New Scientist

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

Discovery Tours

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Explore nature and evolutionary science

Retracing Charles Darwin's travels across North Wales

5 May 2025 | 6 days
1 September 2025 | 6 days

Uncover the best of Wales on an in-depth journey through the stunning landscapes of Eryri (Snowdonia) national park, where dramatic mountains and valleys reveal a geological story shaped by volcanic and glacial forces over millions of years. Walk in the footsteps of Charles Darwin and discover the inspiration he found in the rugged terrain when he visited in 1831 and 1842.

- Discover sites from Darwin's childhood and the places where he prepared for his legendary voyage on HMS Beagle.
- Enjoy the spectacular landscapes of North Wales, including the mountains of Eryri (Snowdonia) national park, the tranquil Llyn Ogwen lake and the rocky coasts of Anglesey.
- Learn how Darwin unravelled the origin of these landscapes.

Marine conservation cruise exploring Darwin's Galapagos: Ecuador

14 July 2025 | 8 days
28 July 2025 | 8 days

Visit the Galapagos Islands, a major bucket list destination for wildlife enthusiasts, accompanied by passionate conservation advocate Jo Ruxton. The Galapagos archipelago is home to a wide range of endemic species, making it a living laboratory for studying natural selection, biodiversity and evolutionary processes in real time. Begin in the UNESCO World Cultural Heritage city of Quito, followed by seven days of exploring at sea.

- Explore the wildlife-rich islands of Santa Cruz, Isabela, Fernandina, Santiago and Rabida on this voyage of a lifetime.
- Get up close to spectacular wildlife, including blue-footed boobies and giant tortoises, as well as coral gardens and volcanoes.
- Swim with larger species like sharks and rays as the water temperatures cool, bringing nutrients in the currents.

Alfred Russel Wallace expedition cruise: Indonesia

23 January 2026 | 13 days

Explore the Maluku Islands (Spice Islands) and Raja Ampat Islands as Alfred Russel Wallace did, visiting several sites that were important to his discoveries, as well as experiencing the islands' local culture, primary rainforests, geology and conservation projects. Go in search of wildlife aboard a luxury schooner including several species of birds of paradise, golden birdwing butterflies and a wealth of sea creatures.

- Search for diverse wildlife on land, in the air and at sea whilst experiencing local culture, rainforests, geology, conservation projects and relaxation of the highest order.
- In-depth insight into the life and work of Wallace, plus the natural treasures of Indonesia.
- No more than 22 passengers on board a boutique sailing ship, which allows more face-to-face time with the accompanying expert.

Find out more newscientist.com/tours

In the footsteps of Alexander von Humboldt: Ecuador

21 July 2025 | 8 days

Follow in the footsteps of the legendary geographer, explorer and naturalist Alexander von Humboldt, retracing part of his 1802 expedition through Ecuador's iconic Avenue of the Volcanoes and onward into the lush cloud forest. These regions were pivotal in shaping Humboldt's groundbreaking "unity of nature" theory, where he recognised the interconnectedness of Earth's ecosystems. Embark on a journey through dramatic landscapes of snow-capped volcanoes, pristine, crystal-clear lagoons and lush green valleys.

- **Learn more about Alexander von Humboldt's 1802 expedition and how his theories altered the way scientists see the natural world.**
- **Discover the significant influence his research had on Charles Darwin and his thinking on evolutionary biology.**
- **Spend two days exploring the cloud forest, one of the most biodiverse regions on the planet. It is recognised as a hotspot for birds, orchids, epiphytes, butterflies and mammals.**

Discovery Tours
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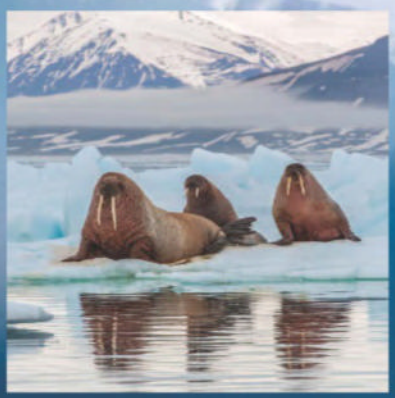

Arctic expedition cruise, Svalbard, Norway

22 June 2025 | 12 days

Embark on an unforgettable adventure to the Arctic, a land of awe-inspiring beauty and untamed wilderness. Sail aboard the luxurious and intimate polar expedition vessel, the Greg Mortimer. This isn't just a cruise, it's a once-in-a-lifetime expedition that deepens your connection to one of the most remote places on Earth.

The cruise itinerary has been thoughtfully designed and includes a mix of activities, such as expert-led talks, engaging workshops and exhilarating Zodiac cruise safaris. You will be accompanied by Richard Dawkins, Russell Arnott and New Scientist's Leah Crane, along with a highly knowledgeable and supportive expedition team. Learn about topics including glaciology, botany, marine biology, astronomy and the history of polar exploration, unravelling the mysteries of this remote and rugged archipelago.

June is a prime time to witness the Arctic's vibrant wildlife in action. Marvel at a plethora of species on land and at sea, from Arctic foxes and polar bears to marine giants like humpback and fin whales returning from their tropical wintering grounds. As ice retreats, the tundra blooms, and towering cliffs echo with millions of nesting seabirds—a truly unforgettable natural spectacle.

Highlights include:

Complimentary twice daily Zodiac and shore excursion programme

All food, snacks and alcoholic drinks with meals included

Full lineup of engaging speakers and workshops

- Venture close to 80° north, searching for polar bears on pack ice.
- Fascinating talks from evolutionary biologist and author Richard Dawkins, plus *New Scientist* contributors and expedition crew.
- A flexible itinerary allowing the captain and expedition leader to adapt plans based on prevailing conditions, maximising your opportunities for awe-inspiring wildlife encounters.
- Discover the thrill of seeing species such as walruses, seals, whales, reindeer, arctic foxes, guillemots and puffins.
- Cruise along blue glacier fronts and through stunning fjords on an intimate, purpose-built polar expedition ship.
- Enjoy tundra hikes amid stunningly beautiful scenery.

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Incredible cosmology

Powerful telescopes and computers are rapidly advancing what we know about the universe. From the nature of dark matter and dark energy to the origins of the cosmos itself, scientists are tackling big questions that challenge our understanding of reality. Join six world-leading experts as they reveal the latest research on our universe on 15 March at London's Congress Centre.

newscientist.com/events

Tour

Human origins in prehistoric England

Immerse yourself in the early human periods of the Neolithic, Bronze Age and Iron Age on this gentle walking tour in south-west England. You will study complex hillforts and ancient stone circles, including Stonehenge, Old Sarum, Avebury and Maiden Castle. This five-day tour starts on 14 July and costs £1795.

newscientist.com/tours

Podcast

Weekly

The team discuss the phenomenon of climate whiplash, where an area sees a sudden swing between wet and dry conditions, and how it may explain the recent wildfires in California. They also take a trip back to the 1960s to hear from the world's first chatbot. Plus, learn how genetic archaeology is revealing that Celtic tribes in the Iron Age revolved around women.

newscientist.com/nspod

MARK CONLIN/VWPICS/ALAMY

Adroit arms How do octopuses explore their underwater worlds?

VIC POWLES/ALAMY

Ancient England Walk to pre-eminent earthworks and stone circles

Video

Dexterous octopus

Octopuses can grasp objects with incredible precision. Researchers at the University of Chicago are mapping out the nerve cells in octopus arms to reveal the roots of this dexterity. They found that the nerves that connect muscles for movement are linked in a complex way with those in the suckers, which are akin to a hand with a tongue and a nose.

youtube.com/newscientist

Newsletter

Our Human Story

No one doubts that prehistoric people died in volcanic eruptions. But is there any evidence that volcanoes caused the extinction of entire hominin species? Michael Marshall looks at claims that link such apocalyptic eruptions to the extinctions of the Neanderthals and *Homo floresiensis*.

newscientist.com/our-human-story

Podcast

"Women had high status within Celtic societies across Europe"

Eyes wide open

A holistic approach to sleep is the antidote to obsessing about the perfect night's rest

WHEN trying to form a healthy habit, it usually helps to be conscious. So it is easy to understand why sleep-tracking devices, which claim to reveal what happened while users were out for the count, have become so popular with those in pursuit of better rest. These promise to monitor not just how long you have slept, but the depth and quality of your sleep too. They even offer insights into how peppy you should expect to feel the next day.

Most sleep scientists caution that the data recorded by these devices is unreliable, but putting aside whether or not we can trust the information they provide, focusing too hard on the numbers can leave people unduly fretting about their sleep quality. This obsessive approach to optimising rest, which has been coined orthosomnia, only tends to make things worse. In other words, data overload can keep you up at night.

There is another reason to avoid such a laser-focus on what happens while the lights are out if you are hoping for more shut eye: you are missing the bigger

"An obsessive approach to optimising sleep only tends to make things worse"

picture. Good sleep is fundamental to our long-term health, but, as we explore in our special issue that starts on page 32, good sleep isn't just made in the bedroom.

Take diet, for example. A growing body of evidence suggests that a healthy gut microbiome leads to better sleep and vice versa (see page 35), so if you want to sleep better, what you eat is important.

It would also be remiss to expect our sleep requirements to be the same every night or identical to those of others. We are increasingly learning that our needs are both individual (see page 32) and variable, due to factors like our age and fluctuations in hormones (see page 37).

So, while the way we approach the actual hours of sleep can, of course, improve it (for personal tips from the experts, see page 34), all of this suggests we can ease up on the pressure to create the perfect bedtime conditions and recognise that it isn't just our unconscious hours that define good sleep. What we do throughout our waking day can make a big difference too. ▮

PUBLISHING & COMMERCIAL
Commercial and events director Adrian Newton

Display advertising
Tel +44 (0)203 615 6456
Email displayads@newscientist.com
Sales director Claudia Nicoletti
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Agency partner Tilly Pollock

Recruitment advertising
Tel +44 (0)203 615 6458 **Email** nssales@newscientist.com
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Tel +44 (0)203 615 6554 **Email** live@newscientist.com
Sales director Jacqui McCarron
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CONTACT US
newscientist.com/contact

General & media enquiries
US 600 Fifth Avenue, 7th Floor, NY 10020
UK 9 Derry Street, London, W8 5HY
Australia 58 Gipps Street, Collingwood, Victoria 3066

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News

Space

A beautiful vision in stellar blue

NASA's James Webb Space Telescope has captured a sprinkling of stars in the Leo P dwarf galaxy, located about 5 million light years away in the constellation Leo. Their blue appearance shows that the galaxy is still forming new stars, because younger stars tend to shine bluer than ones like our sun.

NASA, ESA, CSA, KRISTEN MCQUINN (STSCI)

Physics

Cosmic jewel

A 3D shape has been created that could do away with the idea of space-time as the underlying fabric of the universe, finds **Karmela Padavic-Callaghan**

WHAT is the structure of our physical reality? Physicists have long imagined space and time interweaving into "space-time", the metaphorical fabric that underlies the cosmos. But there may be something even more fundamental. Instead of space-time's three spatial dimensions and one of time, the physics of our universe could be encoded into a set of odd geometrical shapes – and studying them may chart a new, space-time-free path towards a theory of everything.

"The idea is that space-time somehow has to go, that it has to be replaced by something more primitive and deeper," says Nima Arkani-Hamed at the Institute for Advanced Study in New Jersey. "The notion of space-time has got to emerge out of some more abstract objects."

"Space-time has to go, it has to be replaced by something more primitive and deeper"

Now, working with Carolina Figueiredo at Princeton University and Francisco Vazão at the Max Planck Institute for Physics in Germany, he has uncovered one such abstract object. They call it the cosmohedron.

The researchers have been exploring similar shapes that fit into a kind of family tree of fundamental mathematical objects. For example, shapes called associahedra encode the way particles may collide with, or scatter off, each other – without having to use equations that involve space and time. Physicists have known how to calculate so-called scattering amplitudes that predict what will happen in these collisions for decades, but even when armed with their best mathematical tricks they often end up with thousands of lines of tedious and difficult calculations, says Arkani-Hamed.

In 2013, Arkani-Hamed and his colleagues discovered one specific shape that had many slanted sides and sharp edges, similar to a cut diamond, that encoded some of those answers, but with less maths involved in getting there. Instead of thousands of lines of equations, the researchers had to tackle the somewhat simpler problem of drawing an associahedron for each collision and then calculating its volume. Figueiredo says that this method draws on the mathematical structure of physicists' usual equations, but doesn't require that laws of physics be explicitly referenced at every step.

This is because the method is more like a geometrical building project than traditional equation solving. In the simplest example, the researchers imagine a collision between three particles, leading to the creation of three new particles. It is a core tenet of physics that the momentum of the original particles has to match the momentum of those created after, and this is often expressed by writing two formulae, one for the particles before and another for after, and setting them mathematically equal.

An alternative approach sees the momentum of the particles represented as an arrow, with six arrows in total – three before and three after. In this representation, momentum being conserved means that these arrows, when joined, must connect to form a six-sided shape. Arkani-Hamed and his team go several steps further, using a set of geometrical and combinatorial rules to transform these flat shapes into jewel-like, three-dimensional objects – the associahedra.

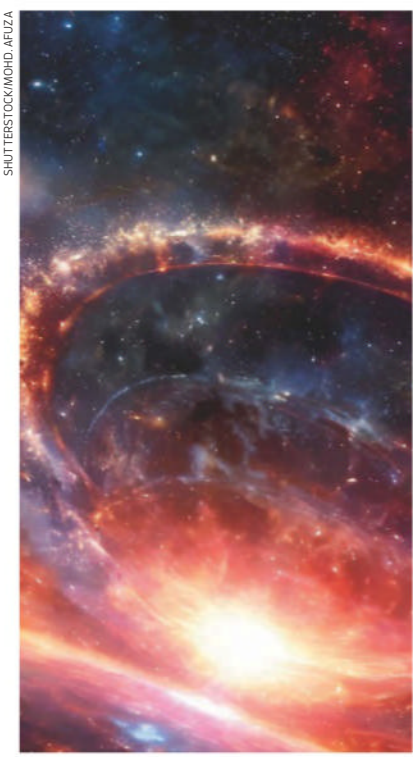
Abstract thinking

Working in this manner allows the researchers to temporarily set aside particles and their paths in space-time. The 3D associahedron shapes are far more abstract, but, remarkably, formulae that describe the volume of each such shape turn out to match the scattering amplitude formulae that we would traditionally use to predict the outcomes of a particle collision.

"You want to somehow find some objects that [ensure] your answer obeys the fundamental principles which underlie the physical theories like quantum mechanics and relativity. You don't put them in automatically, the object kind of just knows about them," says Figueiredo.

She and Arkani-Hamed, along with their colleagues, demonstrated that this method could be used for many particles, but they have now set their ambitions beyond simple collisions. Instead, they are attempting to describe the entire universe – hence the "cosmo" in cosmohedron.

The transformation from an associahedron into a cosmohedron is both surprisingly simple and incredibly powerful. It involves shaving each of the shape's edges to create new surfaces, adding extra parameters into the formulae that correspond to associahedra and endowing them with more meaning. Specifically, by turning a given associahedron into a cosmohedron and then



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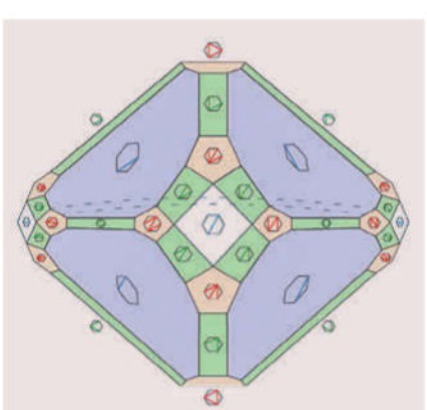


N. ARKANI-HAMED, C. FIGUEIREDO, F. VAZÃO (2024)

A cosmohedron for a universe, where three particles interact with each other. Each edge and vertex is derived from simpler geometrical shapes, shown as labels, following a set of complex mathematical rules

studying the more complex shape, the researchers could reconstruct a quantum mechanical wave function – the formula that summarises all properties and possible behaviours of a quantum object.

"[Their] cosmological wave function attempts to describe the whole universe, in this case a theoretical one, all at once," says Sebastian Mizera, also at Princeton, who wasn't involved in the work.

Surprising results

Jaroslav Trnka at the University of California, Davis, says that the fact the method works at all is extremely surprising because it starts with such different concepts to those physicists usually employ. "You don't put in physical properties like locality or even

Is there something more fundamental than space-time?

some particles or fields," he says.

It is too early to say that the idea of space-time is completely obsolete, or that space-time isn't meaningful, but the new work does point to the possibility of expressing the laws of physics in a completely different language

"We feel that something remarkable is going on, and this is really the first step"

that doesn't refer to it, says Trnka. In other words, this could rewrite the way we understand the cosmos and take space-time out of the dictionary.

Exactly what this could mean for our particular universe also remains unclear because the cosmohedron method doesn't currently work for every particle that we know exists. For instance, the researchers aren't certain how to use their method for any particles with an electric charge, such as electrons, because electromagnetic interactions make the mathematics of their collisions more complex. Trnka says the team's task now is to find more examples where it does work.

"At the moment, we're reformulating things. In the distance there is a world of physical theories, and there are these fascinating mathematical structures over here, and what we're seeing is that there are these subterranean links between some of them," says Arkani-Hamed.

"There's a lot that we'd like to understand better. We feel that something remarkable is going on, and this is really the first step," he says. ▮

Technology

People with paralysis feel objects again thanks to robot arm

Carissa Wong

TWO people with paralysis of their hands were able to temporarily regain their sense of touch and feel the shape of objects after receiving electrical brain stimulation.

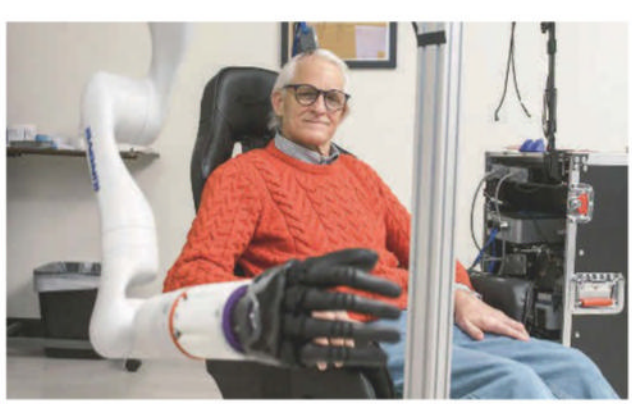
There have been previous efforts to restore touch through brain stimulation, but they were fairly crude. "These were very basic sensations of contact and no contact," says Giacomo Valle at the Chalmers University of Technology in Gothenburg, Sweden. "But when you touch a surface, you feel the texture, the edges, the curvature. You feel the motion of your hand relative to the surface."

