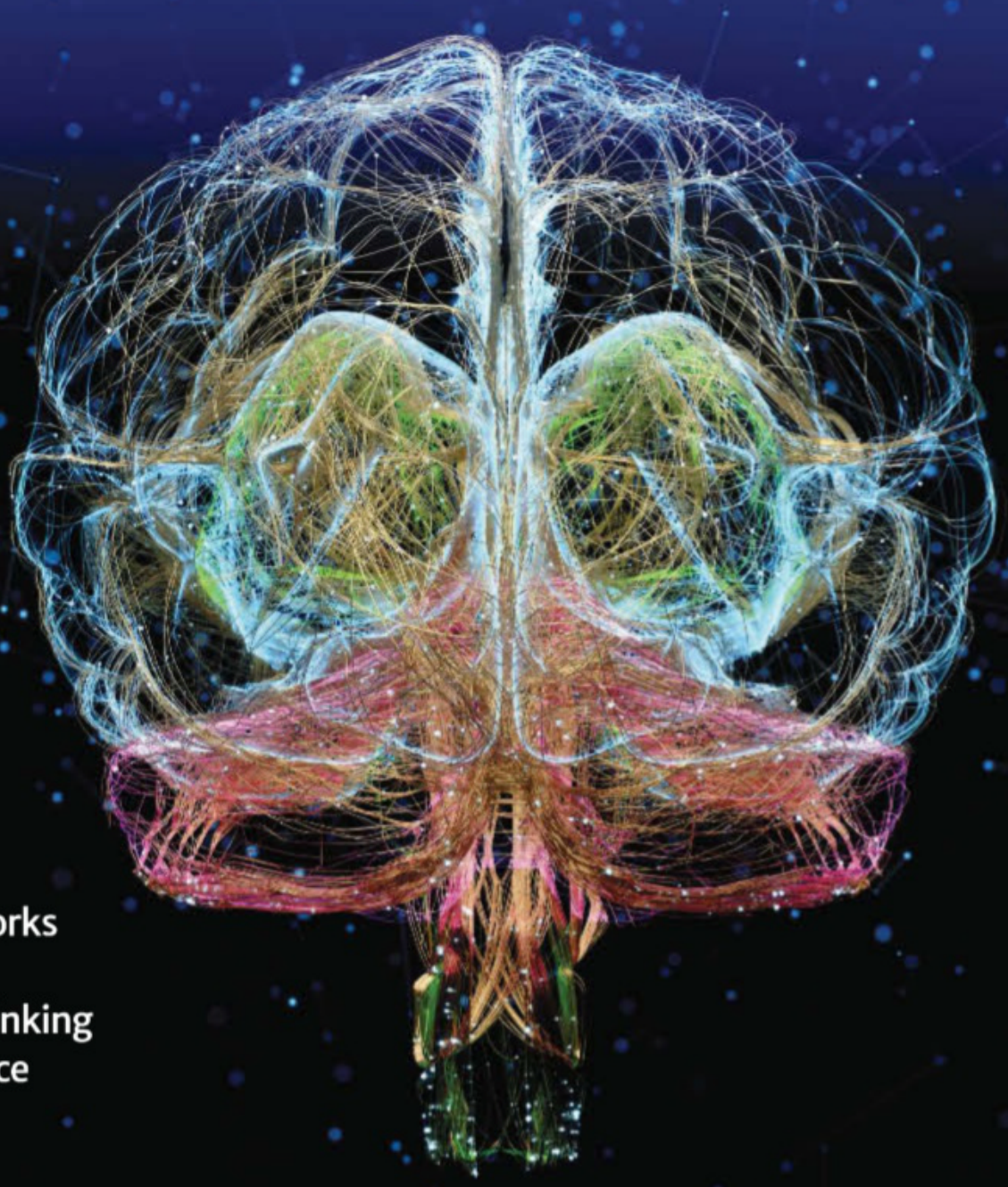
Weird, right? If you don't think so, that itself is odd. As I write in *The Disordered Cosmos* (now available in paperback), the universe is always more queer and fantastical than we think. The fundamental nature of space-time is an example of this fact. We exist in space-time and nothing in daily life necessarily makes us think it is a particularly strange phenomenon. Then again, we exist, and we are pretty odd, so maybe we should expect the nature of most things to be, on some level, unexpected. ▮

New Scientist Academy

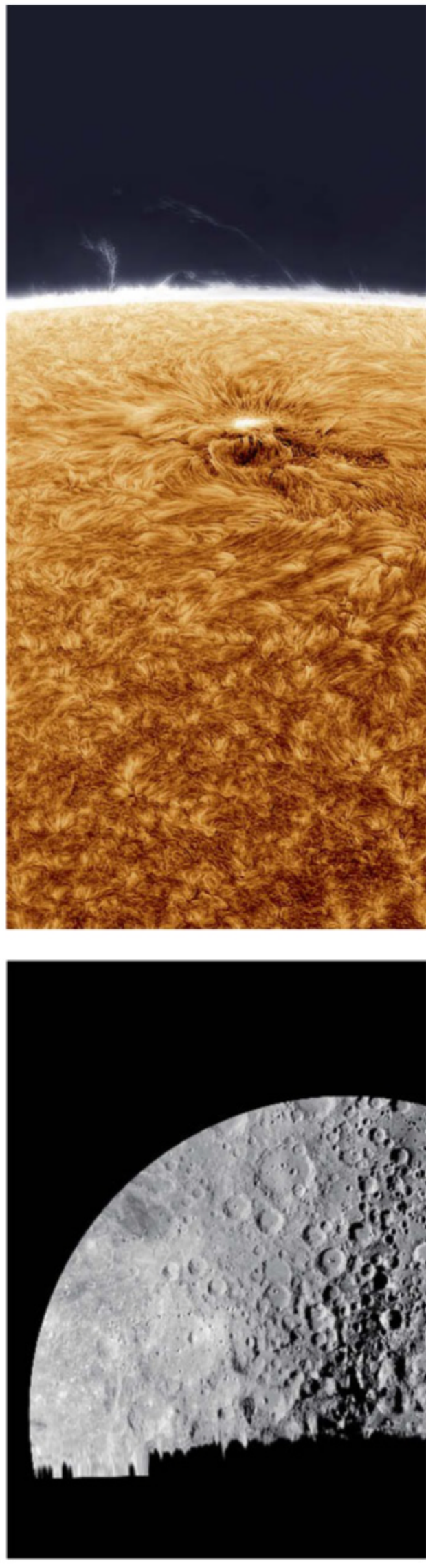
ONLINE COURSE
~~£249~~ NOW
£99

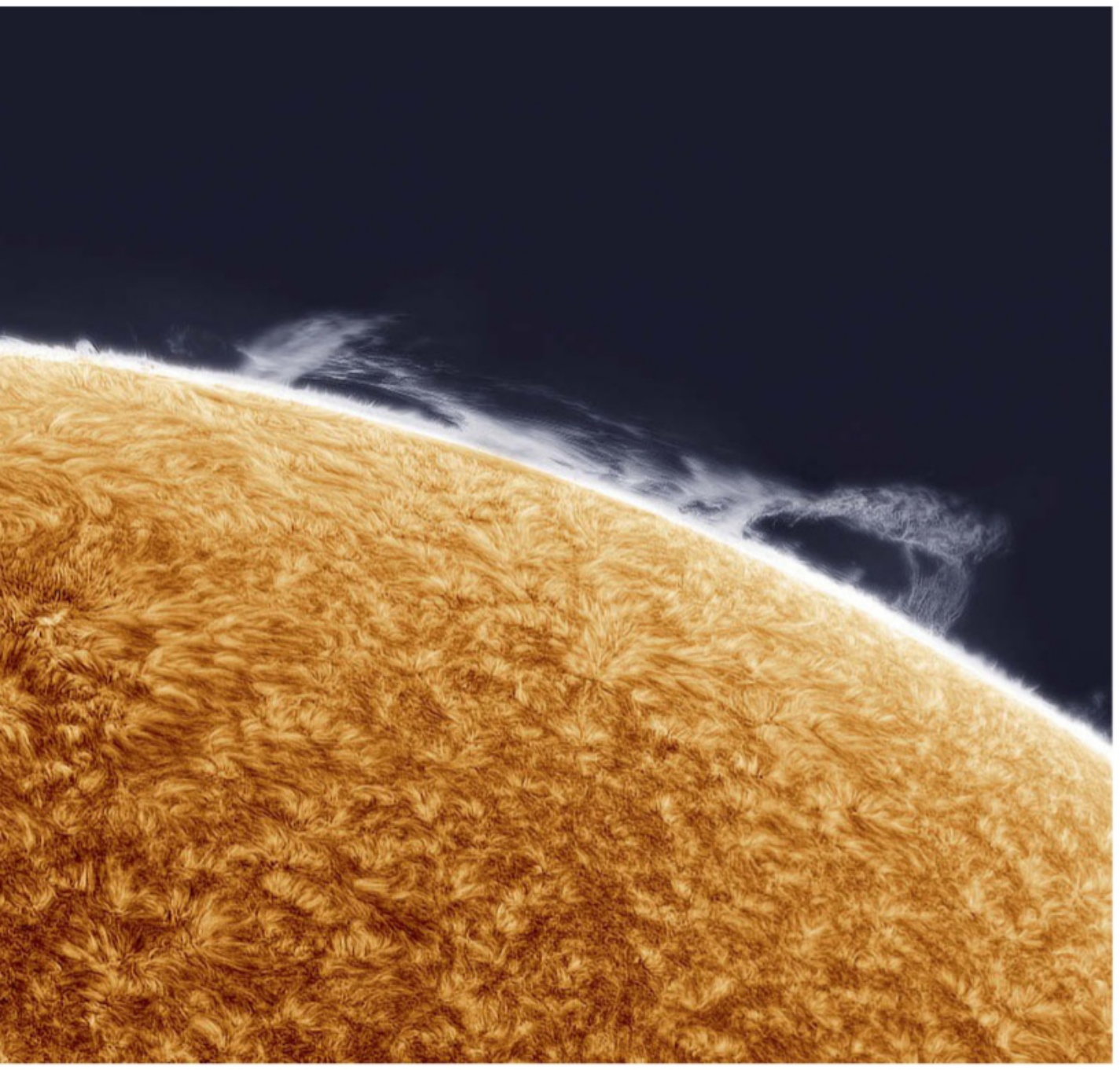
KNOW YOUR BRAIN

Your head holds the most complex object in the known universe.
Here's how to keep your brain happy and healthy as you grow older.



Understanding how your brain works
can help you make the most of it.
Our course covers all the latest thinking
and breakthroughs in neuroscience
newscientist.com/brain-course





Out of this world

THESE dazzling cosmic images are shortlisted in the Astronomy Photographer of the Year competition, run by the Royal Observatory Greenwich in the UK.

The far-left image depicts Comet C/2021 A1 and was captured by Lionel Majzik using a robotic telescope at the Remote Skygems Observatories in Namibia. Also known as Comet Leonard, after Gregory Leonard who first spotted it on 3 January 2021, this particularly bright body of ice and dust passed close enough to Earth, at 34 million kilometres, to be seen with binoculars, though it has since disintegrated. The photo has been shortlisted in the Planets, Comets and Asteroids category.

Simon Tang's shot of solar features called prominences looping out from the sun's surface can be seen top right and was shortlisted in the Our Sun category. Prominences are formed when stellar material erupts and is shaped into arcs by the sun's magnetic fields. Here, the most noticeable prominence can be seen on the right as wispy features at the sun's edge.

The south pole of the moon features in Tom Glenn's image, seen bottom centre, which made the Our Moon shortlist. Glenn merged two photos taken on different dates to give this view of the moon's southernmost point, which is of interest to researchers since it contains water ice that could be used by future lunar missions and stations.

Finally, the panoramic image shown bottom right depicts the Northern Lights over the Vestrahorn mountains in Iceland. It was taken by Stefan Liebermann and is shortlisted in the Aurorae category. The winners will be announced on 15 September.

Gege Li

Editor's pick

More takes on the enduring mystery of time

18 June, p 38

From Peter Basford, Potters Bar, Hertfordshire, UK

We have elegant concepts of time that enable us to converse systematically about past, present and future events on the scale of our solar system and to some extent well beyond it. However, we are required to prove the need for any assertion that these concepts aren't merely useful tools, but have physical reality.

If the universe consists simply of the unfolding of chains of cause and effect, no paradoxes arise. The arrow of time is implied. There is no "time" to travel in.

