New Scientist

**WEEKLY** April 26 - May 2, 2025
No3540 US $7.99 Canada CAN$9.99

SPECIAL REPORT
**THE POLAR CRISIS**
The dramatic global impacts of shrinking sea ice
*The race to drill the deepest-ever ice core*
Why exploiting the Arctic won't lead to riches

# RETHINKING PARKINSON'S

## Why it might be two conditions, not one – and how this radical idea could lead to new treatments

## LIFE ON AN EXOPLANET?

What to make of the strongest hints yet of alien biological activity

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

Discovery Tours

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# Uncover the mysteries of the world with leading experts

## Land of fire and ice: Iceland

**9 June 2025**
**18 October 2025**
**18 days**

Discover the awe-inspiring might of the planet and marvel at the sights, sounds and smells of erupting geysers, hot springs and bubbling fumaroles. Get up close to majestic glaciers, waterfalls and tectonic plates as they pull apart and learn about remarkable geological processes and volcanology from the accompanying expert.

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- Explore the famous Jokulsarlon Glacier Lagoon, a beautiful sea of floating icebergs
- Spend time exploring the Reykjanes Peninsula to see where two tectonic plates meet and the volcanic fissures created

## Ancient caves, human origins: Northern Spain

**17 June 2025**
**26 August 2025**
**7 days**

Venture into the depths of history to witness some of the earliest expressions of human creativity in an idyllic part of northern Spain. Explore how our ancestors lived, played and worked. From ancient Palaeolithic art to awe-inspiring geological formations, each cave tells a unique story that transcends time.

- Visit historically important caves, including Las Monedas, El Castillo, El Pindal, Tito Bustillo and La Peña
- Throughout this tour you will be accompanied by local archaeological experts and cave custodians, who will provide insight into the history and significance of the sites visited
- Discover local cuisine and explore the beautiful towns and cities of Santander, Oviedo and Bilbao

## The birth of modern medicine: Paris, France

**20 July 2025**
**5 days**

Discover the foundations of medicine in Paris, where the 'Paris School' of hygiene and hospital teaching flourished. From mummified écorché figures to bone-lined catacombs, the early history of medicine is sometimes gruesome but always fascinating. Be introduced to key figures including Louis Pasteur, who pioneered the first vaccines and Rene Laennec, whose stethoscope is still a symbol of medical professionals today.

- Discover Paris's role as the leading European centre of 18th century medicine, from the churches that administered the first hospitals to medical developments during the French Revolution
- Experience the beauty and tranquillity of the architecture and gardens of Paris
- Visit the Musée Curie, a small but significant museum dedicated to the life and groundbreaking scientific work of Marie Curie and her family

**Find out more at newscientist.com/tours**

LAST FEW PLACES REMAINING

## The science of primary rainforests and wetlands: Malaysian Borneo

**10 August 2025**
**10 days**

Discover Malaysian Borneo's amazing flora, fauna and geology and learn firsthand from local conservationists how it is being protected. Explore primary rainforests and wetlands, including the iconic Kinabatangan river, Tabin rainforest and Danum valley, home to some of the world's most biodiverse habitats.

- Search for orangutans, sun bears, proboscis monkeys, gibbons, civet cats, langurs and many more iconic species in their natural surroundings
- Enjoy wildlife safaris, cruises, treks and evening walks through hectares of pristine and undisturbed tropical rainforest
- Stay in secluded lodges and nature resorts nestled deep within lush forest reserves, offering an immersive experience in Borneo's wilderness

## Dinosaur hunting in the Gobi desert, Mongolia

**16 August 2025**
**15 days**

Embark on an exhilarating and one-of-a-kind expedition to uncover dinosaur remains in the vast wilderness of the Gobi desert. Participate in live prospecting and fossil digging across keys sites, with the potential to witness a significant palaeontological discovery. The expedition will also delve into the desert's unique geological formations, providing a comprehensive understanding of the fossilised record.

- This hands-on experience offers the unique opportunity to contribute to significant scientific discoveries, while exploring the region's fascinating geology and ancient ecosystems
- Venture to the iconic Flaming Cliffs, a dramatic landscape where the first dinosaur eggs were uncovered
- Spend time exploring the museums, sites and laboratories of the Mongolian Institute of Palaeontology

## Astronomy and culture through Silk Road cities: Uzbekistan

**23 August 2025**
**14 days**

Embark on a fascinating journey through Uzbekistan, where the rich history of astronomy intertwines with vibrant cultures and vast landscapes. Explore the pivotal role the silk road played to astronomy, the historical trade route that facilitated the exchange of scientific knowledge and astronomical advancements across Eurasia.