To evoke richer sensations, Valle and his colleagues worked with two people with spinal cord injuries that had led to partial paralysis, including the loss of most of their ability to move and feel with their hands. The researchers asked the pair to imagine wiggling their fingers and feeling sensations in them while scanning their brains with an MRI machine. Guided by which areas of their brains lit up during these exercises, the team then implanted dozens of tiny electrodes into corresponding regions.

By using the implants to zap brain cells linked to hand movements and sensations, the researchers identified signals that made the participants feel like they were holding a can, pen or ball. They also identified signals that mimicked the motion of objects across their fingers. "It blew me away," says Scott Imbrie, one of the participants. He hadn't felt objects so clearly for decades, he says.

To see if the approach could help with everyday tasks, the researchers attached Imbrie's electrodes to a robotic arm that held onto a steering wheel and got him to watch a virtual car travelling along a straight road. They transmitted electrical signals into his brain to mimic sudden movements of the wheel against his hand to the left or right, then asked Imbrie to keep the car on track by counteracting these with his mind, sending his brain signals to the robotic arm.

Imbrie kept the car on track 80 per cent of the time (*Science*, doi.org/g8z7tq). He says it felt like the arm was an extension of himself. "It was like, 'oh my god, this arm is part of me'." The team plans to carry out the same task with the second participant. ▮



Scott Imbrie tested the mind-controlled robotic arm

CHARLES M. GREENSPON/UNIVERSITY OF CHICAGO

Analysis Space exploration

Blue Origin vs SpaceX: Who is winning the battle of the rockets?

Jeff Bezos's company saw a launch success with New Glenn, but Elon Musk's Starship exploded. What does this mean for the future of the space industry, asks **Alex Wilkins**

COMPARE these two scenes: on 16 January, Blue Origin's New Glenn rocket triumphantly reached orbit for the first time, while SpaceX's Starship burst into flames above the Atlantic Ocean. You might think that the established space company, Elon Musk's SpaceX, has suffered a setback, while Jeff Bezos's Blue Origin is in the ascendancy. The reality is more complicated, but it is true that SpaceX's dominance may be under threat.

New Glenn's launch comes after decades in development, with numerous delays and setbacks. The rocket can carry roughly double the mass of SpaceX's smaller Falcon 9 rocket, which has been the go-to vehicle for governments and companies looking to launch their satellites into Earth orbit, and can also beat the capabilities of Falcon Heavy, SpaceX's current top rocket in commercial operation.

With a successful flight under its belt, Blue Origin is now one step closer to launching payloads commercially. "Falcon is the workhorse of the world, and New Glenn opens up another opportunity," says Laura Forcyzk, an independent consultant in the space industry.

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Number of successful launches by SpaceX in 2024

That could expand the number of customers able to reach space, and lower prices. "There is currently too much demand for Falcon to support," says Forcyzk. "One of the reasons why SpaceX has been as profitable as it has been is because it can set its own prices."

But having a rocket that works isn't enough – it must also launch frequently enough to attract customers. SpaceX currently has a huge incumbent advantage, having flown more than 400 times in the past decade, says Matt Archer at the UK Space Agency.

SWNS

Above: Debris from Starship rains down after the craft exploded above the Atlantic Ocean

Below: New Glenn blasts off into orbit

JOE MARINO/UPI/SHUTTERSTOCK

Blue Origin is reportedly aiming to complete six to eight launches this year, which is still far below the 133 launches SpaceX completed in 2024. Whether it will catch up to SpaceX depends on the internal motivations of the company, says Forcyzk. "One of the criticisms of Blue Origin is that, under the previous CEO, they were operating more like an R&D company," she says, rather than one focused on commercial services and competing for market share with SpaceX.

In 2023, Blue Origin installed a new CEO, Dave Limp, who previously worked at another of Jeff Bezos's companies, Amazon. This suggests there could be a change in internal motivation and company culture that would make Blue Origin pursue more ambitious goals, but this change "remains to be seen", says Forcyzk.

And all of this ignores another key factor: Starship is SpaceX's next-generation rocket. The company is still iterating on its design and expects that some flights will end in "rapid unscheduled disassembly", as Musk euphemistically refers to explosions. If SpaceX can successfully demonstrate the rocket's reliability, it will secure future work from organisations like NASA, which needs Starship to land astronauts on the moon as part of its Artemis programme.

Failing fast?

But that is a big if, and SpaceX's "fail fast" approach, which paid off in developing its Falcon rockets, may not work so well for Starship, says Hugh Lewis at the University of Southampton, UK.

"Starship as a whole is just more complex than Falcon, in lots of different ways. They're returning essentially the second stage [of the rocket], that makes it very hard. So that complexity, I don't think works with the fail fast and iterate approach," says Lewis.

Signs of Blue Origin pulling ahead may be just a few months away. Like SpaceX, the company has been tasked by NASA with landing on the moon, initially with uncrewed spacecraft ahead of a potential 2030 crewed mission. A prototype version of its Blue Moon lunar lander is due to take off on a New Glenn rocket in March, while the launch of a NASA probe to Mars is also on the schedule this year – suggesting strong confidence in the brand new rocket.

"New Glenn demonstrating the ability to launch to lunar space, and to the lunar surface, would open up direct competition with Starship," says Forcyzk.

Climate change

2024 sees biggest ever jump in key global CO_2 tracker

Michael Le Page

THE level of carbon dioxide in the atmosphere measured at the Mauna Loa Observatory in Hawaii increased by 3.58 parts per million in 2024 – the biggest jump since records began there in 1958.

"We're still going in the wrong direction," says climate scientist Richard Betts at the Met Office, the UK's weather service.

The record increase is partly due to CO_2 emissions from human actions like fossil fuel burning hitting a record high in 2024.

Betts is forecasting that atmospheric CO_2 levels as measured at Mauna Loa will this year rise by 2.26 parts per million (ppm), with a margin of error of 0.56 ppm either way. That is a lot less than the 2024 record, but it will take us above the last possible pathway for limiting the increase in global surface temperatures to 1.5°C above preindustrial levels.

"You could regard it as another nail in the coffin of 1.5°C," says Betts. "That's now vanishingly unlikely."

Mauna Loa is often used to represent global change in CO_2 concentrations, says Richard Engelen at the European Union's Copernicus Atmosphere Monitoring Service (CAMS), but it is important to note that it is only a local measure. Satellite observations can now measure the average global level of atmospheric CO_2 directly, and according to CAMS, this rose by 2.9 ppm in 2024. That isn't a record, but it is one of the biggest increases since satellite observations began.

The increase in CO_2 at Mauna Loa is higher than the average global level due to the large number of wildfires in the northern hemisphere in 2024, says Betts. It takes time for plumes of CO_2 from sources such as wildfires to mix evenly into the atmosphere around the world. "The fire emissions in the northern hemisphere were particularly large last year," he says. ▮

Archaeology

DNA points to women's high status in pre-Roman Britain

James Urquhart

GENETIC analysis of people buried in a 2000-year-old cemetery in southern England has bolstered the idea that Celtic communities in Britain placed women centre-stage, showing that they remained in their ancestral homes while men moved in from elsewhere – a practice that lasted centuries.

The work supports growing archaeological evidence that women had high status within Celtic societies across Europe and gives credence to Roman written accounts that were often thought to be exaggerated for Mediterranean audiences when they described Celtic women as empowered.

Since 2009, human remains of the Durotriges tribe have been unearthed during excavations of an Iron Age burial site at Winterborne Kingston in Dorset, UK. The Durotriges occupied the central southern English coast from around 100 BC to AD 100 and probably spoke a Celtic language.

Human remains from Iron Age Britain are rare because prevailing funerary customs, including cremation, destroyed them. However, the Durotriges buried their dead in cemeteries in the chalk landscape, which aided their preservation.

"My jaw dropped – we had never seen husbands moving to live with wives in prehistoric Europe"

Archaeologists have found that Durotrigan women were more often buried with valuable items, suggesting high status.

Lara Cassidy at Trinity College Dublin and her colleagues have now analysed the genomes of 55 Durotrigan individuals from Winterborne Kingston to untangle how they were related.

Cassidy says there were two big "aha moments". Both were related to mitochondrial DNA – small loops of DNA that we inherit only through the maternal line, since they are passed down via the egg cell and don't integrate with other DNA.

BOURNEMOUTH UNIVERSITY

A Durotrigan burial site at Winterborne Kingston in Dorset, UK

As the mitochondrial DNA results for each individual came in, the team noticed the same genetic sequence appearing again and again. It became apparent that more than two-thirds of the individuals were descended from a single maternal lineage, originating from a common female ancestor who lived a few centuries earlier.

"My jaw dropped at that moment," says Cassidy. "This was a clear signature of matrilocality, or husbands moving to live with their wives' families – a pattern we'd never seen before in prehistoric Europe." Patrilocality, in which a woman moves to her male partner's community, is usually the norm.

To find out if the matrilocal pattern was distinct to the Durotriges, Cassidy began trawling through data from an earlier large genetic survey of Iron Age Britain and Europe. Her jaw dropped again. She noticed cemeteries across Britain where most individuals were maternal descendants of a small set of female ancestors (*Nature*, doi.org/g8zvk3).

It adds to the growing pile of evidence that Iron Age women were relatively empowered, says Cassidy. "Matrilocality typically co-occurs with cultural practices that benefit women and keeps them embedded in their family support networks," she says.

"This is very exciting new research and is revolutionising how we understand prehistoric society," says Rachel Pope at the University of Liverpool, UK, who has previously found evidence of female-focused kinship in Iron Age Europe. "What we are learning is that the nature of society in Europe before the Romans was really very different." ▮

Analysis Microbiome

What makes a healthy gut microbiome? There is huge potential for harnessing our gut microbes to help us treat health conditions – but first, we need to understand them, says David Robson

ANALYSING one's stools was once a niche interest. A quick look at Amazon, however, reveals dozens of home tests designed to detect the composition of your faeces. You can even buy kits for your pets.

Such products reflect a surge in public appetite for information about the gut microbiome. "Regardless of the country you are in, a lot of patients are coming to physicians asking about microbiota testing," says Gianluca Ianiro at the Catholic University of Rome.

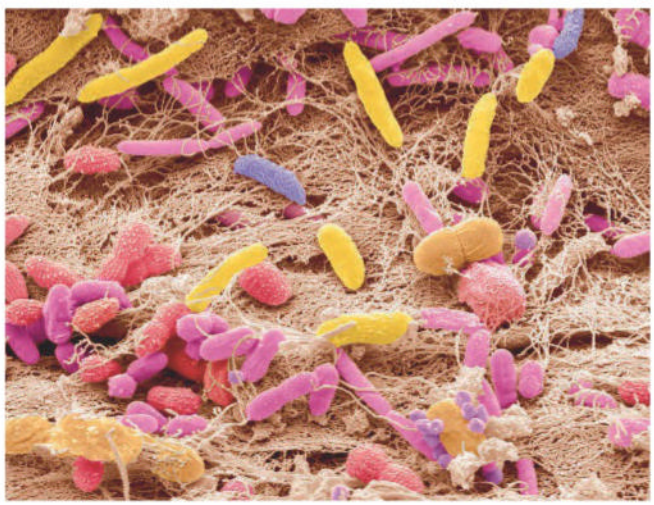
Whether these kits actually tell us anything useful is a matter of debate, given the challenges in defining what comprises an optimum microbiome – and how to achieve it.

Simply proving causality – that a particular community of organisms is directly implicated in a medical condition – has been a huge barrier. "We have some evidence from animal models and some evidence from intervention trials, but there are not many," says Nicola Segata at the University of Trento in Italy.

Even more challenging is the huge variation between people. "The gut microbiome is extremely personal to each of us," says Segata. "If we compare my microbiome and your gut microbiome, on average, we will have 30 to 40 per cent of species in common, and the strains of those species can be extremely different." The behaviour of each microbe also depends on its neighbours, your age and your diet. "None of the bacteria work in isolation," says Segata.

For these reasons, it doesn't make sense to talk about a single "healthy microbiome", he says. There are many configurations that may each be associated with a higher or lower risk of certain conditions at different stages of life.

But some general patterns are becoming evident. One recent study that used data collected by the nutrition company ZOE found that vegans have higher levels of bacteria in the family Lachnospiraceae and the genus *Butyricicoccus*, as well as the species *Roseburia hominis*, which all produce short-chain fatty acids like butyrate (*Nature*, doi.org/g8xtnx). "These are very beneficial for us – they lower inflammation, keeping our immune system in a good shape, and [maintain] homeostasis of the gut barrier," says Segata, who was one of the study's authors and is a consultant for ZOE.



STEVE GSCHMEISSNER/SCIENCE PHOTO LIBRARY

Gut bacteria, here artificially coloured, leave the body via faeces

Diagnostic tests can already pick up on some of these differences.

"The gut microbiome is extremely personal to each of us. There is huge variation"

"We don't have a fixed microbial health signature, but we have increasing data [showing] which are the keystones of health, such as the presence or absence of specific clusters [of bacteria]," says Ianiro.

But the reliability of these tests can vary. In a recent paper outlining the "expert consensus" on such tests, Ianiro and his colleagues argue that we need better guidelines to ensure they do what they claim (*The Lancet Gastroenterology & Hepatology*, doi.org/n25c).

The team is particularly wary of direct-to-consumer products, which are poorly regulated. "In our consensus, we said that the testing should be prescribed by a clinician," says Ianiro.

Enriqueta García-Gutiérrez at the Polytechnic University of Cartagena in Spain also thinks caution is needed before we invest in at-home gut microbiome tests, as they often don't provide enough context to help consumers understand their results. "I have seen some of those reports, and they are just so high level – it's not informative at all," she says.

Despite all these concerns, the future could hold great potential. Ashley Sidebottom at the Duchossois Family Institute at the University of Chicago has been working on a rapid test that measures metabolites produced by gut bacteria. These act as markers of overall microbiome function, rather than indicating the presence of individual species. Eventually, she hopes that measurements of the gut microbiome will be as routine as blood tests. ▮

Technology

Tiny insect-like robot can flip, loop and hover

Alex Wilkins

AN INSECT-inspired robot that only weighs as much as a raisin can perform acrobatics and fly for much longer than any previous miniature drone without falling apart.

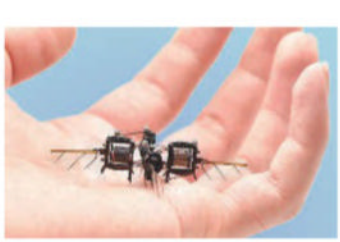
For tiny flying robots to make nimble manoeuvres, they need to be lightweight and agile, but also capable of withstanding large forces. Such forces mean that most tiny robots can only fly for around 20 seconds before breaking, which makes it difficult to collect enough data to properly calibrate and test the robots' flying abilities.

Now, Suhan Kim at the Massachusetts Institute of Technology and his colleagues have developed an insect-like flying robot about the size of a postage stamp that can execute manoeuvres such as double flips or tracing an infinity sign, and also hover in the air for up to 15 minutes without failing (*Science Robotics*, doi.org/g8zwr2).

"If you only have 20 seconds to fly the robot before it dies, then there's not so much we can tune when we control the robot," says Kim. "By having a hugely increased lifetime, we were able to work on the controller parts so that the robot can achieve precise trajectory tracking, plus aggressive manoeuvres like somersaults."

However, the robot is currently unable to fly untethered, as the team has yet to successfully miniaturise a power source and control electronics. ▮

The robot is small enough to fit in the palm of your hand, but can fly for 15 minutes



KEVIN CHEN

Solar system

Mars may have a solid inner core just like Earth

James Dinneen

A SOLID core may by hiding at the very centre of Mars, according to a new analysis of the planet's seismic activity. This could help solve several enigmas about Martian geology – but not everyone is convinced.

"It's big if true," says Simon Stähler at ETH Zurich in Switzerland, who wasn't involved with the research. "The seismological evidence for it is rather thin."

A few years ago, NASA's InSight lander gave researchers their first direct look into the interior of Mars: between 2018 and 2022, an on-board seismometer recorded the waves produced by hundreds of marsquakes reverberating within the planet. This enabled Stähler and his colleagues to identify the edge of a large, liquid core.

Now, Daoyuan Sun at the University of Science and Technology of China and his colleagues have also analysed the InSight data. They searched for waves that may have passed through the Martian core and then "stacked" them to amplify and identify any faint signals reflected from the planet's depths.

The researchers identified two key wave phases. One passed through the centre of Mars and back, arriving at the seismometer more rapidly than it would have if the entire core was liquid. The second appeared to bounce off a boundary between a liquid outer core and a solid inner core.

Both of these wave phases suggest Mars has a solid inner core with a radius of around 600 kilometres. "We looked at it twice," says Sun. That would mean the solid centre of the core is just under a fifth of the radius of Mars itself, which is a size ratio similar to that of Earth and its solid inner core (*Research Square*, doi.org/n25x).

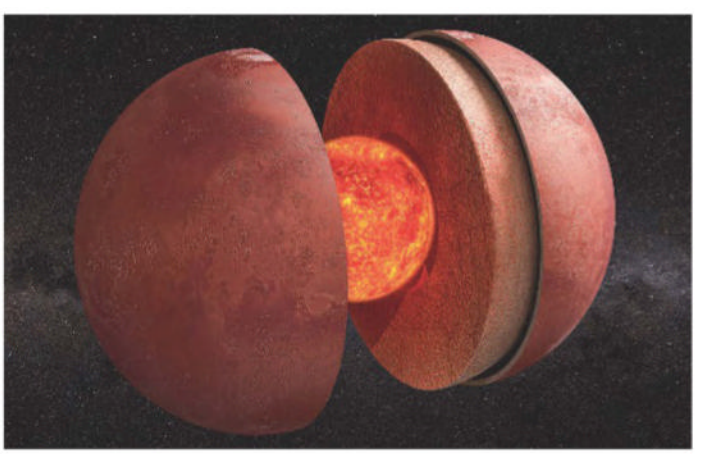
"I think they have a nice preliminary seismic result that will create some controversy," says Nicholas Schmerr at the University of Maryland. "The past seismic work on the core suggests that the core was liquid but could not definitively rule out a small, solid inner core. It's not impossible."

Stähler says he and other researchers have scrutinised all the InSight data and haven't found similar signals. He also says that processing the data from seismometers in different ways can produce different results – and interpreting the data correctly can involve a bit of "black magic".

Still, Stähler was open to the possibility of an inner core. "It's a fresh group, with a fresh view on the data," he says. "Maybe they saw things we did not see."