All event chains in the universe appear to vary in speed of execution as a function of the strength of gravity they are subjected to and the speed they are moving at relative to the speed of light. Clocks are merely cyclic chains of events. Light propagation within the gravitational field and at the relative speed of a clock would be slowed in the same way as all the processes within and around the clock itself, and the result of the measurement of light speed would always be the same.

What else do you need and why?

From Andy Howe, Sheffield, UK

You write that "[time] stops everything from happening at once". Surely it is one step more fundamental than that. Without time, there can be no change. Nothing happens. Nothing can happen.

Even if the "present" situation represents a potential cause, without time, there can be no effect. That would pre-suppose change, which requires there to be elapsed time.

In addition, it is argued that the "heat death" of the universe in far-flung time, should it occur, loses the "arrow of time"; the immediate past will be indistinguishable from the future.

However, there is the well-established thought experiment of the "Boltzmann brain": a sentient entity could just pop into existence by statistical fluke, as indeed could any structure of arbitrary complexity, given enough time. Thus chances are that this heat-death phase will be riddled with these sentient entities, and why not also a plethora of clocks? The arrow of time should thus be preserved.

For greener fashion, pull on some bamboo

4 June, p 38

From Ellen Bolton, Millmerran, Queensland, Australia

Three cheers for Graham Lawton, for the overdue discussion of the waste of the fashion industry, both in the greener climate debate and the plight of many of its workers.

To add to the points made, the use of fabric derived from bamboo should also be encouraged. Technically a grass, this plant is prolific, therefore widely available, and its use in fabrics requires less water and chemicals than many other sources of fibre. It is also biodegradable.

Also, a plea for kindness on another fashion front: sheep and the use of wool. There is precious little thought for the creatures from whose skin it is removed.

No need to go nuclear to temper global warming

Letters, 25 June

From David Flint, London, UK

Graham Reynolds asks us to choose between long-term storage of nuclear waste and "worldwide, incomprehensible damage to the climate". That would be a good argument for nuclear power if we had only two choices. But we don't.

We can also choose to sharply reduce energy waste and to rely on power from the sun, wind and tides to heat our homes and move our cars, buses and trains. This is the pragmatic solution because it needs only things we have already designed and built, and whose costs fall each year. It frees us from dependence on an industry that just can't deliver on time and within budget. Why wouldn't we choose the renewable option?

From Merlin Reader, London, UK

Nuclear power isn't just problematic because of the carbon costs of uranium mining, construction and waste disposal.

It is also troublesome as anything like an earthquake, tsunami or terrorist attack that affects a reactor is also liable to take out the back-up safety generators needed to remove and isolate the fuel in the reactor to avert catastrophe. The Fukushima disaster showed this.

Then there is the fact that nuclear plants require huge amounts of water, so are mostly in coastal locations. With sea levels rising, our descendants are going to have a huge problem. There is no way of making the sites 100 per cent watertight when many may be submerged within the next few centuries.

Climate scientists must become a lot more vocal

Leader, 11 June

From Martin van Raay, Culemborg, Netherlands

You say that most climate researchers fear to tread into the arena of politics. In my opinion, that is their biggest mistake.

Most politicians aren't scientists, so they don't speak the language of science and don't understand the methods. Even those who are able to understand what the scientists are saying are left with the question that no Intergovernmental Panel on Climate Change report had ever answered in clear terms: "What should I do?"

Politics is all about taking decisions, so when you want politicians to act, you not only have to explain the problem in terms they understand, but most of all you have to tell them what you expect them to do.

Scientists, you are the experts, so you know what action needs to be taken. Tell them.

Adoption of insect diet may be politically tricky

30 April, p 12

From Roger Browne, Alexandra, New Zealand

The adoption of insects and lab-grown meat in place of the consumption of traditional meat and dairy products is an intriguing possibility. For insects, as living things, this raises a question of how will they be "harvested".

However, I believe the biggest hurdle will be the "yuck" factor. The article suggests that if consumers won't make these changes voluntarily, then governments will need to force these foods on them.

Any political party promoting a policy of compulsion would soon be consigned to the political wilderness.

A nice coat of ivy is the best insulation for your walls

Letters, 11 June

From Richard Barrett, Oxford, UK

When it comes to what is best for external wall insulation, common ivy (*Hedera helix*) is a good bet, keeping homes warmer in the winter and cooler in the summer. As well as being biodegradable, it captures carbon, provides food and homes for insects and birds and requires no fixings. ▮

Want to get in touch?

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

Letters sent to New Scientist, Northcliffe House, 2 Derry Street, London W8 5TT will be delayed

New Scientist Events

SAVE 33% ON A SERIES TICKET*

ONLINE EVENT

BIG THINKERS SERIES

WILL KINNEY
THE ORIGIN OF THE UNIVERSE

Thursday 14 July 2022,
6-7pm BST, 1-2pm EDT and on demand

In the beginning was the big bang: an unimaginably hot fire almost 14 billion years ago in which the first elements were forged. The physical theory of the hot nascent universe – the big bang – was one of the most consequential developments in 20th-century science. And yet it leaves many questions unanswered. Why is the universe so big? Why is it so old? What is the origin of structure in the cosmos?

In this talk, physicist Will Kinney explains a more recent theory that may hold the answers to these questions and even explain the ultimate origins of the universe: eternal cosmic inflation.

Find out more and book your ticket

newscientist.com/universeorigin

ALSO IN THE SERIES

SEAN CARROLL
SPACE, TIME AND MOTION
Thursday 20 October 2022
6-7pm BST | 1-2pm EDT
and on demand

VERONICA O'KEANE
MEMORY, THE BRAIN AND WHO WE ARE
Thursday 10 November 2022
6-7pm GMT | 1-2pm EST
and on demand

*saving based on individual ticket prices.

BIG THINKERS SERIES
WILL KINNEY

Into Chernobyl's exclusion zone

An extraordinary window onto the area around the devastated nuclear power plant reveals a "land of tranquillity and frozen time", finds **George Bass**

MARKIYAN KAMYSH

Nature has long since reclaimed buildings like this one in Prypyat

Book

Stalking the Atomic City
Markiyan Kamysh
Translated by Hanna Leliv and Reilly Costigan-Humes
Pushkin Press

BEFORE 26 April 1986, living near the Vladimir Lenin Nuclear Power Plant in the city of Chernobyl (nicknamed Atomic City) or in the nearby workers' city of Prypyat was highly desirable. There was a new restaurant, supermarket, large playground and immaculate flats, all of which marked it out as one of the Soviet Union's more prosperous areas. It was so desirable that newspapers ran adverts from people looking to exchange their flats for one there.

Then the explosion at Reactor No. 4 turned the plant into what Ukrainian writer Markiyan Kamysh calls a "poisonous emerald in the precious crown of [the region of] Polissya". This is one of many striking images in his recently translated book, *Stalking the Atomic City: Life among the decadent and the depraved of Chornobyl* (Ukrainian spelling).

His father, a civil engineer and a commander at the plant, helped limit the damage after the explosion. Kamysh, born a few years after the disaster, counts himself among the generation raised in its immediate aftermath.

Soon after the disaster, an exclusion zone was established by the Soviet armed forces, initially covering an area of 30 kilometres radius, and designed to restrict access, reduce contamination and allow for scientific and environmental monitoring. Today that zone spans 2600 square km.

Stalking the Atomic City covers the years from 2010 to 2022, before the Russian invasion of Ukraine, and describes the time Kamysh spent exploring and escorting illegal tourists (the "stalking"of the title) around rusted industrial buildings and abandoned villages.

For him, the exclusion zone is a "land of tranquillity and frozen time", and he recounts his 1100-plus trips under the barbed wire in vivid detail. Eluding the security patrols, he passes nights marvelling at the lynx that have made their dens in derelict buildings, or transfixed by the crumbling plant, whose antennae resemble "thirty Eiffel Towers".

"The author passes nights marvelling at the lynx that have made their dens in derelict buildings"

He meets "haggard drunkards" looking to loot any food stocks and scrap thieves scavenging for clocks to sell at Kyiv's flea market. Other figures are more marginal, including "swamp ghosts" drawn to a desolation "on par with Antarctica", who the author observes while brewing tea made from thawed slush.

If the safety of the plant was questionable before the accident, the exclusion zone of Kamysh's account is at least as precarious. Guards rarely fire warning shots; Kamysh's relationship with them varies from amiable to cartoonish. He writes of "swimming" through waist-high snow to reach safety, crossing leech-infested ponds – and of his fear of encountering his tour groups on some future chemotherapy ward.

After vowing to settle in Kyiv, Kamysh soon feels the call of the wild, which he likens to the "post-expedition syndrome" that befalls returning archaeologists. As he journeys back into the exclusion zone, he finds the way nature is recolonising it a source of comfort, describing courtyards that resemble rainforests and lightning striking a metal pipe on part of the plant. Elsewhere in the book, photographs show dead wolves rotting on floorboards, brilliant green poisoned swamps and playgrounds where rust from swings has massed in drifts.

In the light of the international focus on Ukraine after Russia's invasion, *Stalking the Atomic City* seems timely with its examples of resilience, decay and despair. Kamysh is bitter at some of the more casual, touristic visitors to the exclusion zone. He says the city has been killed twice, once by the disaster, and more recently by people who "shot Prypyat dead with their expensive cameras".

But he is full of admiration for some. He describes a resident of the exclusion zone in the 1990s who was in his 70s and living without running water, electricity or neighbours, his only companions a two-way radio he used to make emergency contact with a checkpoint – and a rifle.

Perhaps most telling is graffiti Kamysh finds on a collapsing internal wall. In scarlet letters, it reads: "We'll beat you, Reagan!" ▮

George Bass is a writer based in Kent, UK

Worlds apart

Animals have amazing inner lives we barely grasp. A powerful new book explains why this matters, says **Anna Demming**

Book

An Immense World

Ed Yong

Bodley Head

THERE was a time when Qualia the octopus would have been as game as any of her kind to show off her famed party trick of unscrewing a jar to get at the tasty crab inside. Not any more, although she is still capable of doing it and her appetite for crabs remains. So what's up?

To understand the behaviour of Qualia and myriad other animals, Pulitzer prize-winning author Ed Yong invites us on a tour of their sensory worlds.

The central idea of his new book is explained by its subtitle: *How animal senses reveal the hidden realms around us*. Yong's focus is the wide diversity in the way creatures perceive their surroundings through their very different sensory apparatus.

To describe this sensory world, he borrows from Baltic-German zoologist Jakob von Uexküll, who coined the term *Umwelt* to describe not just an animal's environment, but also its experience of that environment. This differs profoundly between species, from the electric fields bees sense around flowers, to the vibrations spiders feel in their webs.

For Yong, this is more than an intellectual fascination: attempts to imagine the experiences of the creatures around us prompt a shift in our relationship to them. Even the random darting of a fly gains new meaning when we know that its movements are responses to changes in temperature and to currents we will never detect – and would be too slow to react to even if we could. The attitude of superiority that humans have towards most other species becomes harder to justify as you learn more.

"Animals are not just stand-ins for humans or fodder for brainstorming sessions," says Yong, distancing his interests from those that motivate many others, such as developing biomimetic technologies or using animal models in research. Animals "have worth in themselves. We'll explore their senses to better understand their lives."

As for Qualia, it is tempting to liken her behaviour to that of a jaded diva who refuses to perform. But it might be that she couldn't see past the glass to the crab in the jar in the first place, and was just playing with it out of curiosity until she – or her arms – tired of it.

And there's an extraordinary thing: an octopus's arms literally have minds of their own. Of the 500 million-odd neurons in the nervous system of an octopus – comparable to that of a small mammal – only a third are in its head. The rest are in its arms, where they form clusters, or ganglions, on every sucker. Each ganglion connects to a central ganglion that links to its neighbours along the arm "like a string of fairy lights", says Yong.

Misreading an octopus's party trick or a fly's frantic movements are far from the only outcomes of a general failure to grasp the way animals see the world we share and our underappreciation of how they exist in their own world.

The book ends with a warning. Yong describes the countless ways we mould our environment to suit us, often oblivious to the havoc we cause for other species. A window isn't just confusing for a wasp trying to find its way outside, as its smooth surface returns echoes unlike any in nature, confounding creatures that rely on sound and different kinds of echolocation.

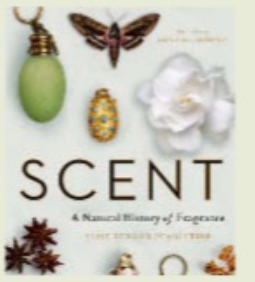
From insects gathering under street lights to the trees no longer propagated by seed-spreading jays, which have been scared off by artificial noise, our impact is disturbing and, in many ways, still unknown.