- Visit the enchanting cities of Samarkand, Bukhara and Khiva, each a jewel of Uzbekistan's rich history
- Discover the Ulugh Beg Observatory, an extraordinary site where the pioneering astronomer Ulugh Beg established his observatory in the 1420s
- Stargaze in clear desert skies that provide incredible views of constellations, planets and celestial phenomena

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# This week's issue

## On the cover





Vol 266 No 3540
Cover image: Sunnu Rebecca Choi


**Special report: The polar crisis**





**"Evolution can begin in systems that we wouldn't normally consider to be alive"**

## News



## Views




SRIVATSAA/GETTY IMAGES



## Features



## The back pages

# Elsewhere on New Scientist

## Online event

### Detecting black holes

Despite the mysterious nature of black holes, observational evidence suggests they are incredibly abundant in our universe. Join theoretical physicist Delilah Gates as she reveals how black holes can be observed and studied using wave-related phenomena, including frequency shifting of light and space-time ripples. This online event takes place on 10 June at 6pm BST / 1pm EDT.

**newscientist.com/events**

## Tour

### In the footsteps of von Humboldt: Ecuador

Retrace part of naturalist and explorer Alexander von Humboldt's 1802 expedition through Ecuador's Avenue of the Volcanoes, and head onwards into lush cloud forests. Humboldt was a key influence on Charles Darwin's theory of evolution. This eight-day tour starts on 21 July and costs £3349. An extended 11-day tour starts on 14 August 2026 and costs £4850.

**newscientist.com/tours**

## Podcast

### Weekly

The team are joined by climatologists Friederike Otto and Joyce Kimutai to discuss the extent to which we can blame climate change for extreme weather events. In a bonus episode, the team unpack the purported finding of a chemical, which can only be produced by life, on an exoplanet 110 light years away from Earth.

**newscientist.com/nspod**


SHUTTERSTOCK/ITVEN

**Event horizon** Ripples in space-time reveal the nature of black holes


SHUTTERSTOCK/MIGUEL LINCANGO

**Mountain toucan** Go birdwatching in pristine Andean cloud forests

## Video

### Science of magic

Magicians have long exploited quirks in our perception of the world to make us experience the impossible. Now, at the MAGIC Lab at the University of Plymouth, UK, psychologist and magician Gustav Kuhn is using tricks to reveal fresh insights into how our minds work. Using eye-tracking technology, he reveals how such blind spots alter our decisions.

**youtube.com/newscientist**

## Newsletter

### Health Check

It is estimated that more than 10 million people worldwide have been born via IVF. Reporter Carissa Wong looks at a new machine that could make IVF run more smoothly by automating some of the steps involved. But larger studies are needed to gauge whether the technique would increase birth rates.

**newscientist.com/health-check**

## Podcast

**"Effective action against climate injustice will only be taken when we manage to tell better stories"**


## Back in stock

By popular demand, best-selling puzzles and make-your-own kits are back in stock. Compile over 40 eco-friendly wooden pieces to make your own walking dinosaur or tackle one of our limited-edition jigsaw puzzles. Plus, your favourite science books are back on our shelves.

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# The cold, hard truth

The race is on to mine the melting Arctic, but chasing riches there is a fool's errand

THE Arctic is a land of riches – not just in its beauty, wildlife and cultural heritage, but in the kinds of commodities we value most: oil, gas, lithium, cobalt, gold and more.

Yet those treasures are no good to us. As our special report on polar science reveals (see pages 14 to 19), extracting the abundant resources of the Arctic for commercial gain is tricky.

Trying to haul oil and gas from the region is an expensive business, even with the dubious tailwind of melting sea ice helping to clear new patches of ocean for drilling. As industry and transport gradually shift to electric and hydrogen power, oil demand will fall, making the expense ever harder to justify.

It is a similar story for minerals, too. Greenland is a hotspot for in-demand materials, perhaps one reason why US President Donald Trump is aggressively pursuing its takeover. But even leaving aside Greenland's lack of infrastructure – roads are hard to come by on this icy island – this is a risky place to invest. The landscape is changing fast as glaciers melt, revealing new, precarious coastlines that threaten landslides and tsunamis.

> "For a hard-nosed business executive, there are easier, less hazardous places to mine"

Across the terrestrial Arctic, melting permafrost is destabilising existing roads, buildings and industrial sites. For a hard-nosed business executive, there are easier, less hazardous places to mine.