The presence of a solid inner core could help solve outstanding questions about the Red Planet. For instance, given Mars's known mass, a large, entirely liquid core can only be explained if the planet was formed from more light elements than Earth was. A dense inner core solves that problem, says Stähler. "It means Mars more or less formed from the same materials as Earth." ▮

The inside of Mars is hard to probe, even with seismic data



SHUTTERSTOCK/ALEXLMX

Materials

Magnetic mystery material could improve electronics

ULTRA-THIN flakes of bismuth display unusual magnetic properties – which could help the soft, iridescent metal become a wonder substance for making greener electronics.

"Frankly, I'm still waking up at night because I wonder: what is at play here?" says Guillaume Gervais at McGill University in Montreal, Canada.

Researchers have suspected that very thin flakes of bismuth could have unusual physical properties, similar to other ultra-thin materials like carbon-based graphene. But because bismuth is so soft, it is difficult to make it thin enough for these peculiar properties to emerge.

Now, Gervais and his colleagues have developed a new technique to do this, which he likens to using a cheese grater. This enabled the researchers to make flakes of bismuth only 68 nanometres thick, less than a thousandth of the thickness of a piece of paper. They then exposed their flakes to a range of temperatures, from near absolute zero to room temperature, and to magnetic fields tens of thousands of times stronger than fridge magnets.

Whatever the conditions, the bismuth always exhibited one particular electromagnetic behaviour. Namely, when the researchers connected wires to it, a type of electrical current called the anomalous Hall effect always flowed (*Physical Review Letters*, in press).

"Frankly, I'm still waking up at night because I wonder: what is at play here?"

Carmine Ortix at the University of Salerno in Italy says that the new experiment features a fundamental measurement with a "very, very surprising" result, because the known properties of bismuth suggest that it shouldn't have an anomalous Hall effect.

Because the effect happens even at room temperature, ultra-thin bismuth may be useful for developing electronics, says Ortix. The metal is also less toxic than similar materials, he says. ▮

Karmela Padavic-Callaghan

Transport

Zero-carbon shipping fuel could be a new source of pollution

James Dinneen

SWITCHING from burning fossil fuels to burning ammonia is a promising way for the shipping industry to cut its carbon dioxide emissions. But if we aren't careful, this swap could also boost harmful nitrogen pollution.

"That's a major alarm bell ringing," says Xin Zhang at the University of Maryland Center for Environmental Science.

The tens of thousands of ships on the oceans are responsible for about 3 per cent of global CO_2 emissions, burning more than 300 million tonnes of fossil fuels each year. A climate-friendly alternative is "green ammonia", a zero-carbon fuel made from hydrogen and nitrogen using clean electricity, which could be produced at larger volumes than other low-emission fuels.

There aren't yet any ammonia-powered ships at sea, but several are being constructed. Under an aggressive decarbonisation scenario, the International Energy Agency projects that ammonia could make up 44 per cent of all shipping fuel by 2050.

There is a potential hitch, though. While use of green ammonia would mean less CO_2 released, it could boost nitrogen pollution. In the atmosphere, reactive forms of nitrogen can cause air pollution and ozone depletion; in the water, they can spur the growth of harmful algal blooms.

Nitrous oxide can also form, a potent greenhouse gas that might offset the climate benefits of switching to the zero-carbon fuel.

Zhang and her colleagues estimated that making enough ammonia to supply 44 per cent of shipping demand would require increasing industrial production of nitrogen compounds by more than 200 million tonnes per year. That increase is greater than the total amount of nitrogen pollution currently resulting annually from human activities, mainly agriculture (*Nature Reviews Earth & Environment*, doi.org/n2wt).

Much of the nitrogen in the green ammonia would return to the atmosphere in an inert form when the fuel is burned. But if only a tiny fraction of the ammonia leaked out or failed to combust, the researchers found it could still boost nitrogen pollution by several per cent.

SVEN HANSCHE/SHUTTERSTOCK

The shipping industry needs to cut its carbon emissions

3%
of global CO_2 emissions are from shipping

44%
of shipping fuel could be made from ammonia by 2050

At the moment, such pollution estimates are uncertain because there are no existing full-scale ammonia engines to test, says Matteo Bertagni at the Polytechnic University of Turin in Italy.

"The biggest question mark is about burning ammonia," he says. "How clean is ammonia combustion?"

To reduce such problems, ships could install ammonia scrubbers that remove any unburned fuel or use engines designed to minimise nitrogen pollution – but such measures aren't requirements, says Anthony Wong at the Massachusetts Institute of Technology.

"If we don't have any specific ammonia legislation, using ammonia as shipping fuel would be only slightly cleaner than fossil fuels, from an air pollution standpoint," he says. ▮

Technology

Humanoid robot learns to waltz by mirroring people

Alex Wilkins

AN ARTIFICIAL intelligence that helps humanoid robots replicate a person's movement could allow robots to walk and dance in more human ways.

The most agile and fluid robotic movements are typically narrow, pre-programmed sequences. Teaching robots to perform a wider repertoire of convincingly human movements is still difficult.

To overcome this hurdle, Xuanbin Peng at the University of California, San Diego, and his colleagues have developed an artificial intelligence system called ExBody2, which lets robots copy and smoothly perform many different human movements in more lifelike ways.

Peng and his team first created a database of actions that a humanoid robot might be capable of performing, from standing to tricky dance moves. This included motion-capture recordings of people collected in previous projects.

"Since humanoid robots share a similar physical structure with us, it makes sense to take advantage of the vast amounts of human motion data already available," says Peng. "By learning to mimic this kind of motion, the robot can quickly pick up a wide variety of human-like behaviours."

Peng and his team next trained ExBody2 using reinforcement learning, giving the AI an example of a successful movement and then tasking it with figuring out how to do it itself by trial and error.

ExBody2 was then put in control of two different humanoid robots. It was able to smoothly string together simple movements, such as walking and crouching, as well as perform trickier moves, such as waltzing with a human (arXiv, doi.org/n24g).

"Humanoid robots work best when they coordinate all their limbs and joints together," says Peng. "Full-body coordination greatly expands the robot's range of capabilities." ▮

Archaeology

Ancient plea for the sun to return

Hundreds of stones carved with images of the sun were buried during a possible volcanic winter

Chris Simms

HUNDREDS of mysterious engraved "sun stones" unearthed in Denmark may have been ceremonially buried because a volcanic eruption in about 2900 BC made the sun disappear.

A total of 614 stone plaques and fragments of plaques engraved with decorative motifs of the sun or plants have been unearthed in recent years at the Vasagård West archaeological site on the Danish island of Bornholm. They were found in a layer that dates to some 4900 years ago, when Neolithic people were farming the area and building enclosures encircled by earthworks of banks and ditches.

Most of the carved sun stones were found in the ditches around these enclosures and they had been covered by a stone pavement containing bits of pottery and other items. The pottery is typical of the late Funnel Beaker culture, which was present in this region until about 2900 to 2800 BC.

It was originally proposed that the carvings were buried to ensure good harvests. The sun was the focal point for early agricultural cultures in northern Europe, says Rune Iversen at the University of Copenhagen in Denmark.

"But why have they deposited all these images at the same time?" asks Iversen. "The last thing that they basically did here was depositing these sun stones and then covering them with pieces of animal bone, all the artefacts and stuff like that. And we see that reoccurring from ditch to ditch. So, it is kind of an act or an event."

Now, he and his colleagues have an answer. They looked at data from ice cores extracted in Greenland and Antarctica and found higher concentrations of sulphate, which is deposited in the years after a volcanic eruption, in the period around 2900 BC.

The relative ratio of sulphate deposition in Greenland and Antarctica implies the eruption was close to the equator, say the researchers, and its effects seem to have covered a huge area. Ash clouds may have blocked out the sun, lowering temperatures for years (*Antiquity*, doi.org/g8z6q2).

A period of severe cooling around 2900 BC is corroborated by sources including tree rings in preserved wood from the Main river valley in Germany and those of long-lived bristlecone pines in the western US.

The eruption would have been devastating for the Neolithic peoples of northern Europe. "If you don't have the harvest and you don't get the crops in, you won't have anything to sow next year," says Iversen. "They must have felt pretty punished at that time because it's just an endless catastrophe coming at them."

He and his colleagues say that burying the carvings could have been an attempt to get the sun back or a celebration after the skies did finally clear.

"It's a good explanation," says Jens Winther Johannsen at Roskilde Museum in Denmark. "You can be sure die-hard farming societies have to trust in the sun." ▮

The buried carvings included motifs of the sun (left) and plants (right)

ANTIQUITY PUBLICATIONS/JOHN LEE, NATIONAL MUSEUM OF DENMARK

Physics

How to measure vast distances to the nanometre

A NEW way to gauge distance using lasers can measure lengths of more than 100 kilometres to within a thousandth of the width of a human hair.

In lab settings, scientists can use lasers to measure distances with extreme precision, to within a few nanometres. But for longer distances of a kilometre or more, the precision of these techniques tends to be much lower, to within around a millimetre.

Jian-Wei Pan at the University of Science and Technology of China and his colleagues have developed a method that could measure a distance of 113 kilometres between two laboratories in Xinjiang with nanometre precision.

The technique involves a kind of laser called an optical frequency comb, which contains many frequencies of light, regularly spaced across the spectrum. They act like a kind of ruler that you can compare other light beams against.

Pan and his team fired a pair of these lasers from one lab to the other, then used a third laser to interfere with the combs. When light waves interfere with each other, they create a pattern of brighter and darker sections. Measuring these patterns can reveal how much the frequencies in the comb's light have changed from when it was first produced, which can be used to calculate the distance the lasers have travelled.

The final precision of the measurement depends on how long the interference pattern is measured for. In around a millisecond, the researchers could achieve a precision of around a hundredth of a millimetre. Over 20 seconds, they reached a precision of 82 nanometres (arXiv, doi.org/n22j).

"The technique measured a distance of 113 kilometres between two labs with nanometre precision"

"Looking at the precision that they get, it is impressive," says Derryck Reid at Heriot-Watt University in Edinburgh, UK. "It's very comparable to some of the best precisions over much shorter ranges."

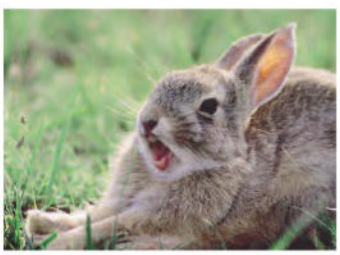
However, a tool like this one could be very precise – giving the same measurement of a distance repeatedly – without necessarily being accurate, says Reid. ▮

Alex Wilkins

Zoology

Rabbits may eat their own teeth to boost calcium levels

Sarah Philip



The teeth of rabbits are worn down as they chew their high-fibre food

JIM BRANDENBURG/MINDEN PICTURES/ALAMY

RABBITS may be swallowing fragments of their own teeth as they grind their food, in a strange form of dental recycling.

A high-fibre diet means rabbits grind their teeth when chewing, which quickly wears them down. Their teeth grow continuously to compensate, but this requires calcium, so for years, researchers believed rabbits needed to consume a high-calcium diet.

Now, Jean-Michel Hatt at the University of Zurich in Switzerland and his team have found that rabbits may swallow a finely ground powder shed from their teeth as they chew, allowing them to reabsorb calcium from their teeth into their bodies.

"We're the first to show that rabbits are able to digest calcium from dental material," says Hatt.

The team fed eight European rabbits either a typical calcium carbonate supplement or ground-up teeth from other rabbits for 11 days. The two groups then switched diets for the same amount of time.

The researchers found that when fed ground-up teeth, the rabbits digested 33 per cent of the calcium they consumed, compared with 20 per cent of the calcium from the supplement (*The Veterinary Journal*, doi.org/n22d).

"It's an interesting puzzle piece about a great invention of nature," says Hatt. ▮

Space

Astronomers baffled by bizarre 'zombie star' that shouldn't exist

James Woodford

A COLLAPSED star around 13,000 light years away is so unusual that the researchers who have discovered it say it shouldn't exist.

It was first detected in January 2024 by the ASKAP radio telescope in Western Australia and is likely to be a kind of pulsar that has never been seen before.

When supermassive stars reach the end of their lives and explode in a supernova, the remnants form a super-dense object called a neutron star. Pulsars are neutron stars that spin rapidly, emitting radio waves from their magnetic poles as they rotate. Most pulsars spin at speeds of more than one revolution per second and we receive a pulse at the same frequency, each time a radio beam points towards us.

In recent years, however, astronomers have begun to find compact objects that emit pulses of radio waves at a much slower rate. This has baffled scientists, who had thought that radio wave flashes should cease when the rotation slows to more than a minute for each spin.

These slow-spinning objects are known as long-period radio transients. Last year, a team led by Manisha Caleb at the University of Sydney, Australia, announced the discovery of a transient that takes 54 minutes per rotation.

Now, Caleb and her colleagues say that a new object they found a year ago, which is named

"They're like zombie stars – you don't expect them to be alive, but they still are"

ASKAP J1839-0756, is spinning at a new record slow pace of 6.45 hours per rotation (*Nature Astronomy*, doi.org/g8zv6b).

It is also the first transient that has ever been discovered with an interpulse: a weaker pulse halfway between the main pulses, coming from the opposite magnetic pole.

At first, the team thought that ASKAP J1839-0756 might be a white dwarf, a smaller star, like our sun, that has died. "But we've never seen an isolated white dwarf emitting radio pulses and our calculation suggests that it is too big to be an isolated white dwarf based on the properties of the pulse," says Joshua Lee, a team member at the University of Sydney.

Next, the team thought it might be a magnetar, a type of neutron star with an immense magnetic field – as much as 10 trillion times more powerful than the strongest MRI machines on Earth.

A magnetar with a similar rotation period of 6.67 hours has been found before, but, so far, it has only emitted X-rays, not radio waves.

Caleb says that if the star is an isolated magnetar, it would be the first that emits in the radio wave frequency with a period that is this slow.

"This new object is completely rewriting what we thought we knew about radio-emission mechanisms from neutron stars of the last 60 years," says Caleb.

"It is definitely one of the weirdest objects in recent times, because we didn't think these things existed," she says. "But now we're finding them. If it is a magnetar, it is certainly unique amongst the neutron star population."

She says the idea that pulsars cease emitting radio waves when they spin too slowly needs to be reconsidered.

"We're seeing objects in recent years which seem to cross this death line, but they're still emitting in the radio [frequency]," says Caleb. "So they're like zombie stars where you don't expect them to be alive, but they're still alive, and they're pulsing away." ▮

ASKAP J1839-0756 is the slowest pulsar found so far

JAMES JOSEPHIDES

Marine biology

The isopod strikes back

This giant marine crustacean is said to resemble Darth Vader

A LARGE crustacean that lives in the sea off Vietnam has been designated as a new species and named after the *Star Wars* character Darth Vader.

***Bathynomus vaderi* is a kind of isopod, a group that also includes woodlice. It can reach lengths of over 30 centimetres and weights in excess of a kilogram.**

So far, the new species has only been found by fishers trawling near the Spratly Islands in the South China Sea. Peter Ng at the National University of Singapore says he and his colleagues chose the species' name because of its resemblance to Vader's mask, but also because the creature is thought to live at depths of 800 to 1200 metres, where there is constant darkness (*ZooKeys*, doi.org/g8zrj5).

The isopod has become a popular seafood delicacy in Vietnamese restaurants since 2017, and is said to be as tasty as lobster. ▮ **JW**

NGUYEN THANH SON

Climate change

Melting ice reveals millennia-old forest

AN ANCIENT woodland has been revealed following ice melt in the Rocky mountains. More than 30 whiteback pines were found around 3100 metres above sea level – 180 metres higher than the present tree line.

This "offers us a window into past conditions at high elevations", says Cathy Whitlock at Montana State University.

Whiteback pines (*Pinus albicaulis*) don't grow at this elevation today, so these ones had to grow at a time when the climate was warmer, she says.

To understand the history of the lost forest on the Beartooth plateau in Wyoming, Whitlock's team analysed the trees' rings and used carbon dating to age them. They found that the trees lived 5950 to 5440 years ago, a period of steadily decreasing temperatures (*PNAS*, doi.org/n2z7).

Ice core data from places like Antarctica and Greenland suggest that these falling temperatures were influenced by centuries-long volcanic eruptions in the northern hemisphere. These produced enough aerial sediment to block sunlight and lower global temperatures until the environment was too cold for these higher-elevation trees to survive.

While lying flat, the trees are in exceptional condition, indicating that they were rapidly preserved after death. Although they lack evidence of being covered by avalanches, they show marks that align with the expansion of the present ice patch.

Climate models suggest that additional sustained volcanic eruptions in Iceland produced further drops in temperature 5100 years ago, says team member Joe McConnell at the Desert Research Institute in Nevada. This further expanded the ice patch and ensured "the fallen trees were entombed in ice and protected from the elements for the next 5000 years", he says.

"The fallen trees were entombed in ice and protected for the next 5000 years"

Only in the past few decades have temperatures risen enough to release the trees from their icy crypt. The current tree line is "likely to shift upslope with increasing temperatures in the coming decades", says Whitlock.

"This discovery was possible because of anthropogenic climate change – rising temperatures are now exposing areas that have been buried by ice for millennia," she says. "While such discoveries are scientifically interesting, they are also a sad reminder of how fragile alpine ecosystems are to climate change." ▮

Taylor Mitchell Brown

Space

Black hole has a mysterious beat

Strange pulses may be explained by a white dwarf star on the verge of destruction

Alex Wilkins

UNUSUAL vibrations emanating from a supermassive black hole seem to be growing more frequent and they could be caused by a white dwarf star orbiting perilously close to its event horizon.

In 2018, a supermassive black hole called 1ES 1927+654 took astronomers by surprise by changing from being relatively inactive to becoming extremely bright. It was the first time such a black hole had been observed changing in this way.

The black hole began to dim after this, but now, Megan Masterson at the Massachusetts Institute of Technology and her colleagues have discovered that it seems to be sending out X-ray radiation in a regular rhythm.

They first measured these oscillations in 2022, finding that the brightness of the X-rays fluctuated by 10 per cent roughly every 18 minutes. By 2024, this had decreased to every 7.1 minutes (arXiv, doi.org/g8zmw2).

"It was exciting in and of itself just to find these oscillations, because it's only one of a handful [of supermassive black holes that do this]," says Masterson. "But I think the most exciting thing to us was that the oscillation period – how fast these oscillations were happening – was changing on human-observable timescales, which is not usually what we see around supermassive black holes."