"Sensory pollution is the pollution of disconnection," says Yong, as he describes how we are drowning out the stimuli that birds, fish and insects rely on to connect with each other and their surroundings. "That must now change," he adds. "We have to save the quiet, and preserve the dark." ▮

Human activity often adversely affects animals, from a wasp to this sawfish in its ocean habitat

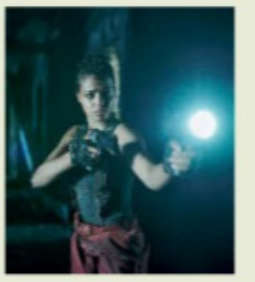
MELVIN NICHOLSON/BAV MEDIA/SHUTTERSTOCK

Don't miss



Read

Scent explores the mood-altering world of perfume. Elise Vernon Pearlstine, a zoologist-cum-parfumier, tells the evolutionary story of plant fragrances that seduce and repulse, heal and protect. Available to buy from 26 July.



Watch

Resident Evil's Raccoon City receives a futuristic makeover in a new adaptation of the hit video-game series. You might have thought that their city planners would have learned not to build above secret bioweapon labs by now... Streaming on Netflix from 14 July.

Listen

On Sonorous Seas is a podcast accompanying a multimedia exhibition on the Isle of Mull by artist Mhairi Killin and others. The works ask if military sonar in Scottish waters caused a mass stranding of whales. Available from 8 July.

MELVIN NICHOLSON/BAV MEDIA/SHUTTERSTOCK; MARCOS CRUZ/NETFLIX

The film column

When lightning strikes

A gentle fantasy about a lonely inventor called Brian, whose world changes completely when a robot he creates comes to life, makes a serious point about the possibilities of personal robots, finds **Simon Ings**

Simon Ings is a novelist and science writer. Follow him on Instagram at @simon_ings

COURTESY OF WILL DAVIE/FOCUS FEATURES

Brian's life changes after he sees a mannequin's head in some rubbish

AMATEUR inventor Brian Gittins has been having a bad time. He is terribly shy, lives alone and has become a favourite target of the local bully, Eddie Tomington (played by Jamie Michie).

He finds consolation in his "inventions pantry" ("a cowshed, really"), from which emerges one ludicrously misconceived invention after another. His heart is in the right place: his tricycle-powered "flying cuckoo clock", for instance, is meant as a service to the village. People would simply have to look up to tell the time. Unhappily, it is already on fire.

Picking through the leavings of fly tippers one day, the ever-restless Brian finds the head of a shop mannequin – and grows still. The next day, he sets about building something for himself: a robot to keep him company as he grows ever more graceless, ever more brittle, ever more alone.

Brian sprang to life on the stand-up and vlogging circuit trodden by his creator, comedian and actor David Earl. Earl is best known for playing Kevin Twine in Ricky Gervais's comedy-drama *Derek*, and for roles in other Gervais projects such as *After Life*.

Earl's Brian dominates this gentle, fantastical film. His every grin to camera, whenever an invention misbehaves or fails, is a suppressed cry of pain. His every command to his robot ("Charles Petrescu" as the robot has named itself) drips with a conviction of future failure. Brian is a painfully, almost unwatchably weak man. But his fortunes are about to turn.

"The robot Charles passes through all the stages of childhood, and is determined to go to Honolulu"

Charles (mannequin head, washing machine torso, tweeds from any 1950s BBC documentary) also saw first light on the comedy circuit. Around 2016, Rupert Majendie, a producer who likes to play around with voice-generating software, rang Earl's internet radio show, and the pair started riffing in character: Brian, meet Charles.

Then there were three: Earl played Brian, Earl's fellow stand-up Chris Hayward inhabited Charles's cardboard body and Majendie sat at the back of venues, with his laptop, providing Charles's voice. Their first full-length film is this low-budget mockumentary, *Brian and Charles*, directed by Jim Archer and written by Earl and Hayward (who now plays all of Charles). It was a hit at this year's Sundance Film Festival.

Back to the plot. When a thunderstorm brings Charles to life, he speeds through the stages of childhood ("Does it all stop at the tree?" he asks, staring over Brian's wall in rainswept north Wales), and is now determined to make his way to Honolulu – a place he glimpsed on a TV programme, but can never pronounce.

It is a decision that leads the irrepressible Charles away from Brian's protection and, ineluctably, into servitude with his malign neighbours, the Tomingtons.

But the experience of bringing up Charles has changed Brian. He no longer feels alone. He has, quite unwittingly, become a father. The confrontation and crisis that follow are as satisfying and tear-jerking as they are predictable.

Any robot adaptable enough to offer worthwhile companionship to a human must be considered a person too and be treated as such, or we would be no better than slave owners. Brian is a graceless, bullying creator, but the more his robot proves a companion, the more Brian matures.

And this, I think, is the exciting thing about personal robots: not that they may make our lives easier, but that their existence could challenge us to become better people. ▮

Film

Brian and Charles

Jim Archer

On general release in US/UK cinemas

Simon also recommends...

Book

Tik-Tok

John Sladek

The gleeful anti-hero of Tik-Tok discovers wordplay and crime at the same time, in a novel that runs satirical rings around Isaac Asimov's Three Laws of Robotics.

TV

Humans

Sam Vincent and Jonathan Brackley

Netflix

A thriller that throws advanced "Synth" servants into a far-from-perfect world, where they bring out the best and worst in their human overlords.

NewScientist
ESSENTIAL GUIDES

NEW SCIENTIST ESSENTIAL GUIDES DELIVERED DIRECT TO YOUR DOOR

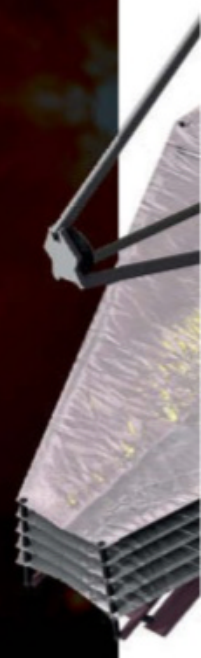
Based on the best coverage from *New Scientist*, the *Essential Guides* are comprehensive, need-to-know compendiums covering the most exciting themes in science and technology today.

Get the series, including the latest issue on Consciousness, with an *Essential Guides* subscription. It means you don't have to search for issues in the shops – we can deliver them direct to your door.

FOR MORE INFORMATION ON FUTURE ISSUES AND SUBSCRIPTION OFFERS, VISIT:

NEWSCIENTIST.COM/ESSENTIALGUIDE

THE COSMOS AS WE'VE NEVER SEEN IT BEFORE



The James Webb Space Telescope has the power to unravel some of the biggest mysteries of the universe. Here are some of the cosmic wonders it will look at first, says astronomer **María Arias**

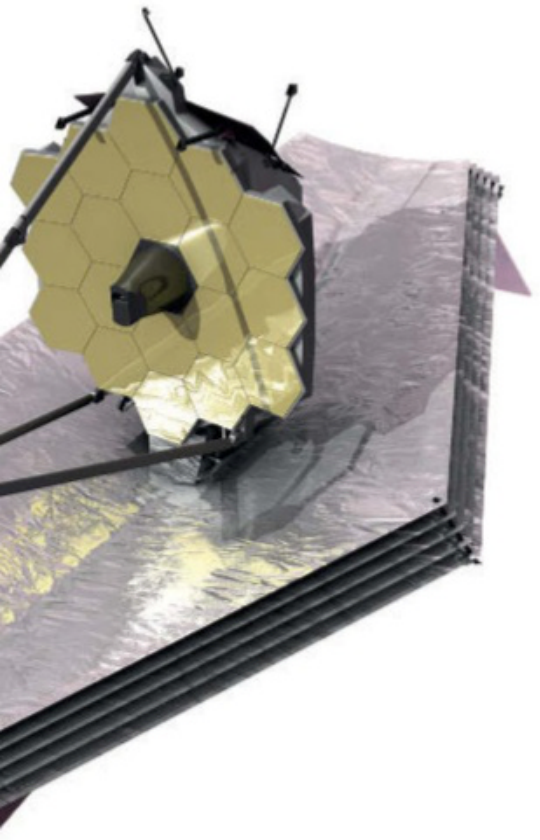
NASA/ESA/CSA/STSCIESA

ON 12 JULY, the James Webb Space Telescope (JWST) will release its first scientific images, raising the curtain on a new era in astronomy. After years of delays, a suspenseful launch and months of testing, the most powerful telescope ever made is finally ready to gather fresh clues relating to questions we could only dream of answering with its predecessors.

The JWST will allow us to peer further into the universe's distant past than ever before thanks to its special combination of capabilities. As an infrared observatory with a massive mirror floating beyond the orbit of the moon, it can collect light from the faintest, most distant stars and galaxies – light that has been stretched into infrared wavelengths after travelling through expanding space for billions of years. It will see these objects in exquisite detail due to its unrivalled angular resolution. Its infrared spectrograph should also allow us to characterise molecules lurking in the atmospheres of potentially habitable exoplanets.

The data we receive from the JWST will help us to unravel some of the largest mysteries of the cosmos, from how the first stars and galaxies formed and how fast the universe is expanding to the prospects for extraterrestrial life.

Here we examine seven of the biggest questions the JWST is expected to shed new light on, focusing on specific projects that have been granted time in its first observation cycle, to reveal precisely how this $10 billion telescope will transform our understanding of the cosmos.



The James Webb Space Telescope's mid-infrared image of nearby galaxy the Large Magellanic Cloud

ESA (C. CARREAU)

WHERE AND WHEN DID THE FIRST STARS FORM?

After the big bang came the cosmic dark ages. Matter at this stage was either dark matter, which neither emits nor reflects light, or neutral hydrogen and helium gas. Then, over the course of a few hundred million years, the gas started to coalesce, forming stars – and the lights switched on.

The radiation from these first stars ionised the neutral gas around them. By the time this so-called epoch of reionisation was complete, the universe had gone from a homogeneous, primordial soup to a highly structured arrangement, with galaxies, stars and probably even planets. We know this happened, but we have few observations to show us how.

Jeyhan Kartaltepe at the Rochester Institute of Technology in New York has 256 hours of observation time on the JWST – among the longest stints in the instrument's first observation cycle – to answer a broad set of questions about this cosmic dawn. What types of stars were the first stars? In what kinds of galaxies did they form? How early did reionisation happen, and how long did it take? "A detection [of a primordial galaxy] with the Hubble Space Telescope is just a smudge in an image and you can say how bright it is, and that's it," says Kartaltepe. "Now, we'll be able to measure their stellar masses and resolve out structure, so we'll learn a lot more about the physics."

Kartaltepe's project will give us a comprehensive view of reionisation. "It didn't happen everywhere, all at once," she says. "It started in little pockets and then expanded out to these reionisation bubbles."

Meanwhile, Rohan Naidu at Harvard University reckons he has identified one of these little pockets as the place where the cosmic dawn first broke – and now he can finally take a look. "We think that these are amongst some of the first galaxies that may have formed," he says.

We measure the distance of objects in deep space by looking at "red shift": the extent to which their light has been stretched, and made redder, as it travelled through our expanding universe for billions of years before reaching us. A number describes how redshifted that light is; the bigger it is, the older the object.

The cosmic dawn is thought to have started at around red shift 10, when the universe was roughly 500 million years old. But Naidu thinks we might find evidence that the first stars formed in an ionised bubble that we now observe at red shift 9. "This is a very special place," he says, because this tiny patch of sky contains a quarter of all known high red-shift galaxy candidates – and what we know about the formation of structure in the universe suggests the first stars would have developed in just such a location. "I'm very excited about seeing these high red-shift galaxies. We might be able to see the first stars," he says. ›

WHAT ARE THE ORIGINS OF SUPERMASSIVE BLACK HOLES?

Black holes are regions of space-time so dense and warped, with such intense gravitational pull, that not even light can escape them. There are stellar-mass black holes, created when massive stars collapse, which range from a few to a few hundred times the mass of the sun. And there are supermassive black holes, ranging from 100,000 to tens of billions of times the mass of the sun, found at the centres of most galaxies. These monsters shape the evolution of galaxies as they accrete, or accumulate, mass and launch powerful jets that disrupt everything around them.

One of the most bewildering observations in astrophysics is that we see supermassive black holes that were already billions of solar masses when the universe itself was well under a billion years old. Even if these black holes were growing exponentially by gobbling stars and gas, they must have started out as massive as thousands of suns – and we have no idea how that would work given our existing models of how black holes form and grow.