Viewing the Arctic as a ticket to bountiful economic growth is a fool's errand. Instead of seeing it as a region ripe for exploitation, we should treat it as a scientific wonder, while also respecting the people who live there. After all, as the fastest-changing region on Earth, it is at the vanguard of our climate future. And there is so much still to learn: how quickly might the ice disappear? How fast will sea levels rise? And what happens if and when the ice is gone?

On a more positive note, researchers are pioneering ever more inventive ways to unlock these mysteries, from a new "drifting" laboratory to ultra-deep ice drills and state-of-the-art submarines. The Arctic is overflowing with opportunities for exploration and discovery. We just need to let go of the idea of monetising them. ▮

# TRIP

## Calm is just a can away


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# News

**Good dog**
Intelligence tests can predict a puppy's personality p9

**Brain boost**
Using digital devices may help ward off cognitive decline p12

**Treatment plant**
Slices of wood could make effective water filters p12

**Sun shields**
Ancient humans may have faced high levels of solar radiation p13

Robotics

## Have your (robotic) cake and eat it

**This isn't your normal wedding cake. The gummy bears on top can dance, their heads and arms moving thanks to injections of air through a pneumatic system, and the LED candles at the bottom are powered by batteries made out of chocolate. Such edible electronics have been proposed as a solution to electronic waste. The cake was unveiled at Expo 2025 in Osaka, Japan, on 13 April.**

JAMANI CAILLET/EPFL

Space

# Strongest evidence yet of alien life

On a distant planet, the James Webb Space Telescope has picked up signs of molecules that, on Earth, are produced only by life – but researchers urge caution, finds **Alex Wilkins**

ASTRONOMERS claim to have seen the best evidence so far of life on another planet. But other researchers have urged caution until the findings can be verified and alternative, non-biological explanations can be ruled out.

"These are the first hints we are seeing of an alien world that is possibly inhabited," Nikku Madhusudhan at the University of Cambridge told a press conference on 15 April.

Astronomers first discovered the exoplanet K2-18b in 2015. About eight times as massive as Earth and orbiting a star 124 light years away from us, the planet sits in the habitable zone of its star, where liquid water can exist. Further observations in 2019 found evidence of water vapour, which led to suggestions that the planet may be covered in oceans sitting under a hydrogen-rich atmosphere, though not all astronomers agreed.

In 2023, Madhusudhan and his colleagues used the instruments on the James Webb Space Telescope (JWST) to look at K2-18b's atmosphere in near-infrared light, and again found evidence of water vapour, as well as carbon dioxide and methane. But they also found a tantalising hint of dimethyl sulphide (DMS), a molecule that, on Earth, is produced only by living organisms, mainly marine phytoplankton. The signs for DMS were extremely weak, however, and many astronomers argued that we would need much stronger evidence to be certain about the molecule's presence.

Now, Madhusudhan and his colleagues have used a different instrument from JWST, the mid-infrared camera, to observe K2-18b. They found a much stronger signal for DMS, as well as a possible related molecule called dimethyl disulphide (DMDS), which, on Earth, is also produced only by life (*The Astrophysical Journal Letters*, doi.org/phnd).

The team claims that the detection of DMS and DMDS is at the three-sigma level of statistical significance, which is equivalent to a 3-in-1000 chance that a pattern of data like this ends up being a fluke. In physics, the standard threshold for accepting something as a true discovery is five sigma, which equates to a 1-in-3.5 million chance that the data is a chance occurrence.

**"We have a boy-who-cried-wolf situation for K2-18b, where previous detections vanished under scrutiny"**

Nicholas Wogan at the NASA Ames Research Center in California says the evidence is more convincing than the 2023 results, but it still needs to be verified by other groups. Once the data is made public – which, as *New Scientist* went to press, was expected to be this month – other researchers can start to confirm the findings, but this could take weeks or months due to the difficulty of interpreting JWST data. "It's not just like you download the data and you see if there's DMS – it's this super complicated process," says Wogan.

Others are more sceptical. "These new JWST observations do not offer convincing evidence that DMS or DMDS are present in K2-18b's atmosphere," says Ryan MacDonald at the University of Michigan. "We have a boy-who-cried-wolf situation for K2-18b, where multiple previous three-sigma detections have completely vanished when subject to closer scrutiny. Any claim of life beyond Earth needs to be rigorously checked by other scientists, and unfortunately many previous exciting claims for K2-18b haven't withstood these independent checks."