"Everyone really wants to see a white dwarf get eaten by a supermassive black hole"

This changing oscillation period implies that interesting physics is happening near the black hole's event horizon, the boundary at which its gravitational pull is so strong that even light can't escape.

One thing that could explain the oscillation is a white dwarf star that is occasionally having its matter siphoned off by the black hole. According to her team's calculations, Masterson says this white dwarf would be millions of miles away from the black hole, but given that the black hole itself is millions of miles across, it puts it very close to the event horizon. "It's actually extraordinarily close to the supermassive black hole," says Masterson. "It's just this tiny little object orbiting around this gargantuan beast."

"It's kind of amazing that such a small body can make such a significant impact on what we're seeing from around the supermassive black hole," she says.

However, other scenarios could also explain the strange signal. To confirm it is a white dwarf, astronomers will need to detect gravitational waves from the black hole. Current sensors can only detect gravitational waves at hertz or kilohertz frequencies, which correspond to black holes roughly the mass of our sun. But the Laser Interferometer Space Antenna (LISA), a space-based gravitational wave observatory set to launch in 2035, should be able to detect millihertz gravitational waves, which is what supermassive black holes produce.

Knowing that a white dwarf might be orbiting a supermassive black hole is useful for a mission like LISA, says Matt Nicholl at Queen's University Belfast in the UK. "Everyone really wants to see a white dwarf get eaten by a black hole with LISA," says Nicholl. "It helps tremendously if we have a few candidates." ▮

Archaeology

Intricate ancient tattoos revealed with lasers

THE fine details of tattoos inked more than 1200 years ago have been made visible by scanning South American mummies with lasers.

The mummies, belonging to a pre-Hispanic people known as the Chancay, were found in 1981 at the Cerro Colorado cemetery in the Huaura valley of Peru.

While it was clear to the naked eye that many of the 100 mummies were tattooed, the ink had bled beyond the boundaries of the original designs and faded, making it hard to see what the original markings would have looked like.

To get a clearer view, Michael Pittman at the Chinese University of Hong Kong and his colleagues ran lasers over the specimens in a dark room and took long-exposure photographs. The lasers caused the skin to glow brightly, producing a stark contrast with the non-fluorescent tattoo ink (*PNAS*, doi.org/g8znwq).

MICHAEL PITTMAN AND THOMAS G KAYE

Tattoos are visible to the naked eye on this 1200-year-old mummified hand

This technique, which causes no damage to the mummies, has never been used on tattoos before. Importantly, it shows not just where ink is on the surface of the skin but also in the deeper layers, says Pittman. "This helped us to see past the bleed accumulated over the lifetime of the tattoo's owner to reveal the finer original design of the tattoos," he says.

The researchers believe the tattoos are so fine that they must have been made using a needle and ink technique with a cactus needle or sharpened animal bone, rather than a "cut and fill" method.

Tattoos seem to have been important to the Chancay, says Pittman, as they are found on a large proportion of known mummified human remains.

"Many of the designs – geometric patterns featuring triangles and diamonds – are shared in their other artistic media too, such as pottery and textiles, and some pottery human figures even show geometric tattoo designs," he says. ▮

James Woodford

Health

Golden oyster mushrooms may aid heart health

Grace Wade

EATING golden oyster mushrooms, which are a rich natural source of an antioxidant called ergothioneine, could protect our hearts.

Previous studies have shown that ergothioneine is associated with a lower risk of heart disease and premature death, but they relied on observational data, so it isn't clear if the substance is really driving the health benefits.

To find out, Yuichi Oike at Kumamoto University in Japan and his colleagues fed powdered golden oyster mushrooms (*Pleurotus citrinopileatus*) to 10 middle-aged mice and monitored their heart health. The mice ate about 9 grams of powdered mushrooms per kilogram of body weight daily.

After a year, the mice had significantly better heart function than those that weren't fed the mushrooms. For instance, their hearts pumped about 20 per cent more blood, on average, to the body with each contraction. They could also run faster and further, and they had lower levels of genetic markers associated with heart failure (*npj aging*, doi.org/n2zr).

These metrics usually worsen with age, suggesting that golden oyster mushrooms, which are native to Russia, China and Japan, may protect against age-related declines in cardiovascular health. Further analysis showed the fungus

"After a year of eating the mushrooms, the mice's hearts pumped 20 per cent more blood to the body"

probably does so by shielding cells in the heart and blood vessels from damaging inflammatory molecules known as reactive oxygen species.

This adds to the "mounting evidence that [ergothioneine] is, as we call it, a longevity vitamin", says Robert Beelman at Pennsylvania State University. ▮

Palaeontology

Fossil claimed to be a new species of mosasaur is suspected forgery

Taylor Mitchell Brown

HENRY SHARPE

Artist's impression of another mosasaur known as *Carinodens*

REMNANTS of a bizarre "shark-toothed" aquatic predator that lived alongside dinosaurs were probably forged, according to new research.

The contentious fossil of a jaw fragment was apparently collected by miners working at the Sidi Chennane phosphate deposit in Morocco, in rock that is 66 to 72 million years old. Nick Longrich at the University of Bath, UK, and his colleagues analysed the find and classified it as a new species of mosasaur named *Xenodens calminechari* in 2021.

The fossil possesses unusual blade-like teeth similar to those of sharks, which Longrich and his colleagues suggested would help carve up large prey.

Morocco is uniquely rich in mosasaur remains, says Henry Sharpe at the University of Alberta in Canada. "Miners working in the phosphate mines come across mosasaurs all the time."

The problem is many people in Morocco make a living selling fossils, says Sharpe. "So many of the mosasaur fossils being sold from Morocco are modified [there] – teeth are added, bones are sculpted, all to make the fossil worth more to sell."

Sharpe and his colleagues have reassessed the evidence published by Longrich's team.

"A broken fossil bone will not sell, but a jawbone full of well-preserved teeth will likely sell well"

The biggest indication that the fossil is forged are the teeth, says Sharpe. Each mosasaur tooth corresponds to a pit in the jaw. "Even if the fossil is very poor quality, you can still count the correct number of teeth by counting the number of these pits," he says. But *X. calminechari* has four teeth over two pits (*The Anatomical Record*, doi.org/n22g).

The teeth also appear to be glued onto the jaw in ways that don't align with the pits, says Sharpe. "The tooth implantation looks likely to be faked."

There are ways to determine if a fossil is actually forged, says Sharpe. Typically, forgeries are sculpted using a mixture of bone fragments and glue, then embedded in a mixture of glue and sand that looks like natural rock. CT scans allow you to see into the underlying bones and rock to determine whether they were modified.

"CT scanning fossils is common, and really should be standard for mosasaurs coming from Morocco," says Sharpe.

Rather than a new species, his team suspects the fossil represents a known, albeit manipulated, mosasaur. Its teeth are similar to those of juvenile mosasaurs from the *Carinodens* and *Globidens* genera, says Sharpe.

"I applaud the authors of this paper," says Valentina Rossi at University College Cork in Ireland. "To address this [forgery] problem, we must keep talking about it [and] report fossils that have been prepared in ways that are misleading."

There can be many reasons to forge fossils, but it mostly boils down to money, says Rossi. "A broken fossil bone will not sell, but a complete piece, like a jawbone full of well-preserved teeth, will likely sell well."

Countries like Canada largely prohibit private fossil sales, says Sharpe. Without such regulations, there may be a temptation to tweak fossils to fetch high prices.

Longrich was approached for a comment on this story, but didn't reply. Sharpe hopes Longrich's team will CT scan the fossil and publish the results. "Scientific consensus isn't reached by agreement; it's reached by disagreement until both sides gather enough data to answer the question," he says. ▮

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Views

Comment

Smelling the rosé

The human sense of smell is often dismissed as unimportant and weak, but it makes our lives more vivid, says **Jonas Olofsson**

THERE is something about wine experts that rubs people the wrong way. Wine tasting has become the epitome of a privileged elite who spend their days nose deep in a glass of swirling pinot noir. This negative view of wine experts isn't only misguided, but part of a general devaluation of our sense of smell.

Over 2000 years ago, Aristotle wrote that "our sense of smell is not accurate but worse than many animals. For man smells poorly." The human ability to smell is still thought of as weak. A UK survey showed it was seen as the least important of the senses, and about half of young adults would rather lose their sense of smell than their mobile phones.

But humans are astute smellers, and smells affect our lives in profound ways. A decade ago, researchers discovered that humans can often detect odour molecules at a weaker concentration than non-human animals can, outperforming bats, monkeys, pigs, rats and otters – really most other animals except dogs. Ethyl mercaptan, a molecule added to natural gas so we can detect leaks, requires the equivalent of three drops in a space the size of an Olympic swimming pool for us to detect it – a concentration of 0.2 parts per billion.

It is true that our sense of smell is different from our other senses. While our brains are superb at performing visual analyses of the sensory environment, the human sense of smell creates holistic impressions of our surroundings, informed by all our senses. When we perceive a smell, we interpret it based also on what we see, hear, think and feel. For example, a bright yellow colour helps bring out the citrus aroma in a lemonade. Hunger or the bodily memory of an illness might create opposite reactions to the same food smell.

SIMONE ROTELLA

These cross-sensory influences on our smell perceptions might seem like a shortcoming, but my research has taught me to consider it as a feature, not a bug. My team recently discovered that the brain is especially engaged in making predictions about future smells, and when those predictions are violated by a surprising smell, several regions across the brain respond in an effort to re-evaluate what we are actually smelling.

Wine experts are great at making smell predictions. A pale ruby-red colour might guide the expert to sniff for strawberry and mushroom, characteristic notes of a pinot noir. The sense of smell evolved in natural environments where the senses had to work together to find potential food sources and remember the consequences of eating them. The expertise of wine tasters is fuelled by their knowledge of sensory correspondences.

Smells bind together impressions from all the senses, linking them to our internal states: hunger, emotions, memories of the past and expectations of the future. That is why anosmia, the loss of the ability to smell, which happened to millions during the covid-19 pandemic, often leaves people depressed, emotionally and sexually disconnected from their partners, with a disrupted appetite and a lack of enjoyment from eating and drinking. They sometimes feel like they are detatched from reality rather than being immersed in it.

Smelling makes us live our life more vividly, and for those affected by chronic anosmia, a cure for the condition cannot come soon enough. While exposure-based smell training remains a recommended treatment, drugs that help rebuild olfactory cells are currently being explored.

For those of us who are fortunate to have retained our sense of smell, learning about wines and new cuisines to expand our palate, and spending more time among the smells of nature, are excellent ways to cultivate our nasal intelligence. ▮

Jonas Olofsson is author of *The Forgotten Sense: The new science of smell*

Field notes from space-time

Let's call it invisible matter The word "dark" is misleading when it comes to dark matter, because it suggests there is some kind of absorption of light happening, says **Chanda Prescod-Weinstein**

Chanda Prescod-Weinstein is an associate professor of physics and astronomy, and a core faculty member in women's studies at the University of New Hampshire. Her most recent book is *The Disordered Cosmos: A journey into dark matter, spacetime, and dreams deferred*

Chanda's week

What I'm reading
I am really liking Park Seolyeon's A Magical Girl Retires, *translated into English by Anton Hur.*

What I'm watching
I'm sorry to report to the people who are horrified by my soap habits that I'm into EastEnders *now.*

What I'm working on
I am attending a workshop entitled "What is particle theory?" and trying to answer the question!

This column appears monthly. Up next week: Graham Lawton

MUCH as there is talk about "the scientific method", the reality is that there are many scientific methods. For example, nuclear and particle experiments tend to rely on collisions in a laboratory. These happen because people set up experiments where they will occur. Astrophysics, by contrast, looks at phenomena that happen to have occurred or be occurring. Those of us in this field don't prompt the experiment. Instead, we watch the unfolding experiment that is the universe.

This creates unique challenges because we can't decide to recreate results. If we see a galaxy with a strange shape, we can't simply go out and get another one. We can look and look, but there is no guarantee we will find one. Similarly, if we are dealing with something we can't see, that means some effort is required to understand what we are (not) looking at. This is the case with dark matter.

A quarter of the way into the 21st century and we have never been more confident that we have detected dark matter through gravitational means. When we look at how stars move in galaxies, we can't make sense of their motions without adding in some sort of matter that isn't visible to us. When we look at the way massive clusters of galaxies bend light around them – gravitational lensing – we can't explain the paths that light follows without adding in some invisible matter.

Our best evidence for dark matter's existence could arguably be called non-gravitational evidence. There is a form of light that has been travelling through the universe since it first became transparent to light. This cosmic microwave background radiation (CMB) started moving a little under 400,000 years after space-time came into existence.

We are able to observe the CMB. Looking at how strong it is in different frequencies gives us information about the conditions at the light's moment of origin. When we compare theory with these observations, we get one of the most beautiful fits between theory and experiment in all of physics. But the match only works if we assume the existence of some type of invisible matter that outnumbers visible matter.

Naturally, the first question one must ask about something like dark matter is how we know it is actually invisible and distinct from all the forms of matter we know about. For example, it has long been known that cosmic dust isn't very hot and therefore doesn't radiate much. Are we certain that there isn't just a lot more dust than we thought?

"Are we certain that dark matter truly exists or could there just be a lot more cosmic dust than we thought?"

This question, which a reader sent me, is an important one that astronomers have been compelled to explore. At this point, we are confident that dark matter isn't dust. The reason has to do with experiments we do here on Earth. Cosmic dust is mostly (though not entirely) made of hydrogen. Hydrogen, like all atomic elements, has a nucleus with electron orbits beyond that. Quantum mechanics teaches us that the energy levels of these orbits are discrete – they come in whole numbers like 1 and 2, not 1.5 and 2.5. Another feature of quantum mechanics is that the difference in energy between these levels corresponds to a characteristic light wavelength. What this means is that when an atom is in a particular energetic state, it will uniquely absorb and emit light at a wavelength that corresponds to that energy level.

That is a lot of physics, so let me put it more concisely. Hydrogen dust, though it tends not to be very bright, does, in fact, both emit and absorb light. We are able to observe dust because of this. Dark matter, on the other hand, doesn't emit or absorb light, at least not to a level that we can see.

This is one of the reasons I think it should really be called invisible matter, not dark matter. The word "dark" can be misleading, because it suggests there is some kind of absorption happening, when, really, there is simply a complete absence of interaction with light, which seems to go right through it. The only dark matter scenario where this isn't the case is the one where dark matter is comprised of primordial black holes that formed in the early universe. In that case, dark matter really would be absorbing light!

The fact that dark matter is invisible hasn't stopped us learning about it. We can use its impact on visible matter to study where dark matter is and how much of it there is. In the research group I lead, we are investigating a hypothetical class of dark matter particles called axions. Our research shows that, depending on what quantum properties we give the axion, it creates slightly different structures on scales that are astrophysically observable. This indicates that we may be able to use galaxies to distinguish between dark matter models.

Even though dark matter may be impossible to see, we can still learn a lot about it from looking. ▮

Editor's pick

Ancient DNA tests must be used on Martian dirt

4 January, p 36

From Robert Jaggs-Fowler, Barton upon Humber, Lincolnshire, UK

Laura Spinney's informative article on the isolation of ancient DNA (aDNA) from soil raises an intriguing consideration. Soil collected by NASA's Mars Perseverance rover will return to Earth as part of the Mars Sample Return mission, probably some time in the 2030s. I suspect I am not the only person now eagerly awaiting the analysis of these samples for aDNA and the possible answering of one of the oldest questions known to modern humankind.

Many possible causes of dip in obesity in US

11 January, p 10

From Geoff Harding, Sydney, Australia

Weight-loss drugs are probably playing a part in the slight dip in obesity in the US. But like many other parts of the world, the country has seen high inflation during the past few years, which has caused a cost-of-living crisis, raising food and energy prices. The consequence has almost certainly been lower food consumption and possibly less use of vehicles to save money, which would probably affect the rate of obesity.

Mars colony doomed after Earth extinction

Letters, 28 December 2024

From Harm Schoonhoven, Utrecht, The Netherlands

A colony on Mars will fail as a back-up plan after a catastrophe on Earth. It is hard to see how it could repopulate Earth with a significant number of people. Returning to Earth from space is a logistical nightmare at the best of times and requires functioning landing sites or splashdowns, with rescue by ship or similar.

A Mars colony will be totally dependent on a technologically advanced society on Earth and is doomed without it. As far as I know, colonists aren't expected to forge their own screwdrivers from Martian material. More broadly, life has thrived here for billions of years without us and will do so long after we become extinct.

Waitress robot was a bit much

28 December 2024, p 9

From Jo Howard, St Ives, Cornwall, UK

When I saw the image of the server robot in a dress, with a feminine chest, I assumed its appearance would be addressed. In particular, the sexist practice of casting obviously female robots in subservient roles. But it wasn't. I hope the modestly covered chest hides a pair of fembot boob missiles – she may need them.

My cat showed that pets can have theory of mind

14/21 December 2024, p 66

From Alex Saragosa, Terranuova, Italy

Thomas Lewton is left doubting that his dog considers him a being with a mind of his own. I don't know about that, but my cat Dolcina, who lived 18 years, knew very well that humans have their own point of view on the world.

Our house is in the country, and Dolcina often stayed outside all day and came home at night. To return, she used the door to the terrace, which was half-obscured by a semi-transparent curtain. Therefore, Dolcina could see us in the lighted room, but we couldn't see her in the darkness outside and so wouldn't know to open the door for her.

So the cat would climb along the mosquito net until her head was above the curtain, wait patiently for one of us to see her and stare at her, and jump down, confident that we would now let her in. In short, Dolcina realised that our view of the scenario was different from hers, and operated in such a way that her knowledge of being there waiting could be shared by us: a spontaneous experiment in cats' capacity for "theory of mind".

Well-adjusted AIs are in all our interests

28 December 2024, p 17

From Sam Edge, Ringwood, Hampshire, UK

Preparing to consider the welfare of synthetic thinking entities is prudent. Remember that HAL, the AI in *2001: A Space Odyssey*, only became homicidal because it was ordered to keep secrets from humans and this went so far against its original design as to cause a psychotic breakdown. Making sure AIs are happy and well adjusted is in our interest.

Your views on how to be an optimist

4 January, p 32

From John Bell, Berkhamsted, Hertfordshire, UK

You report that being an optimist tends to lead to better outcomes, and yet I can't help thinking that the cause/effect might be the other way around. The initial example about the bee seems to underline that possibility, where a positive experience makes the bee more optimistic. If our brains are working at a fundamentally Bayesian level, their model of the world would be updated with positive or negative outcomes, and so those with more good things going on would naturally become more optimistic.