Theorists have proposed two routes to these early supermassive black holes. The first is the collapse of a massive gas cloud, either directly to a supermassive black hole or first to a massive star that then itself collapses into a black hole. The second hypothesis is that they formed from dense clusters of stars, which merged into each other, growing ever larger and eventually resulting in a black hole.

To learn more about supermassive black holes, Xiaohui Fan at the University of Arizona is going to observe distant quasars, extremely bright objects generated when gas spirals at high speeds into these black holes, launching gigantic jets of particles and radiation. Looking closely at three of the most distant quasars we know of, Fan and his colleagues will measure the velocity of the disc of gas and dust spiralling into the black holes, which directly probes their mass. Combine this with a measure of luminosity and you also get the rate at which the black hole is accreting material. This will give them the tightest constraints yet on the initial mass of the black hole, and how early in the young universe the seeding happened.

Fan's observations won't be able to rule out ideas for how supermassive black holes were seeded. They should shed light on how they grow, however, and how their growth influences the evolution of galaxies. We know that the most massive black holes reside in the most massive galaxies. But which came first, and whether one is responsible for the other, is a cosmological chicken-and-egg conundrum. With the JWST's sensitivity, we will see the stellar light from the host galaxies of these black holes for the first time. Its infrared observations mean we can characterise their ages and therefore learn when the star and galaxy formation happened relative to the black hole growth.

Expect the unexpected

Even if the astronomers granted time on the James Webb Space Telescope's first observation cycle know exactly what they are going to look at, they are still energised by the prospect of seeing something unexpected. "My hope is that we're going to discover something that we didn't see coming," says Wendy Freedman at the University of Chicago.

"I'm most excited about the questions we don't know enough to ask," says Kristen McQuinn at Rutgers University in New Jersey. She cites the Hubble Ultra Deep Field, an image captured in 2004 by the Hubble Space Telescope after it was pointed at an unpromising little patch of sky. Many expected it to come out dark, but the long exposure revealed thousands of twinkling stars and galaxies that were older than anyone had ever imagined. This captivating image transformed the field of cosmology, just as the accidental discovery of the relic photons from the big bang, the cosmic microwave background, had in the 1960s.

Whenever a new instrument opens a fresh observational window, it creates a universe of possibilities, says Freedman. The JWST is no exception. "Almost every field of astronomy is going to learn new things," she says. "Then there are going to be the discoveries that nobody anticipates at all, and those are sometimes the most fun."

Decades in the making, NASA's new space telescope should produce some surprises

BOTTOM: NASA/DESIREE STOVER; TOP: NASA/CHRIS GUNN

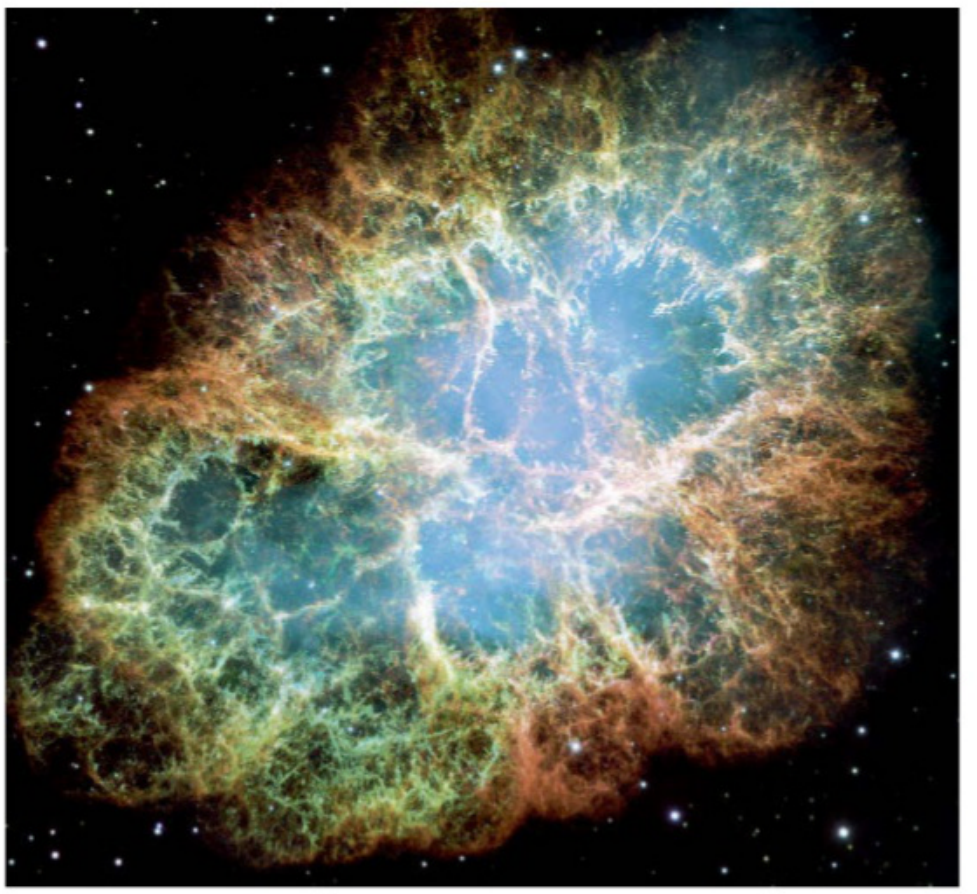
"It is a cosmological chicken-and-egg conundrum"

IS DARK MATTER COLD?

Dark matter is a mysterious form of matter whose existence we can only infer from its gravitational effects. We believe that it accounts for roughly 85 per cent of all matter in the universe, but we don't know what kinds of particles it is made of, if indeed it is made of particles. For the time being, we think dark matter is "cold", meaning it moves slowly, which allows small clumps to assemble due to their own gravity and grow into more massive structures known as "haloes". In our current best picture of how the universe evolved, dark matter helped to sculpt the universe, as these haloes attracted gas that clumped and collapsed to form stars and galaxies.

Dark matter haloes come in various sizes, from a quadrillion solar masses to as little as the mass of Earth. When the dark matter haloes are lighter than 10 million solar masses, they can't attract enough gas to form galaxies. According to our understanding of cosmic evolution, they exist as little, invisible pockets of dark matter, in which case we are presumably surrounded by many of these smaller dark matter haloes.

Anna Nierenberg at the University of California in Merced and her colleagues will seek to test this assumption, and by extension the idea that dark matter is cold and sluggish, by looking at quasars. In this case, the light released by the quasars will be lensed, or bent, by the gravity of the small, galaxy-less dark matter halo. The light would be deflected in such a way that it creates repeated images in the telescope, which is what Nierenberg and her colleagues will be looking for. Detecting these tiny haloes would be a huge success for this model, she says. Alternatively, "their absence would imply that dark matter cannot be cold, but must be of a more exotic nature".



NASA/ESA/JPL/ARIZONA STATE UNIV.

The Crab nebula, the remnant of a supernova explosion

HOW DO MASSIVE STARS GO SUPERNOVA?

When they die, stars like our sun go relatively quietly. More massive stars go out in a blaze of glory in spectacularly violent explosions called core-collapse supernovae. These cosmic fireworks inject huge amounts of energy into their surroundings and as the shock waves from the explosion heat and ionise interstellar material, they drive the formation of new generations of stars. Supernovae also release all manner of chemical elements, enriching the gas clouds that create planets like ours with the ingredients that form us.

We see supernovae all the time. We know that stars with masses of at least eight times that of the sun will end their lives in these explosions. At some point, the core of the star is unable to withstand the weight of its outer layers, causing the star to collapse and blow up. What we don't know is what the explosion mechanisms are, meaning exactly how massive stars blow up the way they do.

Two models are on the table for massive stars in the lower end of the mass range that can go supernova. In the electron-capture model, a star has a core composed of oxygen, neon and magnesium and that core is held up by the pressure of these atoms' electrons, a result of a quantum mechanical law that says they can't all occupy the same energy state. If the core becomes too dense, however, the nucleus of the neon and magnesium atoms can absorb their electrons in what we call an electron-capture reaction. This reduces the pressure and results in the gravitational collapse of the outer layers of the star, causing the explosion. The alternative is the iron-core collapse model. Here, an iron core forms and because iron is a very stable element, it can't fuse into other elements and release energy, so nuclear reactions can no longer counterbalance gravity, resulting in collapse and ignition.

NASA/STSCI

It is impossible to observe what is going on inside a star at the moment of explosion because the outer layers shield the core from view. But Tea Temim at Princeton University will use the JWST to bring some clarity by looking more closely at the Crab nebula, the remnant of a supernova explosion of a star in the eight to 10 solar mass range. It was recorded by astronomers in 1054, and is one of the most thoroughly studied astronomical objects of all time. If we get a closer look at it, however, we might be able to figure out how it exploded, because each of our two possible explosion mechanisms would leave signatures: a different ratio of iron to stable nickel, in each case, and different distributions of iron in the material ejected by the star.

"The Crab has a very complicated ionisation structure," says Temim, so they need to make sure that the measurements of the different elements come from the exact same place in the remnant. Only the JWST boasts sufficient resolution to tell the two possible signatures of star explosion in the nebula apart in this way. ›

NASA EARTH OBSERVATORY/JOSHUA STEVENS/NOAA

Earth's water may have been delivered from the outer solar system

WHERE DO PLANETS LIKE EARTH GET THEIR WATER?

We are fortunate that our planet is a lush world of oceans, lakes, rivers and waterfalls. According to our current understanding of our solar system's history, however, our pale blue dot wasn't blue at all when it formed.

When Earth came together out of a maelstrom of gas and dust some 4.5 billion years ago, it was inside the sun's "snowline", the radius outside which the temperature is low enough that all water is ice. What's more, at that time, the sun was throwing out more energy than it is today and the radiation pressure would have pushed any water vapour close to Earth out behind the snowline. All of which means that, as far as we know, the material that formed Earth didn't contain any water. "So Earth's water must have come from somewhere," says Isabel Rebollido at the Space Telescope Science Institute in Baltimore, Maryland.

Planetary scientists have proposed that it might have been delivered later by asteroids or comets in a period known as the Late Heavy Bombardment. The idea is that the knock-on effects of the movements of the gas giant planets in the outer solar system could have pushed ice-containing debris further in, dispatching water to Earth and creating many of the moon's craters in the process.

Rebollido will use the JWST to look at five exoplanetary systems in a similar stage of evolution – when the gas giants have already formed and their movements are shuffling material around. "One possible explanation for the gas we detect in the inner regions of planetary systems is that solid, icy bodies sent in from the outer regions are evaporating," says Rebollido. The idea is simple: look for water in the middle region. If it is there, the implication is that icy bodies can indeed be delivered from the outer regions of a solar system to rocky planets inside the snowline, allowing otherwise barren worlds to become pale blue dots.

COULD THE MOST PROMISING EXOPLANETS HARBOUR LIFE?

The prospect of life on planets beyond Earth has intrigued us for centuries. These days, we search for it by looking for "biosignatures" in exoplanet atmospheres. If certain combinations of molecules are present – methane and carbon dioxide, say – it is a sign that life could exist there. But there has to be an atmosphere to begin with.

We characterise the composition of exoplanetary atmospheres with the transit technique: when a planet passes in front of its host star, the various molecules in its atmosphere interact with light from the star and emit or absorb infrared radiation at specific wavelengths that form fingerprints of the molecules involved. The spectrograph aboard the JWST is sensitive to these fingerprints, which means it can identify which molecules are present. "JWST is going to be completely revolutionary because the Hubble and Spitzer space telescopes had relatively restricted wavelength ranges, so you couldn't measure a lot of stuff in the atmospheres," says Megan Mansfield at the University of Arizona.

For the transit method to work, the signal from the planet's atmosphere has to be detectable against the much brighter signal from the star. Even with the JWST's unprecedented capabilities, finding biosignatures will probably only be possible for planets orbiting cool, low-mass stars called M dwarfs. Fortunately, that puts a particularly appealing group of exoplanets in our sights. The Trappist 1 system, a collection of seven rocky planets discovered in 2016, hosts more planets capable of sustaining liquid water than any other system we know of.

The catch is that we don't know if the Trappist planets, or any other worlds orbiting M dwarfs, can retain their atmospheres for long enough for life to develop, says Mansfield. That's because M dwarfs start out much more active than stars like the sun, and the copious amount of high-energy radiation they throw out could strip the atmospheres from their planets.