Madhusudhan and his team estimate that between 16 and 24 hours of further observations with JWST could help them reach the five-sigma level, but the difficulty of observing the planet's atmosphere means they can't guarantee this.

ESA/HUBBLE, M. KORNMESSER

**Does exoplanet K2-18b, shown here in an artist's impression, host life?**

## Lost in space

"The relative size of the atmosphere compared to the size of the planet is pretty close to the thickness of an apple skin on top of an apple. That's what we're trying to measure," says Thomas Beatty at the University of Wisconsin-Madison, who wasn't part of the study team.

Madhusudhan and his colleagues calculate that the possible concentrations of DMS and DMDS on K2-18b appear to be over 10 parts per million, thousands of times greater than the concentrations in Earth's atmosphere. This could indicate a far greater amount of biological activity than on Earth, if the signal proves to be correct, but establishing that the chemicals have a biological origin will take more work, he says.

"We have to be extremely careful," said Madhusudhan. "We cannot, at this stage, make the claim that, even if we detect DMS and DMDS, that it is due to life. Let me be very clear about that. But if you take published studies so far, then there is no mechanism that can explain what we are seeing without life."

The difficulty in proving that it couldn't have a non-biological explanation could put K2-18b in the category of a viable biosignature candidate for a long time, says Sara Seager at the Massachusetts Institute of Technology. "It may remain in that category for decades, since the question may never be fully resolved with the limited data exoplanets offer," she says. ▮

Archaeology

# Ancient device thought to be a type of computer may not have worked

Alex Wilkins

THE Antikythera mechanism, a mysterious ancient Greek device that is often called the world's first computer, may not have functioned at all, according to a simulation of its workings.

Since the mechanism was discovered in 1901, in a shipwreck thought to date to around 60 BC, researchers have struggled to work out exactly why it was built. X-ray scans and digital reconstructions show that it was originally a 30-centimetre box containing interlinked systems of bronze gears. These appear able to track the positions of the moon, sun and future eclipses on a large circular dial, as well as other features such as a calendar that includes the dates of Olympic competitions, which were related to astronomical events.

Much of the device has been corroded and damaged from centuries spent underwater, making it hard to measure exactly how the gear teeth may have functioned. In 2006, Mike Edmunds at Cardiff University, UK, and his colleagues used CT scans to try to estimate the accuracy of the device. They found that errors would be relatively large and render its predictions fairly inaccurate – suggesting the Antikythera mechanism may have been for educational use or display rather than a working tool.

AP PHOTO/THANASSIS STAVRAKIS/ALAMY

**A part of the Antikythera mechanism on display in Athens, Greece**

Now, Esteban Szigety and Gustavo Arenas at the National University of Mar del Plata in Argentina have developed a two-dimensional computational model that simulates how the triangular teeth of the gears meshed together, incorporating previous errors measured by Edmunds and others. If those earlier measurements are correct, then the device wouldn't have worked, the model suggests (arXiv, doi.org/phj8). "The mechanism would not have even been able to move, because it would have jammed or also the teeth would have disengaged," says Szigety. "One tooth would rotate and the other wouldn't rotate."

However, he says that this conclusion is unlikely: "How could it be that someone invested so much time and so much effort for it to not work in the end?"

The obvious alternative, says Szigety, is that the past error estimates were too pessimistic, and that the device in fact worked more accurately than previous research has suggested.

However, Edmunds disagrees that smaller errors would mean the device could have been an accurate calculator. "Even if you do come back down to smaller errors that allow it to work, then the major conclusion of my paper isn't altered," he says.

Time spent underwater converted the bronze parts of the machine into a mineral called atacamite, which cracked and shrank when it was removed from the ocean, changing its dimensions, says Aristeidis Voulgaris at the Thessaloniki Directorate of Culture and Tourism in Greece. "Therefore, any attempt to apply precision measurements on the current condition of the gears, axes, includes the effect of the deformation. In this way, we cannot say that 'according to our precise measurements the mechanism never functioned'." ▮

Zoology

## Puppy intelligence tests can predict behaviour as adults

A SET of cognitive tests for puppies can predict how self-controlled and trainable they will be as adults.

Knowing this can help owners tailor teaching styles and better understand their pets' abilities and limitations, says Saara Junttila at the University of Helsinki in Finland.

"These traits are not necessarily good or bad, and they don't [show] whether a puppy is smart or not," she says. "These tests just help know what kind of exercises each puppy needs."