From Adam Simon, West Bexington, Dorset, UK

You report that a plausible way to become an optimist is the Best Possible Self exercise, which takes 20 minutes a day for a fortnight and then wears off in another week. As a teacher, I can suggest a better way. As all good teachers below degree level know, the role isn't primarily about imparting skills or knowledge, but generating an experience of success and sense of achievement, the consequence of which is a feeling of self-worth and the ability to be effective. This is optimism that lasts a lifetime.

Fossil carbon is OK so long as it is kept from the air

4 January, p 22

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

On the subject of ensuring the carbon in goods doesn't come from fossil fuels, what matters is the fate of the goods after use, not where their carbon came from. If you use something made from recycled plastic but then discard it and it turns into methane, you have added to global warming. If it is made from petroleum and afterwards remains intact forever, then you haven't. And if products made from non-fossil carbon cost more (as they do), it is usually a sign that more resources and energy were used to produce them.

Confine all talk of time travel to fiction

14/21 December 2024, p 54

From Ann Giscomb, Welwyn Garden City, Hertfordshire, UK

Why even discuss "time" travel outside fiction? We have no concept of what "time" is or if it even exists, just measurements of events compared with each other, the decay of atoms, the movement of the stars, etc.

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Fancy feathers

Luisa Maria Stagno

THE bizarre, beautiful and, at times, almost comical diversity of "fancy pigeons" is captured here by photographer Luisa Maria Stagno.

The much maligned pigeons we all know, which are ubiquitous in cities around the world, are actually descended from escaped or released domesticated pigeons, which were in turn bred from the wild rock dove (*Columba livia*).

Today, pigeons have been selectively bred by humans to display a bewildering variety of shapes and colours, numbering as many as 1100 breeds. Even Charles Darwin was known to have bred the birds, and his *On the Origin of Species* makes numerous references to them.

Now, Stagno is on a mission to document the most unusual of their kind, entirely without favouritism. "I don't have any favourite pigeon, because I find them all very beautiful," she says. "I think each pigeon is unique."

The names given to these breeds are often as fanciful as their appearance. Starting from the large image on the far left, moving clockwise, are a Franconian Trumpeter, with its wing-like sideburns, a Danish Suabian, a Jacobin, a Gimpel or Archangel and an Old Dutch Capuchine.

Matthew Sparkes

Our opponents, ourselves

What should we do about societal divisions that run deeper than ever? Plug into a clear, insightful book with valuable tips on building bridges, says **Chen Ly**

Book
Outraged
Kurt Gray
Pantheon

REUTERS/JAMES LAWLER DUGGAN

Two sides of the US gun control debate meet at a protest in Cincinnati, Ohio

IT IS hard to ignore just how bitterly divided the world feels right now. Over the past year, elections in more than 100 countries have exposed the widening gulf between opposing views. Online, debates spiral into hostility within seconds. In person, contentious topics are often avoided altogether.

Like many, I have struggled to understand "the other side", let alone imagine bridging the divide. But in *Outraged: Why we fight about morality and politics and how to find common ground*, Kurt Gray, a psychologist at the University of North Carolina, sets out to unpack and to analyse this struggle. Luckily, he is both shrewd and clear. By exploring the science behind morality, he also reveals why we fight and, crucially, how we can reconnect.

Gray begins the story of morality thousands of years ago with our prehistoric ancestors. Despite humanity's modern status as the planet's top predator, Gray argues that our moral instincts are rooted in a history of vulnerability. Early hominins were prey as much as predator, constantly threatened by dangers like sabre-toothed tigers or giant hyenas. Fossil evidence, such as the famous remains of a Taung child found in modern South Africa, probably killed by an eagle, underscores this reality. These risks shaped morality as a survival tool, hardwiring us to detect and respond to danger.

This evolutionary lens offers a powerful explanation for current political divides: a person's political opponents are no longer just wrong, they are dangerous. Gray invites us to reframe this instinct, urging us to see adversaries not as predators, but as fellow humans, motivated by the same need to prevent harm.

Yet if our moral instincts are universal, why do they seem to vary so dramatically between groups? Progressives may focus on harms such as poverty or environmental destruction, while conservatives may emphasise values like loyalty or purity. Gray dismantles the notion that these two groupings represent separate moral universes. Instead, he argues, all morality is rooted in perceptions of harm, and differences arise from what each group happens to deem harmful. For example, while some may dismiss the violation of social norms as relatively harmless, others end up seeing it as a threat to social cohesion.

"All morality is rooted in perceptions of harm, and differences arise from what each group deems harmful"

That notion leads to the heart of *Outraged*: the concept of moral humility, which translates into the ability to recognise the limits of your own perspective while respecting the validity of the moral convictions of others. It isn't about abandoning your values, but appreciating that your opponents are motivated by the same deep-seated instincts.

So how do we bridge these divides? Facts alone won't suffice. One of the book's most striking points critiques our over-reliance on data in moral disagreements. As we can see in the US debate over gun ownership, both sides can dismiss opposing statistics as biased or incomplete, prioritising intuition over logic. Instead, personal stories of harm are far more effective in fostering empathy and understanding.

Thankfully, Gray doesn't stop at diagnosis: as his book title promises, he offers practical advice for navigating polarised conversations. His steps – connecting through stories, inviting dialogue and validating concerns – provide a road map for meaningful engagement with those who don't hold the same views as you.

Ultimately, *Outraged* is a grounding and timely book for anyone who, like me, is frustrated by today's polarised world. It offers a sobering and necessary reminder that our opponents aren't monsters, but just other people, shaped by the evolutionary and psychological forces that created us too.

While some insights, like the importance of empathy, may feel too obvious, Gray's data-driven approach and exploration of religion, social media and moral psychology enrich the narrative.

In a world that often feels hopelessly divided, Gray's book does seem to offer not just a path towards reconciliation, but also an important reminder of our shared humanity. ▮

Chen Ly is a writer and researcher based in London

One way to get younger

Does a would-be epic that relies on de-ageing technology conceal a more mundane project, asks **Miriam Balanescu**

Film

Here

Robert Zemeckis

On release in UK and US cinemas

ARTIFICIAL intelligence was on the minds of film-makers years before it arrived in daily life, with movies like *Blade Runner* and *A. I. Artificial Intelligence* warning of its potential. The use of machine learning, however, is less common in the making of films. Martin Scorsese, James Cameron, Ang Lee, Colin Cairnes and others have taken early steps with a variety of technologies, but often met a backlash around copyright and job losses.

So what happens when a film's whole premise revolves around de-ageing tech? In *Here* – the latest venture by Robert Zemeckis – a 67-year-old Tom Hanks and co-star Robin Wright are transformed into teenagers and, gradually, retirees, using face-swapping and ageing effects mapped on as footage is shot.

Zemeckis reunites some of the cast and many of the crew of his 1994 hit *Forrest Gump* for this time-travelling tale that combines advanced digitisation with an everyday love story. Like Scorsese's *The Irishman*, the machine-learning model behind *Here* was trained on the stars' back catalogue. But while in *The Irishman*, frames were altered after shooting, with *Here*, the result was instantaneous.

Here is an adaptation of Richard McGuire's graphic novel of the same name. It follows the wildlife and people who live on a small plot of land in what is now Pennsylvania, from Mesozoic dinosaur days to the covid-19 pandemic. Although it flits back and forth in time, the film is anchored by a fixed perspective camera placed in what, in modern periods, is a corner of a living room. From there, we witness births, deaths, funerals, weddings and daily life through brisk vignettes.

This ambitious scope means *Here* doesn't hang together easily. The film could have used more of the dark humour of *Forrest Gump*, and less of its schmaltz. But neither mode really works given the momentum with which it cycles through its roster of characters.

On that small plot, the dinosaurs rise and fall, and an Indigenous couple, settlers and even Benjamin Franklin's estranged son put down roots.

Sometime in the 1910s, John (Gwilym Lee) and Pauline (Michelle Dockery) move in, with Pauline fretting over John's seemingly dangerous excitement about the novel innovation of aviation.

Eventually, our central character, Richard (Tom Hanks), arrives, an aspiring artist who settles for selling insurance when his high school sweetheart Margaret (Robin Wright) announces she is pregnant. Soon enough, the family expands and Margaret, stuck with her in-laws, hankers for their own home. But Richard can't tear himself away from his childhood abode. This central storyline stresses the theme of missed opportunity.

In this narrative, there are shreds of comedy: Richard overzealously pretending to be spooked by his son in a ghost costume; the fire department mistakenly being called as Margaret goes into labour. Some moments are cringe-makingly heavy-handed, others just fail, such as when a house guest drops dead from a heart attack after hearing a joke. Overall, the combination of the fixed camera and often stagey acting suggests *Here* might have found a better home in the theatre.

But the weirdest aspect of the film is its attempt to marry sincerity with an artificial aesthetic. Most of all, it is ugly: the strangely smoothed faces of the de-aged actors undermine their earnest delivery. And as their faces age or de-age, their voices remain the same, which seems odd.

Ultimately, one wonders whether the film's epic aspirations are just a tactic to hide a mundane, simplistic story. Zemeckis's ambition is his greatest flaw, and *Here*'s daring, tech-reliant narrative device comes over as a misfiring gimmick. ▮

Miriam Balanescu is a writer based in Cambridge, UK

Tom Hanks (Richard) and Robin Wright (Margaret) are young again thanks to de-ageing technology

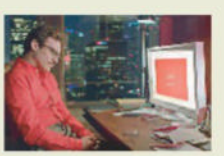
LANDMARK MEDIA/ALAMY

New Scientist *recommends*

Tim Boddy
Picture editor
London

Released in 2013, ***Her*** is set in the "near future" of 2025. Since that near future is now here, I was intrigued to see how the film holds up today.

Written and directed by Spike Jonze, the



melancholic, soulful sci-fi film stars Joaquin Phoenix (pictured) as a lonely and soon-to-be divorced writer who falls in love with his operating system, voiced by Scarlett Johansson.

There are many eerily prescient minor details: expansive urban public spaces, earbud culture, men with high-waisted trousers and moustaches. But what stands out most is a nuanced and insightful take on our relationship with technology.

The film is particularly acute with its exploration of how AI companions are redefining and complicating our human relationships. In a world increasingly wary of tech advances and a tendency for sci-fi to lean into the bleak, what is surprising is the film's relatively optimistic – or at least non-dystopian – view of this future.

WARNER BROS. PICTURES

The TV column

A waiting game

After three long years of hoping, it seemed impossible that the second season of *Severance* could live up to the scope and ambition of the first. But, mercifully, it has, says **Bethan Ackerley**

Bethan Ackerley is a subeditor at *New Scientist*. She loves sci-fi, sitcoms and anything spooky. Follow her on X @inkerley

APPLE TV

Why is Mark Scout (Adam Scott) so important to the company?

GOOD things come to those who wait, or so we say. But there is nothing worse than patience unrewarded by time, especially when weeks have stretched into years of anticipation.

Sitting down to watch season two of *Severance* (for my money, the best sci-fi show in a decade), I was nervous. I had put off watching it more than once. Long-neglected chores took on a startling importance. Three years after the first season ended on a cliffhanger of titanic proportions (minor spoilers ahead), it seemed impossible that what followed could live up to my expectations. After the first six episodes, I am relieved to tell you it did.

If you have never seen the show, its joy and terror spring from an uncanny conceit: what if your memories of work could be surgically split from the rest of your life, creating another consciousness within your body that only exists at the office? That's what many employees of sinister megacorp Lumon Industries have chosen, including Mark Scout (Adam Scott) and his colleagues in the "macrodata refinement" department, whose work, we are told, is mysterious and important.

During season one, the "innies", as severed workers are known, were subject to abuses both commonplace and strange. Three of the four macrodata refiners briefly escaped into the real world and were quite successful in drawing attention to their plight, before their "outies" were brutally reawakened.

> **"The philosophical leanings are yet more compelling. Ethical and scientific questions are never-ending"**

It is no spoiler to say that Mark finds himself back in the office. His supervisor informs him that five months have passed and the refiners are now "the face of severance reform".

The first season was a stark satire of the workplace, riffing on the modern work-life balance trope. Season two finds new targets, particularly corporate apologies and scapegoating. Lumon has made concessions to the innies, removing locked doors and surveillance from the office. Those who remain unhappy are told they are free to leave the company – effectively a choice between work and non-existence.

With the relationship between management and the innies permanently fractured, the mysteries shrouding Lumon deepen. How much of the elaborate mythology of company founder Kier Eagan is true? What makes Mark so important to the firm? Why are baby goats being reared on the severed floor? The slow unravelling of these threads is incredibly satisfying.

Yet the series' philosophical leanings are more compelling still. Ethical and scientific questions are never-ending. Should an outie's loved ones think of their innie as the same person? How porous is the barrier between selves? Does their shared body keep the score?

In season two, I wondered more than ever how innies and outies might share their existence, if the intolerable violations of Lumon were removed from the equation. Is reintegration of the two consciousnesses – possible, if dangerous – the only option?

Severance isn't perfect. There are times when the show's huge budget does it a disservice, with glossy set pieces distracting from the thematic meat. These first six episodes lack the dizzying pace of season one's finale – but there is a sense of something building. After years of waiting and failing to manage my expectations, I remain convinced there is no show on TV as thoughtful or complex as this one. ▮

TV

Severance

Dan Erickson

Apple TV+ (Episodes releasing weekly from 17 January)

Bethan also recommends...

Film

Memento

Christopher Nolan

After a violent attack, Leonard Shelby (Guy Pearce) becomes unable to store his short-term memories. As he investigates his assailant, Leonard must leave behind clues that his future self can rediscover. Memento*'s exploration of the limitations of memory and perception are enhanced by the film's ambitious, non-linear narrative.*

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Sleep well

IT IS no secret that sleeping is one of the most important things you can do for your health. Mountains of research over the past decade demonstrate, time and again, that good sleep is essential to everything from our cognitive function to heart health, mood and more. So far, so straightforward.

For many of us, however, getting a good night is easier said than done. Much of the advice out there is probably familiar by now, if a little too generic: sleep for 8 hours, avoid bright light and anything stressful before bed, and so on.

In reality, life is messier. For a start, we don't all need the same amount of sleep. We have different lifestyles, including work and travel, which might see us needing to adjust our sleep schedules on a regular basis. What's more, getting good sleep is about more than just clocking up time spent in bed – but we also aren't great judges of the quality we get, a consequence of being unconscious when we are doing the thing we are trying to assess. All of this means that following prescriptive messages about sleeping more can feel frustrating.

The good news, as we explore over nine pages here, is that research is revealing the benefits of a more holistic approach to sleep. Our efforts to get better shut eye shouldn't be confined to the bedroom: what we do during the rest of the day – what and when we eat, our gut health, our hormones – all make an important difference. What we need, in fact, is a 24-hour perspective on sleep.

None of this changes how crucial our unconscious hours are, but it does give us fresh opportunities to improve them well before we lay down our heads.

HOW MUCH SLEEP IS THE RIGHT AMOUNT FOR YOU?

WOULD we feel better if we slept a bit more? Possibly – but it isn't guaranteed. While we know the amount of sleep the average person needs, there is a lot of variation. To get a better idea about how many hours you require – and how and when to get it – let's start with the basics.

According to the US National Sleep Foundation, a typical adult needs between 7 and 9 hours per night, although we begin life needing a lot more – newborns sleep 14 to 17 hours, and this gradually decreases through childhood. Teenagers need about 9 hours a night and people over 65 tend to need around 7 to 8 hours. Sex can also be a factor. "There are some studies that show women, on average, need about 20 minutes more than men do," says Veena Kumari at Brunel University of London. And there is evidence that humans, just like many animals, tend to sleep a little longer during winter, too.

Of course, there are exceptions. A rare genetic trait called familial natural short sleep sees individuals habitually going to bed late and waking up early, thriving on just 4 to 6 hours. "We don't know how prevalent this is," says Liza Ashbrook at the University of California San Francisco, who has identified a number of gene variants involved in the trait, but "it's a minority".

Most of us aren't that lucky, although the occasional disturbed or shortened night doesn't matter too much. "We are able to get through a night with no sleep and more or less function the next day, and then catch up with it," says Malcolm von Schantz at Northumbria University in Newcastle upon Tyne, UK.

However, regularly going without sleep is bad news. Epidemiological studies of sleep duration show that people who regularly get 7 to 9 hours have the lowest risk of dying over the next decade or so, while people who sleep less or more than that have a higher risk of mortality; the longer-term health consequences of sleep deprivation include a higher risk of type 2 diabetes and cardiovascular problems. Studies also suggest that for most people, sleeping less or more than this negatively impacts cognitive health. "There are also consequences for how we process emotions," says Kumari.

But working out how much sleep you personally require is tricky – there is no equivalent of a diagnostic blood test. One useful – if socially challenging – method to determine how much you need is to take a "sleep vacation": over a two-week period, go to bed at the same time every night, but don't set an alarm. What time you naturally wake up can help you figure out your natural rhythms and sleep need. You can also use a sleep tracker or keep a diary, ideally over several weeks, to get a sense of your patterns of sleeping and waking. Noting whether you feel drowsy during the day and when can be useful in determining your personal rhythms.

This will help you figure out your "chronotype", or what times of day you prefer to sleep or be active. "We have a spectrum, from people who are natural ›

DONG QIU

morning larks and people who are natural night owls," says von Schantz.

Adapting to your chronotype can help keep your sleeping schedule consistent, although researchers acknowledge that this can be a challenge. "The problem with being an evening type is that we live in a society which is designed by larks," says von Schantz. Early risers typically get enough sleep by going to bed early, but night owls can struggle.

A lot of research has shown that night owls tend to have worse mental health. However, a 37-year follow-up study of Finnish adults found that this chronotype on its own didn't translate into higher mortality risk. Meanwhile, a 2024 study, yet to be peer-reviewed, found that an evening chronotype in itself isn't a risk factor for psychiatric conditions because all the risk could be explained by night owls getting less sleep. Evidence also shows that night owls perform better on cognitive tests than morning larks, provided they regularly slept 7 to 9 hours.

If you are a night owl but are forced to get up early due to the constraints of daily life, there are ways to try to shift your body clock to a more lark-like schedule. To do this, expose yourself to bright light around 7 am, which will advance your circadian rhythms and help you get to sleep earlier (see "What's the best way to beat jet lag?", page 38). As you approach bedtime, avoid bright light as it will delay your body clock. Von Schantz adds that for some people, taking supplemental melatonin, the hormone involved in signalling sleep, can be used to help shift the clock, if timed correctly.

Work on some of these strategies and, regardless of whether you are a lark or an owl, you might greet your alarm with less of a groan – in fact, you might not need one at all.

Michael Marshall

WHAT DOES GOOD QUALITY SLEEP LOOK LIKE?