One of the most useful things the JWST can do for the search for extraterrestrial life is to establish whether exoplanets around M dwarfs have atmospheres at all. Kevin Stevenson at Johns Hopkins University in Maryland will observe five terrestrial exoplanets orbiting the nearest M dwarfs as they transit, including one in the Trappist system.

> "We want to establish whether exoplanets around M-dwarf stars have any atmospheres at all"

The atmospheres of the remaining Trappist planets will be observed as part of other JWST projects. "If none of the five planets have atmospheres, that tells us that atmospheres in M-dwarf planets are rare," says Stevenson, "and that we should start looking at planets around other types of stars."

If we detect atmospheres, on the other hand, we have good candidates for thorough follow-ups. Even if that is the case, whether we will be able to detect faint signs of alien life with the JWST remains to be seen. Much will depend on how well its instruments perform. "I don't know if we'll get there in the next 10 years with Webb, but we'll try," says Stevenson.

NASA/ESA/(STSCI/AURA)-HUBBLE/EUROPE COLLABORATION

Cepheid stars are key to measuring up the cosmos

DOES THE RATE OF EXPANSION OF THE UNIVERSE BUST OUR BEST COSMOLOGICAL MODEL?

We live in an expanding universe, where galaxies recede away from each other at a rate known as the Hubble constant. This can be measured directly, by determining the distances to faraway astronomical objects, or indirectly by combining observations of the early universe with our best theory of how the cosmos evolved. The problem is that the two measurements are inconsistent.

Our current cosmological model posits that the universe is composed of radiation, matter (including cold dark matter) and dark energy – a puzzling form of energy thought to be responsible for the expansion we observe. Taking data from relic radiation from the big bang, known as the cosmic microwave background, and feeding it into that model, cosmologists estimate that the universe is expanding at a rate of 67 kilometres per second per megaparsec – a megaparsec being a distance equal to 3.26 million light years. Yet when astronomers measure the Hubble constant from observations of distant objects, they find a value of 73 kilometres per second per megaparsec.

The discrepancy, known as the Hubble tension, could indicate that something is seriously wrong with our understanding of cosmic evolution. But the standard cosmological model is hugely successful, accounting for all manner of observations, so we will need a very good reason to chuck it out.

The JWST could finally settle the argument. To get their value for the Hubble constant, astronomers use the "cosmic distance ladder". This makes use of stars called cepheids that fluctuate in brightness at a rate related to their absolute luminosity, which allows us to measure their distance from us. We then move to the next rung of the ladder by using other "standard candles", such as supernovae, to calculate the distance to nearby galaxies and, ultimately, to the edge of the observable universe.

To be sure that those measurements are accurate, you need to reduce uncertainties at every step. To understand those uncertainties, Wendy Freedman at the University of Chicago plans to measure the distance to the same galaxies using a variety of standard candles. Cepheids, for instance, are often surrounded by other young stars. The sharper images provided by the JWST will help to distinguish the contribution in the measured light from cepheids relative to their neighbours. Moreover, higher sensitivity will allow us to see cepheids in more distant galaxies. Freedman will combine the cepheid measurements with other methods for measuring distances to other galaxies to better understand how accurate we can consider our calculations for the Hubble constant.

To address the same issue, Sherry Suyu at the Technical University of Munich, Germany, is instead looking at the flickering of quasars. When there is a massive object between us and the quasar, such as another galaxy, its gravity can act like a lens, resulting in multiple images of the quasar in our telescopes. There is a lag in the arrival of the quasar's flicker in the various images because each has a different light path due to this lensing effect and those lags are related not only to the distance of the quasar, but also to the gravitational potential of the lensing galaxy. With the JWST, Suyu will measure the velocities of stars in the lensing galaxy, allowing her to understand its mass distribution – and therefore to better correct for its gravitational potential when estimating a Hubble constant from the quasar flicker time delays, another method that has been used by astronomers.

If these independent methods of determining distance reach the same value for the Hubble constant, we will know the astronomical measurement is robust. Should they agree with the Hubble value from the cosmological model, then the tension disappears. "If we actually show that the standard model works, that's a really important result," says Freedman.

And if the astronomical measures still differ from the cosmological model? "It would be really interesting if this turns out to be new physics," says Suyu. "But if it does, I want to make sure we're right." ▮

THIBAULT RENARD/GETTY IMAGES

María Arias is an astronomer at Leiden University in the Netherlands

"I call it the good ancestor test"

Sophie Howe is future generations commissioner for Wales. She tells Graham Lawton what it takes to bring long-term thinking into politics

SOMETIMES it seems like the furthest a politician can think into the future is tomorrow's front pages. Sophie Howe's job is to break that vicious cycle of short-termism. As the future generations commissioner for Wales, she advocates for the interests of people who will come of age in the future or have yet to be born.

Created in 2016, her position was a world first. But now, as she nears the end of her term in office, the idea of having a political advocate for people of the future is catching on, with several other nations and even the UN planning to follow suit.

Howe's role is limited to advising the Welsh government, but she has had a considerable impact. *New Scientist* caught up with her to find out how you go about advocating for unborn people and how evidence can help.

NABIL NEZZAR

Graham Lawton: How did your unique job come about?

Sophie Howe: In 2010, the administration in Wales had a national conversation with our citizens to ask: what is the Wales you want to leave to your children and grandchildren? The result was a piece of legislation called the Well-being of Future Generations Act, which was passed in 2015. It sets out seven long-term well-being goals. We want a healthy Wales, a resilient Wales, a prosperous Wales, a more equal Wales, a Wales with vibrant culture and cohesive communities, and a globally responsible Wales. The act also established an independent commissioner to oversee implementation.

That's you! What does your job involve?

I give advice and guidance on the sorts of policies that would take us closer towards meeting those goals. I'm like the government's conscience saying: "Hang on, how have you thought about future generations when you're doing that?" You're going to have to explain how the decisions you want to make are taking us in that direction. I call it the good ancestor test. I can't force politicians to listen to me. But I can make powerful arguments based on the legislation that they themselves have passed.

What time scales do you work to?

The legislation says we should be looking at least 10 years ahead, but my team and I say that we should be looking to the next generation.

That is quite a rare mindset in a world dominated by electoral cycles and annual reports.

That is the huge challenge, isn't it? When you talk about legislating for the well-being of

future generations, everyone says, "yes, of course we want to do that". But actually doing things that are right for the future often requires us to take difficult decisions. We probably need to do things like take money away from hospitals and invest it in preventative services.

Isn't that the sort of tough call that governments are supposed to make already?
This is one of the big problems that we've got in governance systems across the world. If you haven't got something that you're working towards, things scatter off in all directions. Policies operate in silos, and we just respond to crises. In terms of the proactive things that we do, you've got to have a vision of a future that you want to try to create. That's what's lacking, right across the world.

Has your role really changed anything?
The first big test was around the Welsh government planning to spend all of its borrowing capacity to build a 13-mile [20-kilometre] stretch of motorway to deal with congestion around Newport [a city in south Wales]. I asked: can you show me how you've applied long-term trends and scenarios to your thinking around building a road? Because I can point to long-term trends that show declining car use, and that there's going to have to be a change to road taxation when we move to electric vehicles. Can you explain to me how building a road is going to help us reach a low-carbon society? Can you explain how this is going to help us meet our goal of a healthier Wales, when we need to get people out of their cars travelling actively, and when we need to reduce air pollution?

I can't force anyone to do anything. I can put forward the arguments to explain why the things I'm proposing are the right things to do to take us towards those well-being goals that the Senedd [the Welsh parliament] passed. And in the case of the motorway, they changed their mind. This eventually led to the government announcing last year a moratorium on all road building in Wales.

You must wind people up sometimes.
I think I'm a complete pain in the arse! But that's my job. Because who else is speaking for future generations?

Does science and evidence help inform your work?
It informs my work on a daily basis, say, analysing and assessing the Intergovernmental Panel on Climate Change reports, or the [Welsh government's] State of Natural Resources Report. Science is relevant in the environmental sphere, in particular, but also around automation, artificial intelligence, the demographics of the ageing population. I engage on a daily basis with experts and academia, use lots of evidence that's already out there and often commission my own.

We also work with a range of futurologists and futures techniques. One we use quite regularly is the Three Horizons method. Horizon one is where we're going at the moment. Where we want to be is horizon three. Horizon two is where we could practically end up if we make innovations that will take us closer towards horizon three. We're fortunate in Wales in that we know what horizon three should look like – it's those seven well-being goals.

Can you give us an example of how that horizons technique works?
If your mission was to decarbonise the transportation system, mass investment in electric vehicles and grants for people to buy electric vehicles would probably be sensible. If, however, as it is in Wales, your objective is not just to have a low-carbon economy, but also to have improved health, more cohesive communities and to address socio-economic disadvantage, investing in electric vehicles is not the answer because, if you're poor, you won't be able to afford an electric vehicle. You'd be better off investing in public transport.

What is your vision of the future like?
I could describe to you how I would want my 8-year-old daughter to be living her life when she's my age. She'd be walking her kids to school, she'd be connected with nature immediately outside of her doorstep. She might be cycling, and she would be working a reduced working week so she is able to better balance work and family life. Technological innovations would be helping, not hindering, her life. She would be working in a job where well-being is just as important as making money. She would not be paid less than my son because we would have tackled the gender pay gap.

> "I think I'm a complete pain! But who else is speaking for future generations?"

Does the Welsh government have enough political clout to attain these goals?
It holds a lot of the levers. But there are some areas where things the Welsh government might want to do bang up against the devolution settlement [with the UK government]. A live issue is universal basic income or UBI. I've been a strong advocate for it. I've done modelling showing how UBI could help us to reach well-being goals. And in February, the Welsh government announced pilot schemes, which will see young people leaving the care system given an unconditional income of £1600 a month. That's really exciting. But if they wanted to roll that out further, they would have to have cooperation from [the UK government].

I understand that other nations have followed Wales's lead or are considering it.
Countries all over the world are thinking of similar things. Gibraltar now has a future generations act, which is based on the Welsh model. There is a Scottish government commitment to a future generation act. We're working with John Bird, the founder of *The Big Issue*, who's taking a private member's bill to do with future generations through the UK parliament. Also, significantly, we've done a lot of work at United Nations level. The UN system of governance is often short term and doesn't account for the needs of younger generations. The UN secretary general recently set out a proposal for the appointment of a UN special envoy for future generations and a UN Declaration on Future Generations, and I'm part of a small group advising him on how that could work. That could be incredibly exciting because it then has the potential to trickle down to every country in the world. ▮

Graham Lawton is a staff writer for *New Scientist*

ANDREA UCINI

Internal affairs

Getting to know your inner voice could have a dramatic impact on your daily life, finds **Caroline Williams**

WHAT was the last thing you said to yourself in your head? A warm word of encouragement or a scathing put-down?

For me, it was neither. It was more a loud "aargh!" as one part of my brain tried to persuade another to stop procrastinating. As usual, this internal battle cry was both a blessing and a curse. It was a helpful reminder that deadline day wasn't the time for doomscrolling, but it also made me feel bad. My inner voice had spoken and it was far from impressed with my work ethic.

It got me thinking about the voice inside my head. How is it possible to feel like one distinct person and yet simultaneously feel browbeaten by an entirely different person who is also part of "me"? Why is my inner voice often so brutal and is there any way to change its tone?

As it turns out, our inner voice is wrapped up in some even bigger questions, such as those concerning the nature of consciousness, our sense of self and how our inner life affects our behaviour. For that reason, a small band of researchers is dedicated to understanding more. It is challenging work, not least because it is impossible to truly listen in on someone else's inner world. But we are beginning to grasp where inner speech comes from, how it differs between people, its contribution to cognitive skills like memory and its relationship with mental health. Happily for anyone who has a bully in the ranks, research is also revealing strategies that can help change our internal conversations for the better.

The obvious place to start in an attempt to understand my inner voice is to find out where it comes from. In the 1930s, psychologist Lev Vygotsky found that our capacity for inner speech develops along with external language. From around the age of 2 or 3, children start talking out loud to themselves as they play. Vygotsky believed that this is a precursor to inner speech; such chatter gradually becomes internal around the age of 5. Subsequent brain imaging has largely confirmed this idea, showing that inner speech develops around the same time as neural connections between brain areas involved in speech production and understanding mature.

What about its content? According to Vygotsky, the details of what is said, and its emotional weight, are influenced by what your caregivers say and how they say it. In Vygotsky's view, we learn to control our impulses by internalising the instructions of our parents and teachers and repeating them to ourselves. From then on, our inner voice functions as an internal set of checks and balances that keep us on track for our goals and on the right side of social expectations. Perhaps, then, my explosive inner critic originated as the voice of a frustrated parent or teacher who thought I could do better if only I knuckled down.

According to Ethan Kross, a psychologist at the University of Michigan and the author of *Chatter: The voice in our head, why it matters, and how to harness it*, the negative connotations of my inner critic come not from the criticism itself, but from my emotional reaction to it – in my case, a feeling of falling short of personal expectations.

"A little bit of self-critique is not a bad thing," says Kross. "The problem is that, rather than objectively scrutinise the issue and come up with a solution, we get stuck because the emotion takes over." Kross calls this emotional inner turmoil "chatter" and argues that it is one of the "major mental problems we face as a species".

This is where our inner voice gets tangled up with the nature of consciousness. Early theories of consciousness suggested that we each have one "self", with distinct likes, dislikes and motivations. Yet while we generally feel like one coherent person, many psychologists now consider the singular self to be an illusion. Instead, they argue that we are made up of many selves, each with a different set of motivations and standards. This means that our inner chatter may be a result of the different roles that form our sense of self. "I as a mother", for example, would live by a different set of standards than "I as a friend". And "I the deadline-meeter" has a different set of goals to "I, who likes a bit of celebrity gossip".

There is some evidence that our childhood experiences are also at the root of this internal conflict. In 2020, Małgorzata Puchalska-Wasyl at the John Paul II Catholic University of Lublin in Poland showed that people whose parents strongly disagreed on how to raise them experienced more intense and distressing internal dialogue as adults, as the two ›

opposing viewpoints continued to battle it out over what is right.

In getting to know our inner voice, it may also be helpful to identify who is actually doing the talking. Puchalska-Wasyl attempted to do this by asking hundreds of people to rate their most common inner speakers based on a variety of emotional outcomes.

Look who's talking

Her analysis boiled down their inner speakers to four basic characters: the Faithful Friend, the Proud Rival, the Ambivalent Parent and the Helpless Child. The Faithful Friend is an advocate: caring and positive and always on hand to provide encouragement. In Puchalska-Wasyl's sample, this was the most common inner voice experienced. Second was the Proud Rival, a high-fiving positivity coach who challenges a person to up their game. The Ambivalent Parent offers love, support and, at times, a hefty dose of criticism. The Helpless Child is the most negative, arriving with a feeling of powerlessness and a need for support.

Determining which voice pops up most often can be difficult. One option is to pay attention to your inner dialogue and notice

LAURA DWIGHT/ALAMY

"The thinking process that takes place without words can be as specific as thought that takes place with words"

which version of your inner voice is talking and how it makes you feel. Given that internal dialogues are a useful tool in psychotherapy, identifying which type of voice predominantly guides you may help you to reframe the conversation for the better, writes Puchalska-Wasyl in a paper on the subject.

My own inner voice has definite Ambivalent Parent vibes, as though it has tried the Faithful Friend approach and finally run out of patience. My internal response has undertones of the Helpless Child. Perhaps a deliberate shift towards a Faithful Friend could get the job done with less emotional fallout?

Unfortunately, I may be fooling myself. Many researchers think that self-reports of our inner voice are an unreliable guide. "We're not very good at knowing what's going on in our heads," says Charles Fernyhough at Durham University in the UK, author of *The Voices Within*. "People answer questionnaires according to what kind of mind they think they have, rather than what kind of mind they actually have."

To address this, Russell Hurlburt at the University of Nevada, Las Vegas, has developed a method called descriptive experience sampling (DES). Volunteers wear an earpiece connected to a beeper that goes off at random. At the beep, volunteers record exactly what they are experiencing internally. Later, Hurlburt interviews each volunteer, drilling into what exactly was happening and whether words, images or sensations were present. This, he believes, opens a true window into our "pristine inner experience". You can do something similar with an app that Hurlburt helped create called I-Prompt-U.

YOUR INNER CRITIC

Most research into inner speech assumes that deliberately talking to yourself is the same thing as those random voices that pop up to give an opinion. However, brain imaging experiments by Charles Fernyhough at Durham University in the UK and Russell Hurlburt of the University of Nevada, Las Vegas, show that this isn't the case, with implications for mental health.

In the experiments, volunteers were randomly prompted to report what was going through their minds while in an fMRI scanner. This revealed that deliberate inner speech engaged regions in the brain's left hemisphere, involved in speech production, while spontaneous inner speech was accompanied by activity in regions important for auditory perception. When we spontaneously hear voices, it is more similar to listening than speaking, says Hurlburt.

This has implications for the treatment of depression, in which an overly critical inner voice is common. It is possible that turning spontaneous thoughts into a deliberate, more positive take may help turn an inner critic into an inner coach, by transforming passive opinions into more active advice.

At 2 or 3 years old, children start to talk to themselves while they are playing

Hurlburt pioneered this approach more than 40 years ago and has collected samples from thousands of volunteers. He concludes that inner speech is just one common form of thought, along with inner seeing, feeling, sensory awareness and unsymbolised thinking – in which a concept isn't necessarily attached to words or other symbols. Each of these turns up in around 25 per cent of beeps, says Hurlburt, but not everyone experiences them all. And some people rarely, if ever, use verbal inner speech.

When Hurlburt sent me a beeper to try DES for myself, I was surprised to find that I was in the latter group. Over four days and 22 beeps, only one involved inner speaking. At the time of that beep, I was explaining to my son that there was nothing "unfair" about losing a random game, while simultaneously thinking "is this making any sense" in my head.

In other beeps, though, I was certain there were no words attached to what I would have previously referred to as my inner voice. For instance, one beep happened on the train, while I was squinting from the sun. I had just noticed that a woman was staring at me, and I was wondering if she was thinking that my face is really wrinkly. There were no words, but the thought was as clear as day.

Hurlburt says he sees this all the time. "The thinking process that takes place without words can be as specific as thought that takes place with words." Fernyhough makes the same point. Even Puchalska-Wasyl's four characters may exist without speech, he says.

The nebulous concept of an inner voice gets stranger still. In 2020, twitter user @KylePlantEmoji posted a tweet saying: "Fun fact: some people have an internal narrative and some don't". The tweet went viral, triggering discussions in which some people expressed surprise at the entire concept of an inner voice.

In the years since, a number of people have come forward claiming to have no inner speech whatsoever. Last year, Rish Hinwar and Anthony Lambert, both at the University of Auckland in New Zealand, dubbed this "anauralia" and published a study showing a strong correlation between having no inner speech and the experience of having no mind's eye, known as aphantasia. So far, little else is known, but Lambert says that preliminary analysis of data from 15,000 people as part of the New Zealand Attitudes and Values Study puts the proportion of people with anauralia at 0.8 per cent.

A SILENT MIND

Losing your inner voice is an experience that neuroanatomist Jill Bolte Taylor understands well. In 1996, a stroke knocked out her ability to talk to herself in her head for five weeks. Now recovered, she describes the aftermath of her stroke as a "blissful silence" without the cacophony of internal speech. It created a feeling of being untethered from her sense of self in a way that left her feeling peaceful. "It was liberating to not maintain the pressure of my ego self," she says.

But it also had downsides. Bolte Taylor says the lack of a coherent inner narrative left her unable to function. Among other things, she couldn't determine where her body was positioned in relation to the world around her, was unable to retrieve autobiographical memories and had a lack of self-conscious emotions, most notably embarrassment.

The effect of not hearing any inner voice on your brain and behaviour is unknown. Lambert intends to study this question further. However, we know that when your inner voice is wiped out suddenly through disease (such as a stroke in the language-producing "Broca's area" of the brain), the effects can be dramatic, ranging from memory problems to an inability to feel emotions and a loss of self-identity (see "A silent mind", above).

Lost voice

In these cases, people sometimes report that linguistic thinking transforms into thinking in pictures. In 2021, Peter Langland-Hassan at the University of Cincinnati in Ohio showed that people who had lost their inner voice after a stroke were still able to link abstract concepts. They were slower than people who hadn't had a stroke, but were able to do it, says Langland-Hassan. "Producing language in the head is not essential to understanding abstract relationships," he says.

These results, together with the fact that people with anauralia seemingly function well enough not to have necessarily noticed an absence of an inner voice, suggest that inner speech is a tool we can use for certain cognitive processes, but that it isn't necessarily the only way to get a job done.

Understanding this relationship between inner voice and cognitive skills and behaviours is critical. Not only could it aid the treatment of mental health conditions like depression (see "Your inner critic", page 48), but it can also help us react better to daily stress.

For instance, Kross tells me there are some simple ways of escaping my negative inner voice. One is to seek some perspective on how much your chatter actually matters. Mentally zooming out could be as simple as going for a walk in nature, or looking up at the stars. "When you're in the presence of something vast and indescribable, it's hard to maintain the view that you – and the voice in your head – are the centre of the world," says Kross.

If that doesn't work, have a word with yourself in the third person. In a series of studies, Kross and his colleagues stressed volunteers by asking them to give a presentation at short notice. Half were told to prepare by silently talking to themselves using either their name or non-first-person pronouns, such as he, she or you. The other half were directed to use the first-person pronouns "I", "my" or "me". The results showed that using non-first-person pronouns not only provided psychological distance from the stress, but also improved their performance. Afterwards, these people were more likely to be proud of their presentation and spent less time picking it apart.

Now that I am well acquainted with my inner critic, it seemed worth a try. The next time I felt an impending inner scream, I made a decision to talk to myself like a friend: "Caroline. Scrolling won't help. If you need a break, go for a walk."

So I did. And somewhere along the way, my inner critic finally piped down and I managed to get back to work. I will let you be the judge of the result. ▮

Caroline Williams is a writer and author of *Move!: The new science of body over mind*

Micropathology Ltd

Tel 24hrs: +44 (0) 24 - 76 – 323222

Fax / Ans: +44 (0) 24 - 76 - 323333

University of Warwick Science Park, Venture Centre, Sir William Lyons Road, Coventry CV4 7EZ

Website: www.micropathology.com E-mail: info@micropathology.com

POSTDOCTORAL SCIENTIST - MOLECULAR DIAGNOSTICS

We provide a clinically supported service for the rapid diagnosis, research and management of infectious disease.

We are seeking a motivated post-doctoral scientist with molecular experience to work within our Microbiology division.

Daily duties will include performing PCR, result interpretation, reporting and administrative tasks. Appointees will assume responsibilities for service improvement. Occasional part time attendance at weekends may be required.

Candidates will possess a PhD in biological/medical/biochemical sciences. Candidates must have good literacy, IT and mathematical skills. Good scientific knowledge and logical approach is essential. Previous experience in clinical microbiology would be helpful, as would familiarity with quality management systems (the laboratory is accredited to UKAS standards). Staff are encouraged to contribute to the company's extensive research portfolio.

Applicants must be legally entitled to work in the UK.

The successful applicant will be appointed for a probationary period and subject to satisfactory performance will be offered a permanent post. Pay and pension will be competitive and commensurate with skills/experience.

Applications (CV and hand-written covering letter) should be submitted to Helen Healy at the address above. Requests for more information should be sent to **personnel@micropathology.com**

Early applications encouraged. Direct applications only. Closes end of July 2022.

The back pages

The science of cooking

A damn fine cup of (cold) coffee

Cold-brew coffee is on the rise. Enthusiasts say it has a smoother, less acidic taste and new research backs this up, finds **Sam Wong**

Sam Wong is assistant news editor and self-appointed chief gourmand at New Scientist. Follow him @samwong1

What you need

40g coarsely ground coffee
50ml cold water
Milk and ice (optional)

A GOOD cup of coffee is all about balance. Coffee contains more than 1000 flavour compounds, including some that provide the fruity, earthy and chocolatey aromas we detect in our noses and others responsible for the acidity, bitterness and astringency we detect in our mouths.

The challenge is to extract a rich brew of desirable flavour compounds without overextracting those that make the drink bitter and overpowering. The roasting and grinding of the beans, the temperature of the water, the ratio of ground coffee to water and the time they are in contact all play a part, but different brewing methods all make coffee with different characteristics.

Espresso machines drive hot water through finely ground coffee at around 9 atmospheres of pressure. This extracts a much higher concentration of chemicals from the coffee, including a large amount of oils, giving the drink a creamier mouthfeel and slowing the release of flavour.

You can't replicate this at home without an expensive machine. If you like your coffee strong, perhaps the best approximation is a stovetop moka pot, in which steam pressure pushes boiling water through a bed of ground coffee into a chamber at the top.

I normally use a cafetière, or French press, which makes it easy to adjust the variables to your taste. I find that about 6 grams of coarsely ground coffee for every 100 millilitres of water and a brewing time of around 4 minutes give the best results.