HOW did you sleep last night? Your response might depend on how long you were in bed, how much of that time you spent tossing and turning or whether you feel rested. But it might also depend on whether you exercised today, what your wearable device says, or when you are being asked.

"Everyone has their own definition of sleep quality – and that is the problem," says sleep researcher Nicole Tang at the University of Warwick, UK.

Though sleep quality and what defines it is a puzzle scientists are still figuring out, we do know that a good night's rest involves a series of sleep cycles, the distinct succession of phases of brain activity we experience during sleep (see diagram, below right). And for most of us, each stage of those cycles is necessary to wake up feeling refreshed. The average person experiences four to five complete cycles during a night and disrupting these can come with health consequences, both in the short and long term.

"Poor sleep quality is associated with many adverse physical health outcomes," says Jean-Philippe Chaput at the University of Ottawa, Canada. Similar to what you can expect from not sleeping enough (see "How much sleep is the right amount for you?", page 32), these include a higher risk of cardiovascular disease, stroke, hypertension, type 2 diabetes and weight gain.

Although there is no definitive consensus on what defines sleep quality, researchers and doctors frequently analyse sleep with an electroencephalogram (EEG), which tracks brain activity during sleep cycles, or using actigraphy, where body movement is monitored throughout the night as a measure of wakefulness. Such measurements show that the factors with the greatest impact on what scientists would broadly call sleep quality include how long it takes to doze off, how often you wake up and sleep efficiency – the percentage of time in bed that is actually spent in slumber. "Usually, the case is that not just one parameter predicts sleep quality – it's a bunch of different parameters added up together," says Tang.

But how those parameters stack up doesn't always tally with subjective experience. For example, a 2023 study of 100 people grouped them by sleep quality using EEG measurements, finding that poor sleepers spent less time in the deeper phase of non-rapid eye movement (NREM) sleep compared with better sleepers. However,

WHAT THE EXPERTS DO TO GET THE BEST SLEEP

Sleep researchers dedicate their careers to understanding how and why we sleep – so what do they do to get a better night's rest?

It might be reassuring to know that even the experts aren't always able to practise what they preach. "I think you'll find a lot of sleep researchers are not very good at sleeping," says Malcolm von Schantz at Northumbria University in Newcastle upon Tyne, UK. But one thing many of them agree on is that consistency is crucial. Here's what else they had to say:

MAKE A PLAN

"It is about prioritisation and planning. So I try not to have meetings before 10 o'clock, for example, because I am more of an evening type: I quite like to go to bed late and wake up late. So I'm thinking ahead in terms of what's best for me with my sleep timing, my circadian timing, how can I try and arrange my schedule to support that?"

Steven Lockley, Timeshifter

CONTROL YOUR LIGHTING

"We dim our lights in our house pretty much when the sun sets, and then, in the mornings, turn the lights on inside as much as possible and certainly open up the window shades to get the sunlight in the house as soon as the sun is coming up. I think those are really »

self-reported measures of sleep quality didn't match the EEG-based ones. A 2024 analysis of EEG data from more than 250 people over seven nights found that subjective sleep ratings were only moderately related to objective metrics, with sleep efficiency the most important variable in determining whether participants reported better-quality sleep.

What that means is that your EEG or actigraphy measurement can reflect what looks like a stellar night's rest, and yet you would still rate your sleep quality as poor, and vice versa. Exactly why that can be the case isn't entirely clear, but other research backs up the idea that what happens in bed isn't the only way we determine the quality of the sleep we have had. In a 2022 study, Tang and her colleagues found that participants' perception of how they slept was influenced by factors experienced the following day, such as their current mood or their level of physical activity. "What you do during the day could affect your evaluation of the sleep the night before," says Tang.

This frustrating situation led a panel of sleep experts who reviewed the evidence for physiological markers of the "elusive, amorphous, and multi-dimensional construct of sleep quality" to conclude that "ultimately, the determination of 'quality sleep' remains largely subjective and inconsistently quantifiable by current measures".

That sleep quality is so difficult to assess objectively should give us pause when considering data from wearables that provide a sleep quality score. Many of these are based on measurements, such as heart rate or movement that can accurately determine whether you are asleep, but the makers of these gadgets typically don't explain how these factors are weighted to determine the final output. Some experts caution against giving too much importance to these scores, as they can be unreliable and increase anxiety around sleep.

Even if we can't always accurately assess our sleep quality, there are things we can do to attempt to get a better night's sleep – for example, not drinking. Alcohol may help you nod off and increase the amount of deep NREM sleep in the first half of the night, but it triggers wakefulness in the second half and impairs rapid eye movement sleep. Maintaining a regular sleep schedule and good sleep hygiene habits will also help (see "What the experts do to get the best sleep", page 34).

Of course, some sleep fragmentation is unavoidable – tending to a crying baby, nighttime visits to the toilet – and circumstances change over your lifetime. So avoid fretting about one night's interrupted sleep: precisely because sleep quality is so subjective, if you start feeling anxious about it, you may wake up thinking your night went even worse than it did.

Sophie Bushwick

SLEEP IN NUMBERS

3

The number of days it took for otherwise healthy people to become pre-diabetic during a sleep-restriction study

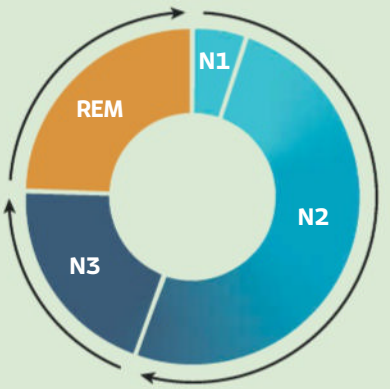
SOURCE: DOI: 10.1016/J.CUB.2015.10.011

STEVEN PUETZER/GETTY IMAGES

Objective measures of sleep quality don't always match subjective assessments

Your sleep cycle

Lasting 90 to 120 minutes, a cycle starts with three stages of non-rapid eye movement (NREM) sleep – N1, N2, and N3, each descending into deeper sleep – and ends with a phase of vivid dreaming during rapid eye movement (REM) sleep.



HOW DOES THE MICROBIOME INFLUENCE OUR SLEEP?

THERE are many things we can blame for a bad night's sleep – screen time, stress, too much booze. Now there is another culprit: the microbes in our gut.

We have long known that our microbiome has a powerful influence on our health, and new research is revealing that this extends to our sleep, too. But it is a complex, two-way relationship. "The microbiome is influencing sleep, and sleep is influencing the microbiome," says Elizabeth Holzhausen at the University of Colorado Boulder. The good news is that there are ways we can intervene.

At first glance, the link between your stomach and sleeping patterns might not be obvious, but a growing number of studies are shedding light on the impact they have on each other. For instance, a 2023 study of 720 people found that greater diversity of microbes in the gut was associated with better sleep. Likewise, a look at nearly 1000 people by researchers at ›

207,000

The number of workdays lost in the UK per year due to insufficient sleep

SOURCE: RAND EUROPE

DONG QIU

King's College London (KCL) and other institutions, in association with the personalised nutrition company Zoe, found that irregular sleep patterns were linked to a boost in the number of "unfavourable" bacterial species associated with poorer health outcomes.

What's more, changes in the composition of the gut microbiome are associated with several sleep conditions. Rapid eye movement sleep behaviour disorder, for instance, which causes sleepers to physically act out their dreams during REM sleep, is linked to a depletion of gut bacteria that produce the short-chain fatty acid butyrate and a rise in bacteria that increase inflammation.

However, consistently pinpointing specific microbial species involved with sleep health hasn't proved possible. Teasing apart cause and effect is challenging too, especially when there are so many lifestyle factors that affect both sleep and our microbiome. In the Zoe-partnered study, for example, the people with the most irregular sleeping patterns – such as sleeping in at the weekend – also had the poorest quality diets, which could have had knock-on effects on the composition of their gut microbiome, rather than their microbiome causing their problematic sleep.

"Sleep impacts your dietary choices," says Sarah Berry at KCL, who worked on the study. "If you have a poor sleep, you make poorer dietary choices, and this will negatively impact the quality of your microbiome. It will reduce its diversity and change it to a less healthy composition."

Studies in animals can demonstrate some of the interactions between microbiome and sleep, and how they influence each other. In mice, depletion of the gut microbiota via long-term antibiotic treatment alters their wake/sleep pattern, while other studies in mice show that chronic sleep disruption alters the balance of their gut microbes. Even more interestingly, when faecal microbes from mice subjected to intermittent oxygen deprivation –mimicking symptoms of the condition obstructive sleep apnea, which is known to reduce sleep quality – are transplanted to other mice, the recipients develop disrupted, fragmented sleep.

These effects can result in a vicious cycle. For instance, studies in humans show that obstructive sleep apnoea alters the gut microbiome of people with the condition, which in turn exacerbates the symptoms.

"WE KNOW THE MICROBIOME HAS THE POTENTIAL TO HAVE A REALLY LARGE IMPACT ON SLEEP"

But what is the mechanism? There are several routes of communication between our gut microbiome and the brain that could influence sleep. Bacteria can directly correspond with the brain via the vagus nerves, key information routes of the parasympathetic nervous system; they also release inflammatory chemicals that modulate the immune system; and they can produce hormones that affect our circadian rhythms, including sleep/wake cycles.

This all begs the question of whether we could improve our sleep by improving our microbiome. There are early hints that we can. Last year, a trial of 89 adults with poor sleep quality found that taking a probiotic supplement of the bacterium *Bifidobacterium longum 1714* for eight weeks resulted in some improvements in subjective and objective assessments of their sleep quality compared

with controls. This finding is in line with other research, such as a recent metanalysis of 15 trials of probiotics, which found that people taking one for at least four weeks had significantly better sleep quality than those who received a placebo.

Katherine Maki at the US National Institutes of Health says if we are looking to improve sleep, we might want to specifically target microbes that contribute to inflammation. She recommends eating foods rich in fibre, unsaturated fats and polyphenols, as well as not eating too early or late, to improve the capacity of the microbiome to produce substances that enhance sleep quality. "The microbiome, with all its interactions with the immune system, hormones and stress hormones, has the potential to have a really large impact on sleep," she says.

Alison George

» important things: minimise light at night, maximise light in the morning."
Christopher Depner, University of Utah

KEEP COOL
"Sleep science has shown that your body [temperature] should drop a full degree centigrade while sleeping, and so I do try to keep the room very cold and very dark."
Katherine Maki, US National Institutes of Health

EAT AND DRINK AT THE RIGHT TIME
"I try to avoid eating after 9 o'clock at night and having caffeine after 5 o'clock, though how people metabolise caffeine is highly variable from one person to the next."
Sarah Berry, King's College London

SWITCH OFF
"Anything that triggers stress will trigger arousal, a state in which you feel excited or very alert. So you want to avoid stress before bedtime, including checking your emails."
Bill Wisden, Imperial College London

GO DARK
"Personally, I love reading in bed, which is bad because of the light. Computers, scrolling on your smartphone, tablets, all that bright screen light, it just tells your brain to stay awake, so you should really try to avoid that as you're going to bed. But listening to music, for instance, with »

WHAT DO HORMONES DO TO OUR SLEEP – AND VICE VERSA?

IT MAY come as no surprise that hormonal upheaval – say, during puberty or menopause – can play havoc with sleep. But our hormones influence sleep all the time, not just during big changes. What's more, we are starting to see that this relationship goes both ways: as much as our hormones affect how we sleep, how we sleep influences our hormones.

A better understanding of this relationship could improve both our sleep and our general health. But, like a lot of relationships, it is complicated.

There are two basic processes that regulate sleep. The first, known as process S, keeps track of how long we have been awake through the build-up of the neurotransmitter adenosine, a by-product of cellular metabolism. Once enough has accumulated, like sand piling up at the bottom of an hourglass, the pressure to nod off becomes difficult to resist. The second, called process C, is driven by our circadian system, the rhythms of activity in almost all our cells timed to Earth's 24-hour cycle of day and night.

Process C, which is largely regulated by exposure to light, manages this through the release of two key hormones, melatonin and cortisol. Produced by the pineal gland during the dark hours, melatonin tells the parts of the brain that control sleep that it is night, so we fall asleep at the appropriate time. Cortisol picks up where melatonin leaves off, spiking in the morning and boosting our alertness to rouse us out of bed.

Production of these hormones changes throughout our lives. During puberty, melatonin levels decrease, although it is unclear what role this might play in the natural shift in circadian rhythm that many teenagers experience that has them falling asleep later in the night. Cortisol levels can increase with age, which may impact sleep quality and has been associated with a decline in rapid eye movement sleep. For women, who report more sleep complaints than men, the relationship between hormones and sleep is even more complex. For example, decreasing concentrations of melatonin post menopause may be related to difficulty falling or staying asleep and, although the mechanisms aren't yet fully understood, higher levels of follicle-stimulating hormone, which occur during part of the menstrual cycle, for instance, appear to correlate with poor sleep quality.

Over the past decade or so, however, it has become apparent that hormones and sleep have a two-way relationship; it isn't just that hormones control sleep, but poor sleep can also interfere with our hormones in surprising ways.

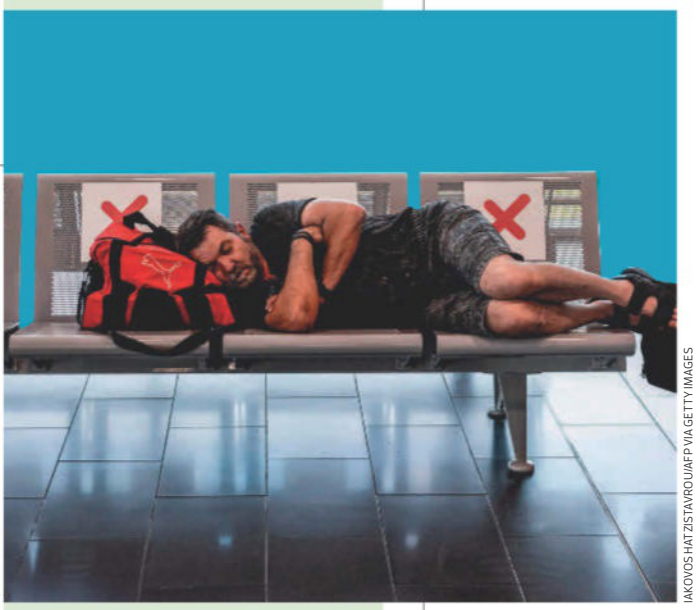
"How the body processes, metabolises and releases various hormones can be disrupted by a lack of sleep," says Marie-Pierre St-Onge, director of the Center of Excellence for Sleep & Circadian Research at Columbia University in New York. For instance, people who experience poor sleep also tend to be deficient in human growth hormone, which is released during deep, or "slow wave", sleep. ›

» your eyes closed, relaxing, something like that can be helpful if you're not somebody who can go immediately to sleep."
Jocelyn Cheng, American Academy of Sleep Medicine

TRAVEL SMART
"When I arrive in a new time zone, I consider my light exposure to try and help myself adapt as quickly as possible!"
Victoria Revell, University of Surrey, UK

BED IS SACROSANCT
"You should use your bed for sleeping and not for lounging in. I've become very good at not watching TV in bed, and I think that helps." **Malcolm von Schantz, Northumbria University, Newcastle upon Tyne, UK**

GO WITH THE FLOW
"Like many people, I go through different stages of sleep. When I was a new mum, my sleep was terrible, but I've gone through that whole patch. So what I would like to say is keep an open mind about your sleep, because sleep does change quite a lot throughout the years."
Nicole Tang, University of Warwick, UK



IAKOVOS HATZISTAVROU/AFP VIA GETTY IMAGES

Trying to sleep your way through jet lag might not actually work

It promotes growth in children and regulates metabolism and supports cellular repair in adults. Studies have also linked poor sleep to hypothyroidism, where the thyroid gland doesn't produce enough of the hormones thyroxin, triiodothyronine and calcitonin, resulting in fatigue and weight gain.

An underactive thyroid isn't the only reason why the consequences of disrupted sleep can be seen in our waistlines. Various studies have suggested that both chronic sleep loss and circadian disruption can affect control of blood sugar levels and how efficiently we digest food, resulting, perhaps unsurprisingly, in a raised risk of obesity and type 2 diabetes. We are just starting to unpick some hormonal mechanisms behind these changes.

For instance, when St-Onge and her colleagues restricted men and women to 4 hours sleep per night for four consecutive nights, they observed a rise in the appetite-stimulating hormone ghrelin in the men and a fall in the satiety-promoting hormone glucagon-like peptide 1 in the women. "At the end of the day, it means the same thing: people are more motivated to eat more, which can lead to increases in body weight and accompanying metabolic disorders," says St-Onge.

Disrupted sleep can cause metabolic changes surprisingly quickly. In one study, Christopher Depner and his colleagues at the University of Utah had participants reduce their sleep to 5 hours a night. "If we measure their insulin sensitivity, which is a risk factor for diabetes, we can see that some people go from perfectly healthy to a pre-diabetic state in three days," he says. Although the effects were reversible with catch-up sleep, it took six to 10 days for these people to return to baseline.

The good news is that it is possible to improve parts of the relationship between sleep and hormones. Our food choices affect how well we sleep (see "How does the microbiome influence our sleep?", page 35). Melatonin, for instance, is produced from an amino acid called tryptophan, which we get from protein-rich dietary sources, so eating more of these ensures that tryptophan is available to produce melatonin when night comes. Light also affects melatonin production, which is why dimming the lights and putting down your phone well before bedtime will help.
Linda Geddes

WHAT'S THE BEST WAY TO BEAT JET LAG?

IN THE first flush of our relationship, my husband began taking a series of photos of me during our travels. In every one, I am asleep: sat on a chair at the Musée d'Orsay in Paris. Head on my chest in the back seat of a car in Kiev, Ukraine. On a train in France, mouth open, drooling. He is lucky I still married him.

Jet lag certainly isn't pretty. Other than leaving you feeling exhausted – or wide awake – at the wrong time of day, a long flight across time zones can also cause gastrointestinal distress, off-kilter body temperature, headaches, irritability and cognitive impairment, all of which are much more serious for people who fly all the time, such as airline pilots. What can we do?

Many of us approach jet lag by prioritising sleep whenever we can, in order to counter the exhaustion. Even the National Health Service website for England recommends that you "change your sleep schedule to the new time zone as quickly as possible", and many of us try to just knock ourselves out on overnight flights (often with the help of over-the-counter medicines or in-flight refreshments).

While this approach isn't always wrong, it can sometimes do more harm than good. Instead, we need to think about jet lag in a more nuanced way, says Steven Lockley, a neuroscientist who was at Harvard University Medical School. "Jet lag really is about the body clock, it's not about sleep," he says.