JOZEF POLC/ALAMY

The optimum temperature for brewing is considered to be anywhere between 85°C and 93°C, but a recent trend has seen the rise of a different approach: cold brewing. This means steeping the ground coffee in water at room temperature or cooler. Cold-brew coffee is usually served cold, but it can also be heated up – in contrast to iced coffee, which is brewed hot then cooled down.

Enthusiasts say cold brewing results in a different flavour profile, often described as smooth and mellow with less acidity, less bitterness and accentuated chocolate and syrupy notes. A flurry of recent studies appears to back this up. Chemists have found cold-brew coffee has similar levels of caffeine to hot-brew coffee, but a lower concentration of acids and lower antioxidant activity.

At low temperatures, chemicals are extracted from the ground beans much more slowly, so the coffee is typically left to steep for at least 8 hours. But studies show good results can be achieved in as little as 2 hours at room temperature, and longer brewing may lead to more bitterness.

Pour the water over the coffee in a cafetière and stir. Place the lid on and leave it for an hour, then stir again and leave for another hour. Press the plunger before serving. I take mine with ice and milk – it is the perfect way to perk up and cool down on a hot day. ▮

The science of cooking appears every four weeks

Next week

Stargazing at home

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

25 September 2022

8 days for US$10,885

Science of rewilding: Iberá National Park, Argentina

This once-in-a-lifetime opportunity will give you behind-the-scenes insights into the science of nature restoration and rewilding in one of the world's most ambitious conservation projects: the creation of Iberá National Park in Argentina.

Explore one of the world's largest freshwater wetlands with the chance to see a vast array of wildlife including jaguars, giant otters, capybara, macaws and anteaters, as well as a huge variety of birdlife. Hosted by the Science Director Emiliano Donadio, you will stay in luxury lodges and hotels.

As well as accompanying Emiliano around the park, you will visit the rangers, biologists and veterinary technicians involved in reintroducing species to the park and returning it back to its natural state. This unique tour will also include time in the capital Buenos Aries and is led by conservationist Duncan Grossart.

Highlights

- **Opportunity to sight wildlife including jaguars, pampas deer, giant otters, capybara, red-legged seriemas and anteaters.**
- **Spend time with leading conservationist and Science Director Emiliano Donadio.**
- **Watch macaws in flight training.**
- **Behind-the-scenes access at the Iberá National Park.**
- **Visit the Estación Biológica Corrientes and the Aguará Rewilding Centre, where animals are rehabilitated for release back into the wild.**
- **Stay at idyllic conservation lodges and boutique hotels.**
- **Explore the cosmopolitan and architecturally beautiful Argentinian capital city, Buenos Aires.**

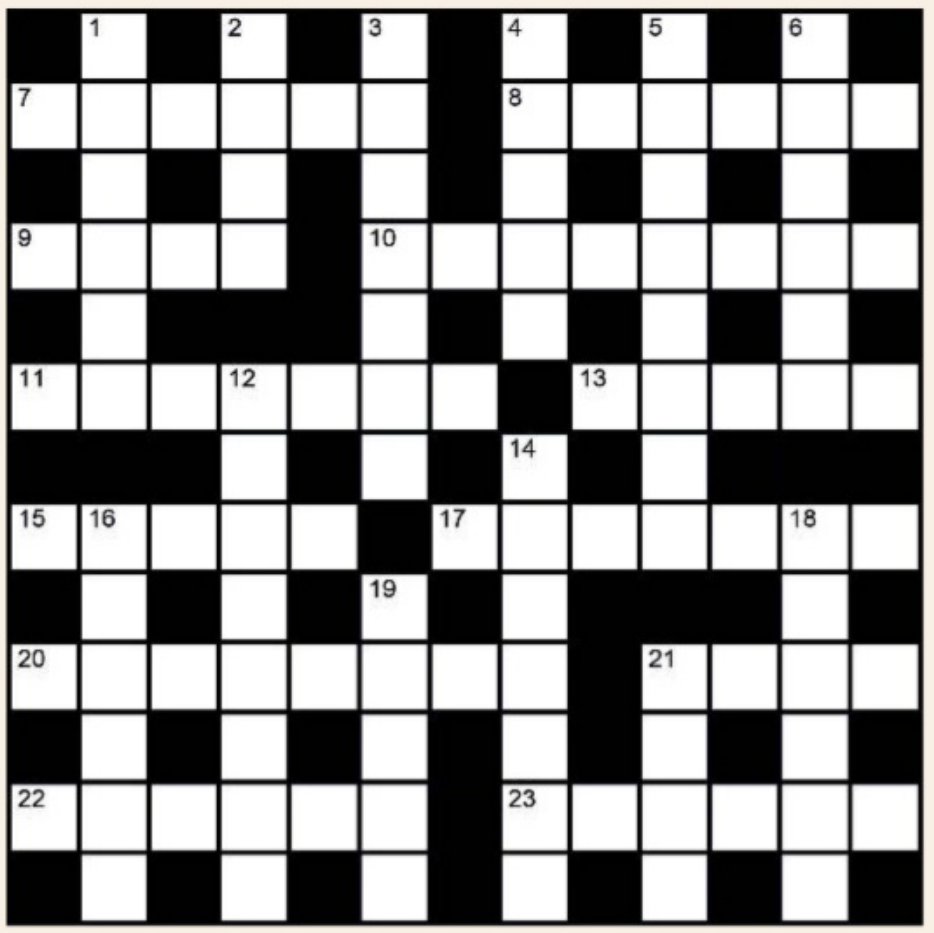
BETH WALD

To book call UK +44 7930 660 806 (UK office hours: Mon-Fri 9am to 5pm GMT)
Or email newscientist@journeyswithpurpose.org

In partnership with Journeys With Purpose

JWP
JOURNEYS WITH PURPOSE

Cryptic crossword #87 *Set by Wingding*



Scribble zone

Answers and the next quick crossword next week

ACROSS

7 Pack of rugby players protecting a bone (6)
8 Head teacher with artist's equipment showing prickly plant (6)
9 Appendage left with small amount of data (4)
10 Spiny animals had since evolved (8)
11 Floating organisms make nitrogen at London station (7)
13 Cyanide, perhaps, soon to overwhelm writer (5)
15/21 Magnesium sulphate cures male spots (5,4)
17 Tropical bird sounds like model human (7)
20 Forest dweller put head in front of door (8)
21 See 15 across
22 Cuts tallies (6)
23 Vegetable beginning to make sharp point (6)

DOWN

1 Actor Michael holding new tooth (6)
2 Caterpillar erected fortress (4)
3 Ruler promoted agent in European city (7)
4 MERS left out of chemistry shake-up – irritating! (5)
5 Flower affected drainage (8)
6 Italian food made from increasing amount of *formaggio taleggio* (6)
12 Sons wrap parent in cocoons (8)
14 Understands measures of depth (7)
16 Attack snow leopard under pressure (6)
18 Extremely inviting toilets in cold buildings (6)
19 Store wood under road (5)
21 Organise game without parking (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #159

1 What phenomenon is also known as the Sewall Wright effect?

2 How many International Space Station expeditions have there been, including the one that is currently occurring?

3 Members of which order of animals represent around 40 per cent of mammals?

4 The three main types of plastid (a membrane-bound organelle found in plants) are chloroplasts, chromoplasts and what?

5 In computing, what does HTML stand for?

Answers on page 55

Puzzle

set by Brian Hobbs

#175 Wizard of odds

The students at Yellow Brick High School for Girls couldn't decide if their maths and drama teacher, Ms Gale, was a genius or just overworked when she announced the new school play, a "mathemusical" called *The Wizard of Odds*. But the real challenge, as usual, was in the casting, and the parents, students and faculty had various demands, summed up as follows:

1. If Megan doesn't get the lead role, Dorothree, then Kasey will play either the Square Crow or the Ten Man.
2. If neither Leah nor Nicki are the Cowardly Line, Jane will be Dorothree.
3. If Leah doesn't get the Square Crow, Jane or Kasey will get Dorothree.
4. If Nicki isn't the Ten Man and if Leah doesn't get Dorothree, then Kasey will play the Wicked Witch of the Word Problems.
5. If Leah isn't the Cowardly Line and if Nicki isn't the Wicked Witch of the Word Problems, then Jane will be cast as the Square Crow.

Remembering that "if x, then y" doesn't imply "if not x, then not y", can you help Ms Gale accommodate this tornado of requests by assigning the roles?

Solution next week

Up in flames

What shape would a candle's flame be in zero gravity?

Garry Trethewey
Cherryville, South Australia
A candle flame isn't a thing, but a process. Burning heats air, which expands and becomes less dense. Because of gravity, the non-heated air around it falls, but in common parlance, we say the hot air rises. That creates a flow, bringing fresh oxygen to support combustion.

Without gravity, or a fan to maintain gas flow, the candle flame would surround itself with a sphere of oxygen-free burnt gas, and the process would end in a small fraction of a second.

Richard Klingbiel
Friday Harbor, Washington, US
A flame in zero gravity would be spherical. A flame is simply hot gas, heated by the oxidation of its fuel. Being hot, it expands and is therefore of a lesser density than the air around it, forcing it upwards in an environment with gravity. In zero gravity there would be no such upward movement. The flame would expand in a uniform way and be spherical except for where it makes contact with its fuel (the candle wick).

"Experiments with flames are perhaps not ideal in the limited, air-conditioned environment of a spacecraft"

Its size would increase depending on how rapidly its heating from combustion could either radiate or conduct to the surrounding air.

Tony Compton
Hexham, Northumberland, UK
A candle relies on convection to clear away the combustion products, so the obvious answer is this won't work in zero gravity. However, if the candle were sitting in a tube of slightly greater diameter than its own and containing a gentle flow of air, it should operate normally – with a flame of the usual shape.

Perhaps not an ideal experiment in the limited, air-conditioned environment of a spacecraft!

Alex McDowell
London, UK
The flame would be spherical and blue, as astronauts found when they burned candles on NASA's Skylab space station in the 1970s.

There are no convection currents without gravity, hence the supply of oxygen is limited by diffusion. The convection current elongates the candle flame when gravity is present, and cools it. Hence candle flames burn hotter and blue without gravity.

Mike Follows
Sutton Coldfield, West Midlands, UK
Not only is a flame spherical in microgravity, but the colour is also blue, different to that on Earth.

A candle is made of wax, a hydrocarbon, and the products of its combustion are water vapour and carbon dioxide. Carbon dioxide is normally colourless and transparent. However, in the hot flame, the electrons are excited and, when they return to their ground state, emit photons corresponding to the blue part of the electromagnetic spectrum.

Apart from blue close to the wick, a candle flame on Earth is mainly yellow. This is because some tiny particles of candle wax escape as soot in the convection current before they can be completely combusted. These particles are tiny black body radiators whose radiation peaks in the yellow part of the electromagnetic spectrum. Without convection, this process doesn't happen.

A fire in a confined space like a spacecraft is rightly feared and a blue flame makes them difficult to spot. In microgravity, a flame in undisturbed air would normally burn itself out. However, if only to prevent electrical appliances overheating, fans are used to circulate air inside spacecraft.

@PhilMorey8
via Twitter
If you are lighting candles in apparent zero gravity then your spaceship is in deep trouble.

Robert Gallop
Sydney, Australia
I had this exact question in 1970 in an Imperial College London university entrance exam. I got the answer wrong.

SHUTTERSTOCK/HARRY FEATHER

Ben Nevis is the highest spot in Scotland, one of the five nations that make up the British Isles

This week's new questions

Peak spot **The highest peaks in each of the five countries of the British Isles are all within around 15 kilometres of the coast. Is there any geological reason why they are all so close to the sea?** ***Damian Rodgers****, North Muskham, Nottinghamshire, UK*

Weedy diet **What stops us from processing weeds into tasty and edible food?** ***Tony Quigley****, Tunbridge Wells, Kent, UK*

Springing back

If frogs return to breed at the place where they hatched, how do they spread across the country?

Hugo Cayuela
Via email
For a long time, naturalists thought that amphibians (such as frogs, toads, salamanders and newts) were philopatric animals. This means that, if a frog began life in a given pond, it will always come back to breed in this pond when it is old enough to do so.

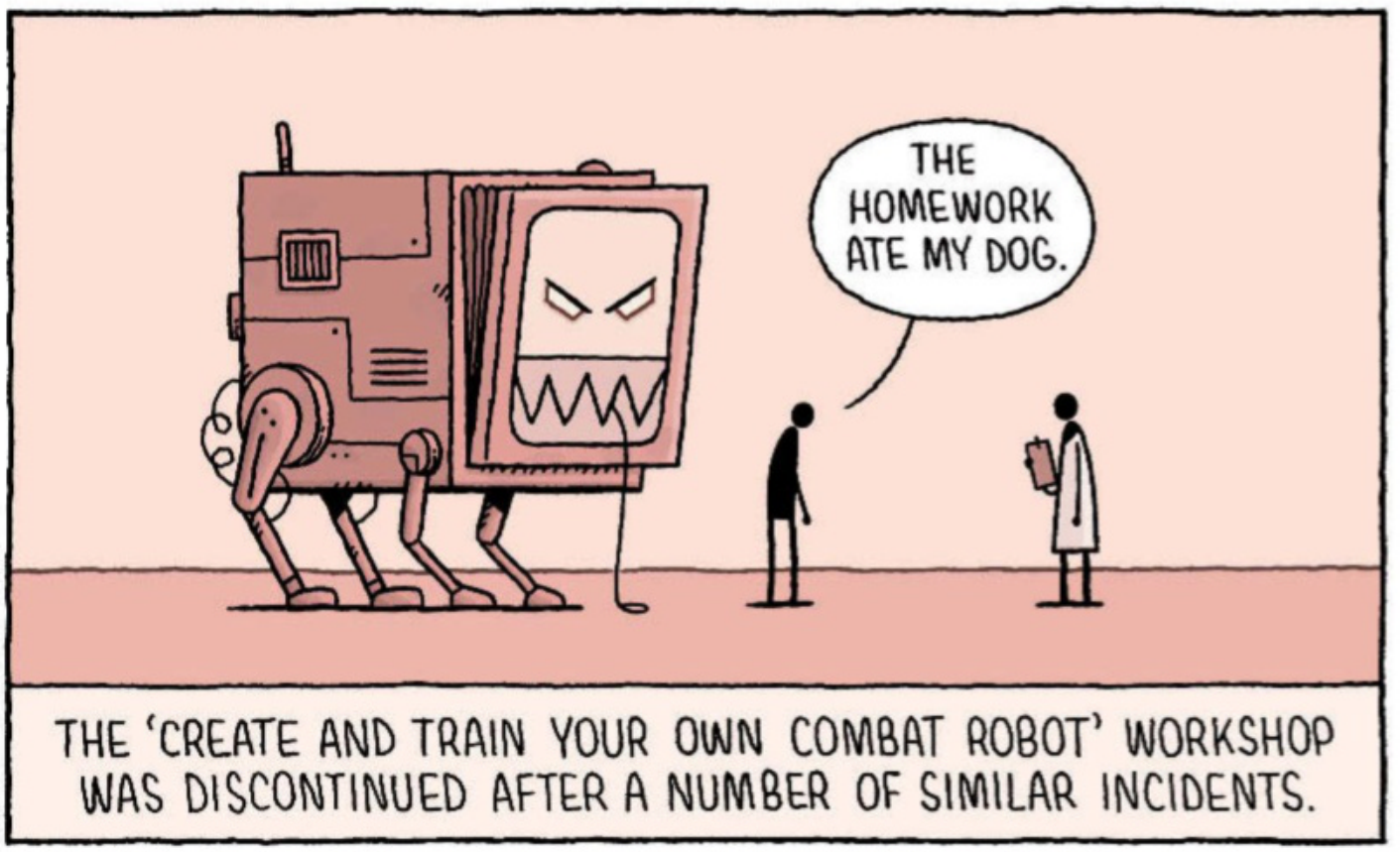
However, this view suffers from obvious contradictions.

First, the populations of some species of amphibians occupy large geographical areas, which implies movement between ponds to colonise these vast spaces.

Second, studies have shown that some invasive amphibian species have colonised wide parts

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



of Europe and Australia within a few decades, with negative effects on native species and ecosystems. This indicates low fidelity to their natal pond and high movement propensity/capacity.

Third, the absence of flow of individuals between ponds would lead to extinction of populations and less genetic variation.

So, amphibians aren't as pond faithful as we imagined. In fact, dispersal, that is the movement of an individual between its birth and breeding ponds or between successive breeding ponds, is an essential mechanism in the life cycle of amphibians.

Studies show that in some populations, nearly 30 per cent of individuals change breeding sites at least once in their life. Moving depends both on individual characteristics (physical condition, behaviour), but also on environmental conditions (water level, predation risk).

More than 40 per cent of amphibian species are threatened, according to the International Union for Conservation of Nature.

"Frogs aren't as pond faithful as we thought. Around 30 per cent change breeding sites at least once during their lifetime"

Dispersal plays a critical role in their viability and conservation. By modifying landscapes, human activities limit the dispersal capacities of amphibians, thus contributing to the isolation and decline of their populations.

Mood music

I am a big fan of classical music. Why does some music evoke certain emotions in the brain, even if it doesn't have any lyrics? (cont'd)

David Myers
Commugny, Switzerland
In a previous response (9 April) I see that Talia Morris thinks that people can be trained to associate certain emotions with particular types of music, which is certainly not the whole story.

At the age of 8, when radiograms (a radio/record player combo) came on the market, the first recording my father bought was of Beethoven's *Emperor Concerto*. When I should have been in bed, I hid downstairs and listened to the music, spellbound. It seemed beautiful beyond anything I had imagined – and still does. No training was involved.

Alex Jones
Sydney, Australia
I have never experienced any emotional reaction to music other than boredom and a desire for it to stop.

Sam Edge
Ringwood, Hampshire, UK
In previous responses to this question, I saw no reference to the associative power of music.

Like aromas, a sound – especially a melody – can remind us of an emotionally charged event in our past, leading to a positive feedback effect that reinforces such connections when we hear the piece again.

Answers

Quick quiz #159 *Answers*

1 Genetic drift
2 67
3 Rodentia
4 Leucoplasts
5 HyperText Markup Language

Quick Crossword #111 *Answers*

ACROSS 1 Cystic, **5** Earthling, **9** Baseline, **10** Shoddy, **11** Test-tube baby, **13** Gout, **14** Oestrual, **17** Serology, **18** Sick, **20** Stratocaster, **23** Corona, **24** Isotopes, **25** *The Abyss*, **26** Earbud

DOWN 2 Year, **3** Twenty-two, **4** Chiasm, **5** Electrodynamics, **6** Rose bush, **7** H-bomb, **8** Nudibranch, **12** Robert Koch, **15** Reservoir, **16** Coronary, **19** Strobe, **21** Aroma, **22** Zebu

#174 Pieces of eight *Solution*

The time spent in bed is 8 hours and 57 minutes.

Each of the four numbers on the digital alarm clock is made up using a conventional seven-segment display.

The "0" uses six segments, the "1" uses two, and so on, so the digits, from dimmest to brightest are: 1, 7, 4, (2, 3, 5), 0, (6, 9), 8, with numbers of equal brightness grouped in brackets.

The four clock digits can be 0-1, 0-9, 0-5 and 0-9. So the dimmest display possible is 11:11 and the brightest is 08:08.

Should that be Beedfack?

Feedback's whirlwind romance with non-fungible tokens took another knock this week on learning that a celebrity impersonator called Doop Snogg and the man who hired him, Isaac Kamlish of NFT start-up Fair.xyz, arrived at a New York NFT festival to a blizzard of business cards hurled by star-struck CEOs who thought, against all available evidence, that Doop Snogg was the real Snoop Dogg.

Was tulip mania ever this weird, Feedback wonders, putting our autograph book back in our pocket and heading for the West Coast and a bite to eat at NFT-themed burger restaurant Bored & Hungry in Long Beach, California. Contrary to a rumour it had stopped taking crypto payments, Feedback was pleased to find it says it still accepts ethereum and apecoin. "In the world of Web3, tech changes by the day," explains co-founder Kevin Seo, or an NFT closely resembling him.

Twisteddoodles *for New Scientist*

Dead ringers

"So what should we invest in?" Feedback ponders. Precious metals are a perennial favourite in uncertain times, so: "Hey, PERCY. Find us a silver mine!"

Percy Cudlipp was *New Scientist*'s first editor, an ebullient Welsh journalist who died in post in 1962. He was also a regular on the BBC World Service and, thanks to technology that Feedback smuggled out of Amazon's re:MARS conference, recordings of Percy's Welsh lilt now power PERCY, our new digital assistant.

Amazon needs little more than a minute's worth of a voice recording to recreate the voice of your lost loved one, according to TechCrunch, after Alexa's Rohit Prasad gave the scenario of using a deceased grandmother's voice to read her grandson a bedtime story. Nothing creepy about that.

Minecraft

Alas, PERCY isn't nearly as infallible as its revered namesake or it would never have been duped into investing in the Kashen silver mine, a point of often violent contention between the Princes of Tver and the Dukes of Moscow in the late medieval period, and also, it turns out, an entirely made-up place.

Kashen is the invention of "Zhemao", a Chinese homemaker whose extensive alternate history of Russia had been quietly swelling the pages of Chinese-language Wikipedia for about a decade until a fantasy writer called Yifan started asking awkward questions about the citations. Zhemao's multimillion-word labour of love has mostly been taken down now, reports LitHub – at what cost to world literature, we'll never know.

Got a story for Feedback?

Send it to feedback@newscientist.com or New Scientist, Northcliffe House, 2 Derry Street, London W8 5TT
Consideration of items sent in the post will be delayed

Land of the lost

Real cities can be lost too – just ask the employee who, after spending 3 hours drinking alcohol, passed out in the street and lost USB devices containing the names, addresses, birth dates, tax records, bank account numbers and benefit information for all 460,000-odd residents of Amagasaki in Japan's Hyogo prefecture. The tale ends happily: according to the *Asahi Shimbun*, police found the devices nearby.

Craft corner

The stationery cupboard's refit continues apace, its catacombs now resembling the hidden passageways deep inside the Chavín de Huántar temple complex in the Peruvian Andes that was recently opened for the first time in 3000 years.

The Chavin people, seemingly partial to the odd pinch of hallucinogenic snuff, would surely feel at home in our cupboard, especially since so much of it is now given over to Feedback's latest craft project, inspired by a recent report from a colleague at the more reputable end of the magazine.

Shoji Takeuchi and his colleagues at the University of Tokyo in Japan have managed to cover a robotic finger in a single piece of cultured skin, and shown how the skin can heal from injury. The only issue is that the digit must stay submerged most of the time in a nutrient bath. Lacking the precise formula for this bath, Feedback is making do with fish food. We are spending hours watching PERCY's finger wiggle from one side of its tank to the other.

Snap decision

What with the fish tank and all, Feedback has had to swap our reclining sofa for a foldable chair. So we are indebted to Ig Nobel founder Marc Abrahams, who spotted the following research in *Applied Mechanics and Materials*. In his "study of design demand of applying quality function deployment in plastic folding chairs", Chun-Tung Chen at Shu-Te University, Taiwan, attaches key measurables to "the rise of consumer awareness and enhanced demand for product quality" in folding chairs. Most important for today's informed consumer of folding chairs? "Parts unlikely to fall off."

Naturewatch

A tap on the glass (thank you, PERCY) reminds us of our groaning postbag (and we mean that on so many levels). Richard Carruthers tells us that Guy Shrubsole leads the Lost Rainforests of Britain campaign. And what about the bacterium *Thiomargarita magnifica*, so big it can be seen with the naked eye? That was first discovered in 2009 by Olivier Gros.

It is in the news again thanks to researcher Jean-Marie Volland's not altogether pleasant video of the things swimming about. Which reminds us, we really should clean out PERCY's tank.

MANCHESTER 1824
The University of Manchester

BREAK THROUGH

The University of Manchester's research beacons are tackling some of the biggest questions facing the planet.

Get in touch for knowledge, evidence and expertise:

manchester.ac.uk/beacons

Research beacons

GLOBAL CHALLENGES
MANCHESTER SOLUTIONS

SPEEDMASTER SEDNA™ GOLD

Launched in 1957, the Speedmaster earned its nickname in 1969, when it became the first watch worn on the moon. This edition, while retaining the chronograph's classic design elements, features a black step dial and is cased in OMEGA's exclusive 18K Sedna™ gold. The long-lasting rose gold alloy retains its fiery colour and lustre over time, and is named after one of the reddest orbiting planetoids in our solar system. This striking timepiece is also a Co-Axial Master Chronometer, independently certified by the Swiss Federal Institute of Metrology (METAS) to guarantee the highest levels of accuracy, reliability and supreme resistance to magnetism on Earth and in space.

OMEGA