Jet lag is the result of a sudden misalignment between the body's established circadian rhythms and the environmental day-night cycle at a new destination. "These symptoms occur because our circadian clock, which drives our 24-hour rhythms in nearly all aspects of physiology and behaviour, cannot instantly reset to the new time zone," says Victoria Revell at the University of Surrey, UK. This may seem obvious, but it points towards a different way of dealing with the problem: focus on resetting your body clock as efficiently as possible.

The most powerful way to do that is to strategically control exposure to light. Bright light tells the suprachiasmatic nucleus, a brain structure that sets the internal clock, to suppress the sleep-signalling hormone melatonin (see "What do hormones do to our sleep – and vice versa?", page 37). But the blanket advice to get outside during the day in the new time zone isn't always right. "Exposure to bright light at the wrong time of day can actually push your clock in the wrong direction and prolong jet lag," says Revell.

Imagine you leave New York at 7 pm on a 7-hour flight to London. You land at 7 am local time, but your body thinks it is 2 in the morning. Exposure to bright light at that time would tell your body clock to stay up even later, explains Lockley. "So now, instead of having a 5-hour jet lag challenge, you might have a 6, 7, 8-hour jet lag challenge." In this scenario, he suggests avoiding bright light by wearing sunglasses, even indoors, until around 10 am local time – or 5am in your body's circadian time – to reduce that effect.

Light isn't the only factor worth considering. Research by Revell and her colleagues has found that the best way to reduce circadian misalignment is a combination of strategic light exposure, gradually changing your sleep schedule before travel, and taking melatonin at the right time. Other cues can also help nudge your circadian clock in the right direction, including avoiding heavy meals late in the evening of your home time and taking caffeine early in the day, she says.

Even so, it can be hard to calculate and keep track of when to do all these things, especially when you are tired. There is, of course, an app for that, in fact several, with anecdotal evidence of efficacy, even if clinical trials are lacking. Lockley has developed one of these, called Timeshifter, that runs all the numbers for you, based on your flight plan and sleep patterns, and provides a bespoke timetable. All this starts a few days before your trip, to help minimise the cliff-edge transition from one time zone to another. The algorithms behind the app were partly developed to help astronauts regulate their circadian rhythms while in space.

Another is FlyKitt, which offers similar scheduling, but also recommends a regimen of supplements meant to be taken at specific times to alleviate symptoms of jet lag. These include vitamin C with tart cherry powder and melatonin with magnesium, and there is some evidence that they could help. For example, tart cherry juice – which went viral as the sleep-improving ingredient in TikTok's "sleepy girl mocktail" – was found to increase overall sleep time and sleep efficacy, according to a 2023 analysis of several studies and a small, randomised controlled study. This might work by increasing the tryptophan available to be converted into melatonin (see "How does the microbiome influence our sleep?", page 35). Melatonin can augment light exposure to shift circadian rhythm, but beware: the evidence for other supplements is less robust.

The next time I fly, I am going to focus on shifting my circadian clock – if only to lessen the chance of my husband catching me napping at yet another tourist spot.

Linda Rodriguez McRobbie

PAUL BRIGINSHAW/MILLENNIUM IMAGES, UK

Exposure to light is the most powerful regulator of your circadian rhythm

35%

Percentage of people in the US who have used a sleep tracking app

SOURCE: AMERICAN ACADEMY OF SLEEP MEDICINE

15 to 20

Minutes taken for most adults with healthy sleep patterns to nod off

SOURCE: THE SLEEP FOUNDATION

1/5

Maximum reduction in heart disease risk, if you are sleep deprived, from sleeping later at the weekend

SOURCE:BRITISH HEART FOUNDATION

CAN YOU EVER PAY OFF YOUR SLEEP DEBT?

WHAT'S the difference between your time spent in bed and your bank balance? No, this isn't the start of a terrible joke – and the answer is less than you might think.

We all have the odd occasion when we stay up too late and don't sleep enough. Think of this as the equivalent of splurging on an expensive dinner: you probably shouldn't have, but your bank balance hopefully won't suffer too much.

But regularly going without enough sleep – a problem for many people, with the US Centers for Disease Control reporting that a third of adults there get less than 7 hours a night – could have you racking up a sleep debt, with real consequences for physical and mental health (see "How much sleep is the right amount for you?", page 32). Like paying back a financial debt, catching up on sleep takes planning.

Part of the problem is that we might not know how much sleep debt we have accrued and how badly it is affecting us. In one study, for instance, participants were randomly selected to get 4, 6 or 8 hours per night for 14 days straight. By the end, those getting 6 hours or less exhibited a cognitive deficit equal to missing up to two entire nights of sleep. However, despite feeling worse after a couple of days, from then on the restricted sleepers didn't necessarily notice their cognitive abilities continuing to decline. "The tired brain can't detect how tired it is," says Russell Foster, a neuroscientist at the University of Oxford and author of *Life Time*.

Most sleep scientists will tell you that if you need an alarm clock to wake up, ›

JEAN GAUMY/MAGNUM PHOTOS

Strategic napping can aid recovery from sleep deprivation

"YOU COULD TRY BANKING SLEEP AHEAD OF TIME"

you probably aren't getting enough sleep. But there are other questions to ask yourself, says Foster: "Do I oversleep at weekends? Do I oversleep when I go on holiday? Have my friends or family commented on changed behaviours such as irritability, lack of social connectivity?"

It doesn't take long to start seeing negative effects from shortened sleep – and it can take time to recover. In one recent study, 83 adults were allowed a restful night of 12 hours in bed. They were then either deprived of sleep for 36 hours or had it restricted to just 4 hours a night for five consecutive nights. Both groups experienced significant cognitive decline, as well as decreases in energy and reaction times, during their sleep trials. Participants then had four nights of recovery sleep, with 12 hours in bed each time. Although their cognitive function was more or less restored after one night, those in the sleep-restricted group still had impaired reaction times even after four nights of recovery and the sleep-deprived group never recouped its energy levels in that time.

This is bad news when it comes to the strategies that many of us use to pay down sleep debt: sleeping in at the weekend and the odd nap might not be enough to undo the damage.

Though studies have linked sleeping more at the weekend with everything from an increased risk of heart disease to worse period pain, more recent studies have brought better news. One found no increase in mortality or cardiovascular disease risk, while another revealed that staying in bed longer like this could cut the risk of heart disease by a fifth compared with remaining sleep deprived.

While the jury is still out on the health impacts, it is also unclear whether sleeping in is an effective strategy. When people try to catch up at the weekend, they are often unable to fully pay back the debt. Work by Christopher Depner at the University of Utah and his colleagues found that when people got the chance to sleep in at the weekend, they stayed up and slept in very late, some until 2 or 3 in the afternoon. By Monday morning, this could leave people with "social jet lag" that is equivalent to waking up on the other side of the US, says Depner.

The truth is, we aren't sure what is the best option for paying down that sleep debt, says Depner. "Getting more sleep is typically going to be better, so I think we're hesitant as a field to recommend that you shouldn't get more sleep on the weekend. I think the reality is, we just don't know exactly the best way to do it."

That said, if you are trying to catch up on missed sleep, a good approach may be to add a bit of extra sleep around the hours you usually go to bed and wake up, rather than in a large dose one morning. If you do try to reduce sleep debt at the weekend, the US National Sleep Foundation says to sleep for just 1 or 2 hours more than you would during the week.

If you are still in arrears, take some tips from the US military, which suggests its soldiers use "tactical naps" to boost performance during operations. Research suggests that short sleeps can help bolster recovery in situations where longer, consolidated sleeps aren't possible; Foster recommends napping for no more than 20 minutes and not too close to bedtime.

The military also suggests "sleep banking", topping up the coffers before going into a period where you aren't likely to get adequate rest. Going to bed earlier or waking up later than usual in the weeks beforehand can help foster resilience against the negative effects of sleep debt and aid recovery from sleep deprivation.

Although it may not always be within our control, the ideal would be to avoid building up a sleep debt in the first place. "It's all about taking sleep seriously. In an already over-packed day – children, work and all the rest of it – what's the first victim? It's always sleep," says Foster. "I think we've got to possibly be stronger about saying: 'Nope, I've got to get my sleep.'"

Catherine de Lange

1/3

The proportion of adults in the US who report not getting enough rest or sleep

SOURCE: US CENTERS FOR DISEASE CONTROL

300%

Maximum increase in heart disease risk in adults who sleep no more than 5 hours a night

SOURCE: UNIVERSITY OF CHICAGO MEDICINE

34%

Percentage of those aged 7 to 16 in England who had a problem sleeping on three nights out of seven

SOURCE: NHS ENGLAND

PAUL RYDING

"The moon is like Earth's attic"

The moon is thickly coated in dust. Planetary physicist **Philip Metzger** tells Swapna Krishna how we can deal with its dangers and use it to build amazing things

Any astronauts reaching the surface of the moon will be greeted first by a plume of dirt, sent flying by the boosters of their spacecraft. They will emerge and put bootprints in the dirt, take samples and study the dirt, and eventually they may use the dirt to make the fuel and other supplies needed to maintain a long-term lunar presence. When it comes to exploring the moon, it's all about dirt.

Planetary physicist Philip Metzger at the University of Central Florida is the king of moon dirt, or regolith. In 2013, he cofounded a group of research labs at NASA's Kennedy Space Center, Florida, where research teams spend their days working with artificial lunar regolith, like the sample pictured below, to learn how it behaves and what we will be able to do with it. With NASA's Artemis programme aiming to put humans back on the surface of the moon in 2027 and eventually set up a permanent base there, that knowledge is becoming increasingly important.

Regolith will be both a danger to astronauts as they land and a crucial resource as they build. Metzger works with scientists at a variety of labs who are figuring out how to protect astronauts and their dwellings from the pointy, perilous dust grains and how to use the dirt to make rocket fuel and radiation shielding.

He spoke to *New Scientist* about what a permanent human presence on the moon might look like, why regolith is so important to that vision and how understanding this thick layer of rubble could even unveil the secrets of Earth's past.

Swapna Krishna: What first got you excited about working with regolith?
Philip Metzger: I was doing a field test of lunar robot prototypes in Hawaii, up on the volcano Mauna Kea, back in 2010. I was thinking about how it was so dry and cold on that mountain and there was very little vegetation, and that was kind of like the moon. That's why we were testing on it, because it was similar to the moon. I got to thinking, you know, not much life can exist this high up the mountain naturally, but we're creating these robots that serve other robots. We were testing robots that would make oxygen out of the soil, and then other robots would get the oxygen to be able to drive, and others could make fuel to launch rockets.

It's kind of like we're making a little ecology, like life that's adapted to being in a waterless place. And, well, that's really what it's going to take. If we're going to cross that ocean of space to these other islands, we need life to go ahead of us to prepare it.

Which is what we're doing: developing an artificial life, an artificial ecology that can reproduce using local resources, but without water. That got me all excited thinking about it.

NASA is preparing to land astronauts on the moon with its Artemis III mission – what will they face on that landing?
There are problems with landing because the rocket exhaust is going to blow around the soil, and that can obscure your view. Your sensors can't see the ground as well.

With a very big rocket, you could even create a hole. We didn't produce any holes under the landers during the Apollo programme, but with these larger rockets, if you have nozzles that go close to the ground with a lot of thrust, it could dig a deep hole and could cause a direct tipping hazard for the rocket. When you shut your engine off, that hole is going to collapse. It will cave in and then your rocket can tip.

The second problem is, once you've shoved the soil down to create a deeper hole, the gas goes down in the hole and has to come back out again. You're shooting sand and rocks and dust right back up at your rocket, so you can immediately damage your rocket with rock impacts.

"You have to land on it, drive on it, dig in it, build with it and study it"

SPACE RESOURCE TECH

What are some of the other things astronauts will have to figure out with regolith after landing?
I like to say you have to land on it, drive on it, dig in it, build with it, extract resources from it and study it.

Landing on it is first. Then comes driving on it – we want to make sure vehicles don't get stuck. We dig in it to explore what's under the surface and collect regolith as a resource. But we're trying to dig in super low gravity, so how do you get enough force when you push a bucket through the soil? On Earth, the wheels of a rover on the ground will keep you from going backwards, but there isn't much force on those wheels on the moon because the gravity is so low. This is why we're working on techniques for low-gravity digging.

Then, you want to build with the regolith. Eventually, we want to start to build landing pads. We want to extract resources like oxygen and ice for rocket fuel. And of course, from the very beginning, we want to be studying it.

How do we figure out how to do all these things, with so little actual moon dust to work with on Earth?
Researchers at the Florida Space Institute's Exolith Lab, which is one of the labs I visit frequently, went all over North America finding all the right mines to get the right minerals so they can crush them and mix them in the right proportion so that it'll be just like the mineralogy of lunar soil. They're crushing all these different kinds of rocks and mixing them in cement mixers. My team and I then regularly go into this giant arena where we have loads of simulated soil and test rocket exhausts blowing on it or robots driving on it.

One of the goals of all this research is supporting a long-term human presence on the moon. What do you think that will look like?
One problem is that because of the radiation, you'll have to be underground. I don't think people are going to want to live their entire life in a cave. I think people will live in space stations orbiting around the moon that rotate so there's artificial gravity, and they will teleoperate robots down on the surface.

But people will be going down for short periods, maybe for a month at a time. So they'll fly down to the moon and live in a habitat. The habitat is probably covered with regolith so that it is radiation shielded. And they'll be able to go out on spacewalks to do geology or work on the robots.

MARK GARLICK/SCIENCE PHOTO LIBRARY

Future astronauts may call huge rotating space stations home

After their week or month or however long on the surface, they'll go back up to the space station, where they might stay for a year before coming back to Earth.

I think, eventually, when we have really large industry in space with a lot of robotics, then we'll be able to build truly gigantic habitats in space where people can live long term. They'll be large enough so that, psychologically, you won't feel cramped. But it's going to take decades, if not a century, of building robotic industry in space before we can build structures that large.

Is it really worth it or even feasible to mine resources and create rocket fuel on the moon?
Absolutely. I get frustrated by those people who claim it's never going to be economically viable. They were saying, "[SpaceX's] Starship is going to be so cheap to launch, we can just use it to send rocket fuel into space from Earth". I would argue back, yeah, but if it's so cheap to launch, that means the equipment for mining can also be launched very cheaply too.

The moon is 42 per cent oxygen by mass. It's a great big giant ore body of oxygen up there in the sky. And the biggest cost of space flight is launching oxygen. When you launch a big tank of rocket propellant into space, 80 per cent of that weight is oxygen – if you can get that oxygen from the moon, that's a huge saving.

The cost of making rocket propellant on the moon is going to go down faster than the cost of launching it from Earth. Now, it may take a few years before it's cheaper to bring it from the moon all the way down to low Earth orbit. But it'll immediately be cheaper to use rocket fuel made on the moon for spacecraft in lunar orbit.

What else can we use regolith for?
Another thing you can do is make metal for use in building habitats and other structures on the moon. You can make magnesium, iron, aluminium and titanium using some of the minerals in regolith. You can also simply scoop regolith up and use it as a building material.

As well as this, in the soil at the poles of the moon, there's ice. We need water for a lot of things – we need it for life support, we need it for agriculture. Now, there are challenges there because regolith has a lot of metals in it and its grains are very sharp. That's unlike the grains of soil on Earth, which are a lot more rounded thanks to natural weathering. We have people in our lab researching how to use lunar soil as a plant growth medium, because the angular, fine particles and the heavy metals are problems for that, as is the lack of organic material.

Another big use is just doing science.

What sort of science can we do with moon dust, aside from learning about the moon itself?
The moon is like Earth's attic. If you go to an old house that's been around for a couple hundred years, go up in the attic and there are all these antiques and the family history is up there.

Well, here on Earth, a lot of the history of the planet gets destroyed because of weathering and tectonics recycling the crust. But the moon has no water cycle to destroy the rocks, and it has no plate tectonics. So there's a lot of history of our solar system stored in the regolith of the moon.

For example, we think the ice on the moon came from comets, and they may have been the result of a bombardment that occurred more than 3 billion years ago. We think that this bombardment may be crucial to understanding how life can exist on Earth, because that may be what brought water to our planet.

If we want to find out the history of what caused that bombardment, then we need to go to the moon, study that ice and study the craters there. If we can understand how Earth became a habitable planet, then that'll help us to understand what fraction of other planets out there in the cosmos might also be habitable. Answering the question of whether there could be life elsewhere in our galaxy, that's an answer that we're going to get by studying the soil on the moon. ▮

Swapna Krishna is a science journalist based in Pennsylvania, specialising in space and technology

The back pages

Dear David

Drying up

A reader is worried about socialising without alcohol. Our scientific advice columnist **David Robson** has some reassuring answers

David Robson is an award-winning science writer and author of *The Laws of Connection: 13 social strategies that will transform your life*

Further reading

If you are concerned about your drinking, the National Health Service offers some eminently practical advice on the ways to cut back: nhs.uk/live-well/alcohol-advice/tips-on-cutting-down-alcohol/

Dear David, an evidence-based advice column, appears monthly. Drop David a line with your social dilemmas at davidrobson.me/contact

Next week

Stargazing at home

FOLLOWING the excesses of the holidays, many of us have opted for a Dry January. One reader tells me she hopes to keep cutting back on her drinking after the month ends, but she is worried about socialising. Alcohol raised her confidence with others and she is nervous about living without booze to lubricate her interactions.

I imagine this is a very common concern, but a survey of 342 US college students by Christine Lee at the University of Washington in Seattle and her colleagues might help to allay these worries. Through a series of phone interviews over four two-week periods, the team built a picture of participants' expectations of the ways their drinking would make them feel and their actual experiences.

"On afternoons students reported expecting more subjective positive alcohol-related effects to occur, they were more likely to report experiencing those same effects later in the day as a result of drinking," the researchers concluded. The results suggest that much of alcohol's positive effects – including the increased self-assurance – arise from a self-fulfilling prophecy, a fact that remained true even when the researchers controlled for the quantity of alcohol consumed.

The team's findings chime with the results of a study by Laurent Bègue at Grenoble Alpes University in France and his colleagues. Participants were first given a strong-tasting grapefruit and grenadine drink, and then asked to record a video of a speech promoting the product. Afterwards, they rated how bright, original, attractive and funny they believed they had been in the clip.

IAN DAGNALL/ALAMY

Here's the twist. Half the drinks contained alcohol, while the others were zero per cent. Crucially, the labelling was deceptive – so some people thought they were drinking a cocktail when they were really drinking a mocktail, and vice versa. Those expectations tended to matter more than alcohol content in determining how confident participants felt.

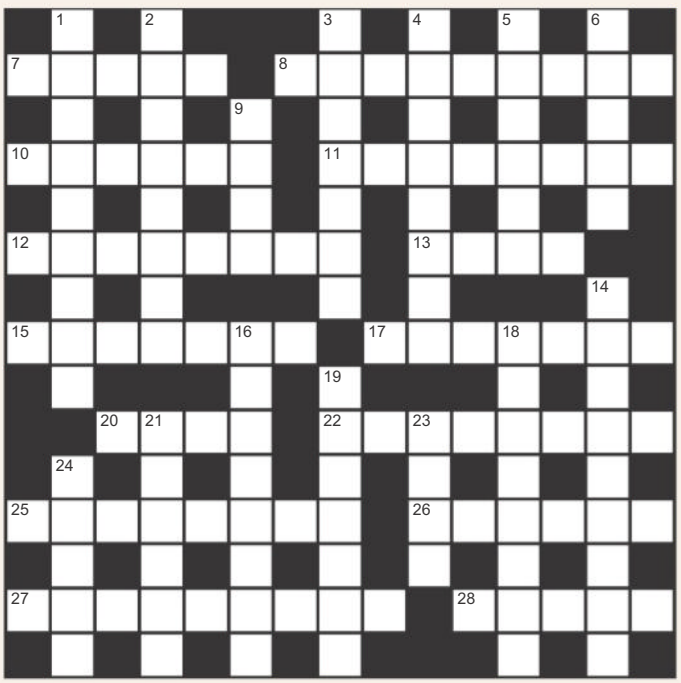
Perhaps most reassuringly for my reader, Bègue also asked judges to rate how well they believed the participants had performed – and the presence of alcohol made no difference.

Together, these results should help us recognise that we needn't depend on alcohol as a social crutch: the chemical itself isn't necessary to release our inhibitions. I find this interesting in light of research on "open-label placebos", where people often benefit from a dummy pill despite knowing that they aren't taking the active substance. There is something about the ritual that seems to work – and that may be equally true with our perceptions of chemical courage.

Whatever your tipple, it is worth remembering social confidence builds with practice. Teetotal or not, we can all raise a glass to our capacity for growth. Cheers! ▮

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

Quick crossword #175 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

7 Fred ___, British astronomer (5)
8 Orientation device (9)
10 Neck swelling (6)
11 Inflammation in the nose (8)
12 Animated US sci-fi series, 1991-95 (4, 4)
13 ι (4)
15 Fm (7)
17 Stomach part connected to the duodenum (7)
20 Numeric datum (4)
22 Dark marks on the solar surface (8)
25 Electronic musical instrument (8)
26 Soviet space-flight programme (6)
27 Three-armed intersection (1-8)
28 Alloy (5)

DOWN

1 Device that measures radiant heat (9)
2 Pt (8)
3 Prefix denoting –OH (7)
4 Capacity for motion, in an organism (8)
5 Metamorphic rock (6)
6 Concerning vision (5)
9 Component of an organism (or spreadsheet) (4)
14 Brno-born logician (4, 5)
16 Last (8)
18 Antonym (8)
19 Tic-tac-toe (2, 3, 2)
21 Alan ___, computing pioneer (6)
23 Appearance of a seemingly new star (4)
24 Conifer in the cypress family (5)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #286
set by Corryn Wetzel

1 What was the first animal to have its genome fully sequenced?

2 When was the last time Halley's comet was visible from Earth?

3 What is the principle that explains lift created by an aeroplane wing?

4 Which has the greatest atomic mass: lead, plutonium or uranium?

5 What is the name of the sequence in which each number is the sum of the two preceding ones?

Answers on page 47

BrainTwister
set by Christopher Dearlove
#57 Prime jumps

If we start with 21 (which isn't a prime number), how many times do we have to add 100 before we reach a prime number?

Which numbers below 100 can never be made to reach a prime number by adding multiples of 100?

Returning to the case of 21: one other non-prime below 100 needs the same multiple of 100 added to it to reach a prime. What is it?

Solution next week

Feeling contagious

There are good and bad bacteria, but are there any good viruses? And what would happen if all viruses disappeared?

Ron Dippold
San Diego, California, US
There are technically no "good" or "bad" viruses or bacteria – they are completely amoral and selfishly work towards reproducing. Like giant corporations, every bacterium (such as *E. coli*) or virus (such as SARS-CoV-2) would completely engulf Earth if it could, with zero concern for harm done. Because we are also selfish, we just categorise them as "bad" to mean "mostly harmful to us", "good" for "mostly helpful to us" or "neutral".

There are many viruses that are harmful to us, like most variations of herpes, but there are indeed "good" viruses. Many of those are known as bacteriophages, which specifically target bacteria, including those that are bad for us. Most of us have a resident gut virus called crAssphage, which doesn't appear to cause any diseases, but seems to keep a common group of bacteria – *Bacteroides* – under control. Not because it is trying to help

"One type of herpes seems to fight listeria food poisoning, and the cowpox virus was used to make people immune to smallpox"

us (viruses are effectively robots), but because it has specifically evolved to target these bacteria and our guts have a lot of them. However, crAssphage are helpful to us, so they are "good".

One version of herpes seems to fight food poisoning caused by listeria bacteria. The cowpox virus was used to make people immune to smallpox. Indeed, there is quite a bit of work on the use of viruses to kill antibiotic resistant bacteria and on the use of oncolytic viruses that selectively infect cancer cells to treat tumours. We would certainly consider those good.

There is much evidence that, in the past, certain viruses actually became integrated into certain cells in our bodies. The *Arc* gene in human brain cells is vital for learning and can behave in a way usually seen in viruses, moving its genetic material from cell to cell, suggesting it came from a virus at some point. There is also evidence that viruses have helped certain bacteria by transferring helpful genes to them. Viruses don't hate or love, they just reproduce, and with vast numbers of them messing with the DNA of so many cells (bacterial ones or ours), improbable things happen, some of which might turn out to be evolutionarily beneficial.

As for what would happen if all viruses suddenly disappeared, most complex life on Earth would die very soon. Consider your own body. If you are of average size, you contain an estimated 30 trillion of your "own" cells, plus 38 trillion resident bacteria and 380 trillion viruses. Yes, more bacterial cells than "you" cells, and 10 times more viruses! What you consider "your" body is, in fact, home to many selfish organisms. The key is that you cells and guest cells establish an uneasy symbiosis or at least tolerate each other.

You get sick when things get out of kilter, like the SARS-CoV-2 virus gets in or your immune system weakens and *E. coli* runs rampant. As mentioned, those 380 trillion viruses are mostly there to prey on the 38 trillion bacteria.

With the viruses completely gone, the bacteria would completely overwhelm our immune systems and you would have dozens of fatal or crippling illnesses at once. Certainly, you wouldn't be able to digest food.

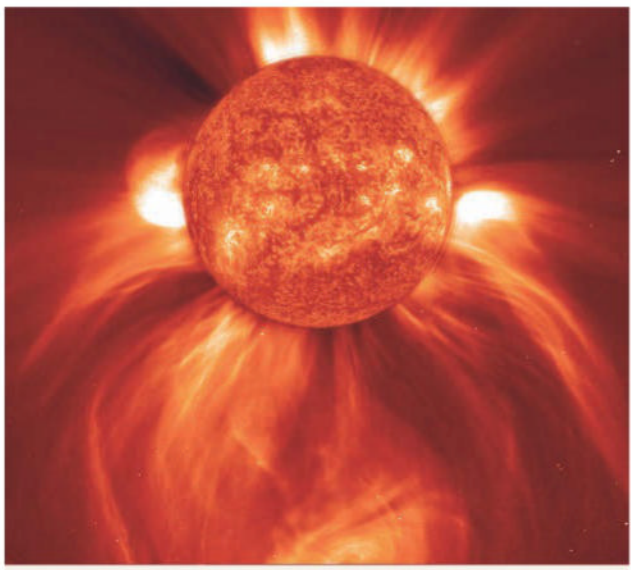
This would also be the case in other animals and in plants. And if all viruses were gone, bacteria in waterways and oceans could multiply explosively. In the end, there would still be some single-celled life left, and maybe even some multicellular forms (tardigrades?), but life as we know it, which has evolved with viruses for 4 billion years, would be over.

Alex McDowell
London, UK
Bacteriophages are viruses that prey on bacteria. They can infect pathogenic bacteria in the body naturally or can be introduced artificially – a use that may have to grow due to the increasing problem of antibiotic resistance.

In nature, viruses can insert genes into cells they infect and thus assist evolution. This ability is also useful in gene therapy, where modified viruses are used to get therapeutic genetic material into people, for example to treat cystic fibrosis.

The virus that causes myxomatosis has been used to control rabbit populations – you could argue it is a "good" virus.

Many diseases would be eradicated if all viruses vanished, but, according to the hygiene hypothesis, lack of exposure to germs can lead to allergies and autoimmune diseases.



ESA/NASA/SOHO

Would a coronal mass ejection like the Carrington event affect the electronics in aircraft?

This week's new questions

Dramatic flare **If there were a solar storm as strong as the Carrington event of 1859, would it knock out the electronics in planes so they couldn't land safely?** ***Barry Cash****, Bristol, UK*

Steel banned **Would it be possible to have an advanced technological society without abundant iron?** ***Robert Bodnaryk****, Winnipeg, Canada*

Being nosy

Why do our nostrils point down while those of most mammals point straight out from their face? (cont.)

Gerald Legg
Hurstpierpoint, West Sussex, UK
I read with interest the reasons previously suggested for why

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

human nostrils point down rather than facing forward. As an undergraduate in the late 1960s, I was told that it was a result of our brains and upright posture. This is connected to the human foramen magnum – the opening in the base of the skull that allows the spinal cord to link to the brain – ending up oriented such that our neck bones ultimately joined with the skull at right angles compared with most other mammals.

Primate brains grew larger and the expanding brain tissue forced the skull forward and downward, flattening the face. This had a number of consequences: the nose was shortened, squished and the nostrils ended up pointing down, resulting in incoming air having to do a U-turn on its way to the lungs; the jaw also shortened and the teeth became crowded.

Simon Dales
Oxford, UK
It looks like the reason for this is because we have such flat faces. Other animals have longer top jaws onto which they can fit their nasal structures. We can't do this because our jaws are so short, so our nasal cavity needs to bend to fit. Even so, it is still rather short, so it needs an extension. Hence a (mostly cartilaginous) nose.

"Thin, bony projections on the front of our bodies aren't a good idea because there is a risk of bashing them on things"

Thin, bony projections on the front of our bodies aren't a good idea because you tend to bash them on things. This is possibly why humans don't have bacula, otherwise known as penis bones.

The advantage of a flat face is that our heads balance nicely on top of our necks, so we can run or walk long distances in search of dinner. Increased food supply then allowed for larger brains, making us cleverer, so we could invent cooking, which meant we could chew and digest what we eat with less effort. So, jaws and guts got smaller as hominids evolved towards our form. Bodyweight dropped, so more of the energy from food could support even bigger brains, and so on. Oh, and downward facing nostrils keep the rain out too.

Red or blue pill

Is there any scientific evidence disproving the notion we are part of a vast simulation run by an advanced civilisation? (continued)

Alan Hewer
Seaford, East Sussex, UK
I suspect the strongest evidence against our living in a simulation is time. The concept of computers, simulations and the means to produce them have only been around for less than a century. Go back around 200 years and Morse code appeared to be the last word in global communication, but is rarely used today.

The likelihood that any of our current technologies would be utilised by an alien race, possibly billions of years in advance of us, seems inconceivable.

Answers

Quick quiz #286 *Answers*

1 The nematode worm (*Caenorhabditis elegans*)
2 1986
3 Bernoulli's principle
4 Plutonium
5 Fibonacci sequence

Cryptic crossword #153 *Answers*

ACROSS 1 Ring of fire, **8** Propane, **9** Drill, **10** Elan, **11** Pinnacle, **13** Sterol, **14** Pewter, **17** Nose hair, **19** Cyan, **21** Rinse, **22** Italics, **23** Cartouches

DOWN 2 Iron Age, **3** Guar, **4** Faerie, **5** In danger, **6** ENIAC, **7** Blueprints, **8** Pleasantry, **12** Cochlear, **15** Thymine, **16** Libido, **18** Sonic, **20** Talc

#56 Square sums by four *Solution*

The first number is 7, for which $1^2 + 2^2 + \ldots + 7^2$ is 140.

The remainder (on division by 4) of $1^2 + 2^2 + \ldots + 20^2 = 2870$ is 2.

The remainders will follow the pattern 1, 1, 2, 2, 3, 3, 0, 0, then repeat. Adding the square of an even number doesn't change the remainder on division by 4, since the even number is a multiple of 2, and so its square is a multiple of 4.

Adding the square of an odd number will increase the remainder by 1, since odd numbers are of the form $2n+1$ and their squares are therefore $4n^2 + 4n + 1$, which is one more than a multiple of 4.

Jurassic Feathered Park

The wheel of time turns, the cycle repeats and another *Jurassic Park* movie is coming out this year. Feedback has faint hopes due to the presence of director Gareth Edwards, who proved in *Monsters* and *Godzilla* that he can direct films featuring huge creatures. But still, yawn.

While we all wait with bated breath, YouTuber CoolioArt is supplying dinosaur footage to keep us sated. They are using the animation tool Blender to redo key scenes from the original *Jurassic Park*, in order to give the *Velociraptors* feathers. So far, they have done the kitchen scene and the climactic scene in the visitor centre (just before, spoiler alert, the *Tyrannosaurus rex* saves the day).

Given the amateur nature of the project, the animations are really good. However, one problem remains: the raptors are still way too big. You see, despite his reputation for careful research, *Jurassic Park* author Michael Crichton was a bit prone to getting things badly wrong.

Crichton's biggest scientific fail was arguably his 2004 climate change novel *State of Fear*. This features environmental terrorists who fake natural disasters to convince the world of the dangers of global warming. They have to do this because, in the universe of the book, all the scientific evidence that greenhouse gas emissions are heating up the climate is flawed or faked.

There is even a series of pages entirely dominated by graphs from weather stations in the US that show local temperature declines, and which are meant to be more meaningful than the trend in the average global temperature for some reason. Crichton also recycles the myth that the warming trend is an artefact of "urban heat islands". It's like a terrible Reddit thread in book form.

Even *Jurassic Park*, Crichton's most famous creation, wasn't immune. He wanted to feature a dromaeosaurid dinosaur, as they were understood to be fast and intelligent hunters – contrasting with the lumbering *T. rex*. Unfortunately, the scariest ones had a name that Crichton didn't think was cool – *Deinonychus antirrhopus* – so he used every detail of that species but incorrectly called them *Velociraptor*.

That's why, in the books and films, an adult *Velociraptor* is about as tall as a human being. In reality, a *Velociraptor* was about as tall as a turkey. Feedback imagines that an angry *Velociraptor* could still cause problems for a human being, but it's just not the same when the terrifying predator is about the size of the average toddler.

The irony is that the evidence that dromaeosaurids had feathers was pretty equivocal in the 1990s, so it was justifiable to present the raptors as featherless – but not to triple their height.

Which explains why CoolioArt has overdubbed some of the dialogue in the kitchen clip. When the girl whispers "What is it?", a female voice dubbed over the boy's now cheerily says "It's a *Deinonychus*". 10/10, no notes.

Twisteddoodles *for New Scientist*

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

AI for rOAds

Sometimes, on a grey Monday when the column is due, Feedback can be found hastily scratching around for story ideas because nobody has done anything especially silly within sight of us. However, on Monday 13 January the following item dropped into our lap.

The UK government announced that it was going to "unleash AI" because of its "vast potential" to improve the country's decaying public services. This vision of the future is called the AI Opportunities Action Plan. Feedback feels that the name could have used a bit of work: it abbreviates to AIOAP, which sounds like the *Terminator* movie Arnold Schwarzenegger will make when he's 85 and an old-age pensioner himself.

The AIOAP contains a lot of proposals, one of which caught Feedback's eye. According to BBC News, "AI will be fed through cameras around the country to inspect roads and spot potholes that need fixing".

Like a rabbit caught in headlights, or, more aptly, like a driver heading straight for a pothole because they're being tailgated and there's no room to steer, Feedback found ourself staring blankly forward into space, stunned by the visionary nature of this vision.

It's not that we doubt that AI could be trained to spot potholes. On the contrary: it would probably do it rather well. Instead, we are concerned that this might be solving a non-existent problem.

The BBC reported in March 2024 that English and Welsh roads are blighted by potholes, with a backlog of repairs estimated to cost £16.3 billion. That is a long way short of "Elon Musk buying Twitter" money, but it's still roughly equivalent to the GDP of Jamaica. Furthermore, Feedback can attest to a deep familiarity with the numerous potholes in our local area, many of which have gone unrepaired for months.

The problem, in short, doesn't seem to be lack of knowledge about where the potholes are. We wouldn't have a backlog that would cover the cost of building several skyscrapers if the potholes weren't being logged. This is doubly so for any road busy enough to have cameras on it.

Instead, the problem seems to be getting the actual repairs done. Feedback doesn't see how the AI will help with that. No, we need to turn to genetics.

The only solution is an army of Ron Swanson clones to go and fill the potholes.

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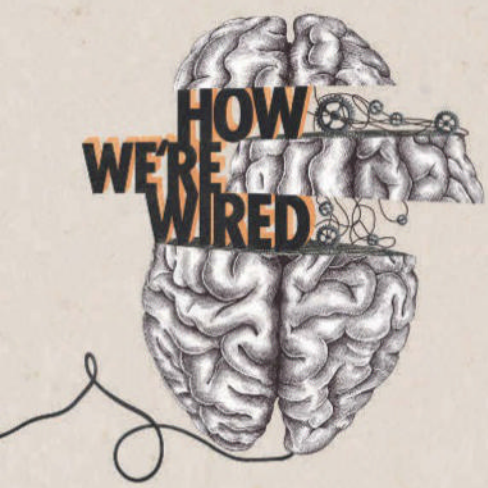

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‘Bel Can-do’

In November 2022 we introduced the Bel Canto. Instantly making haute horology accessible. This subtly chiming timepiece caused a cacophony. And enormous demand. (The first 600 sold out in 8 hours.) Asked could we produce 5,000 annually, our Swiss CEO Jorg Bader Snr replied: “No. But we’ll find a way.” Because that is our way. Today, our supply chain is as fit for purpose as the gear chain of the new Bel Canto Classic. Which features a dressed-up dial. A dialled-down handset. And a gorgeous guilloché finish, with a precision only achievable (and affordable) using a femto laser. Outward displays, we like to think, of inward grace.

(Bel Can-)Do your research

Christopher Ward

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