Junttila and Katriina Tiira at smartDOG Ltd in Hyvinkää, Finland, previously discovered they could classify dogs' intelligence and personalities by breed using a battery of cognitive tests. They wondered whether an adaptation of those same tests might work on puppies – and predict how they would behave as they grew older.

To find out, Junttila, Tiira and their colleagues evaluated hundreds of dogs aged between 3 and 7 months based on seven tests. Some of them looked at the puppies' problem-solving skills or how they responded when they encountered a new person or place, for example.

Over the next few years, the team tested 99 of these dogs again as adults up to the age of 8 and assessed behaviours in 227 of them based on detailed owner surveys.

The researchers found that, generally, test performance stayed essentially the same over the years. The puppies' results also frequently aligned with their behaviour and skills later in life (*Applied Animal Behaviour Science*, doi.org/phnc). Young dogs that are quick to follow pointed fingers, for example, will probably be faster to understand tricks and toilet training. This is because they may be more attuned to human cues, the researchers say.

**"Young dogs that are quick to follow pointed fingers will probably be faster to understand toilet training"**

But, paradoxically, puppies that gaze at humans to ask for help may end up more fearful of strangers as adults. Junttila and Tiira suspect that this reflects a lack of confidence in problem-solving combined with a tendency to pay more attention to their surroundings, including people.

Sophie Jacques at Dalhousie University in Canada says the findings echo similar trends in people. "Developmental scientists have repeatedly found that young children's ability to control their behaviours improves substantially over development, but their temperamental traits like extraversion or shyness stay fairly stable." ▮

Christa Lesté-Lasserre

Space

# The race to visit near-flying asteroid

An asteroid's extremely close flyby of Earth offers us the chance to learn more about these space rocks – including how to deflect others like it, finds **Robin George Andrews**

IN FOUR years, on 13 April 2029 to be exact, a large asteroid named Apophis will fly by Earth just 32,000 kilometres above the surface. Apophis, like the recently identified asteroid known as 2024 YR4, was once thought to be on a crash course with our planet. After its likelihood of hitting us was lowered to zero, and some presumed sighs of relief, astronomers began planning for the day it would make its exceptionally close flyby.

When it does, a fleet of spacecraft – featuring missions by NASA, the European Space Agency (ESA) and the Japan Aerospace Exploration Agency (JAXA) – is going to chase it down.

"This kind of approach of a body of Apophis's size occurs only once every few thousand years," says Patrick Michel at Côte d'Azur University in France, a member of ESA's Apophis-hunting project. "This is extraordinary."

To prepare for this moment, astronomers and planetary defence researchers from around the world gathered at the University of Tokyo from 7 to 11 April for a very unusual workshop.

Each space agency shared its mission's objectives, while making sure that they would coordinate with one another to get the most out of this opportunity.

Although multiple spacecraft will effectively be racing to get to Apophis first, "nobody is winning or losing", says Michel. If the historic team-up goes according to plan, everybody will have a better understanding of how to defend the planet from killer asteroids.

Shortly after Apophis was discovered in 2004, it caused a bit of a fright. According to early orbital calculations, this 450-metre-long asteroid – big enough to cause damage on a continental scale – stood a 2.7 per cent chance of striking Earth in 2029. Thankfully, follow-up observations ruled out this calamitous possibility, instead showing that it will safely pass by Earth.

ESA

**An artist's impression of the RAMSES mission to Apophis**

However, it will get extremely close to the planet, passing below the height of geostationary satellites. Weather permitting, people in Europe and Africa will be able to see it with the naked eye, as a hastily moving glimmer. "It [will be] evening twilight skies when Apophis is brightest," says Richard Binzel at the Massachusetts Institute of Technology.

**450**
**Length of the asteroid Apophis, in metres**

**5 million**
**How far the OSIRIS-APEX craft will be from the asteroid when it starts observing, in kilometres**

**6**
**Number of months the RAMSES craft will fly alongside Apophis**

There are thousands of asteroids just like Apophis in near-Earth orbits yet to be discovered. If one is found to be heading our way, any mission attempting to deflect or destroy it would greatly benefit from knowing what their structure is like. Are they rigid objects that could absorb the impact of a ram-like spacecraft or rubble piles prone to chaotic fragmentation?

Apophis won't just passively pass by the planet. It is likely to shift to a slightly different orbit, while its surface geology and interior structure will be disturbed. "There is going to be seismic shaking on Apophis," says Dani DellaGiustina at the University of Arizona. These asteroid quakes will hint at its geologic make-up.

Throughout the close encounter, a bevy of ground-based observations, including those using radar, will give us a precise measure of the asteroid's size, shape and trajectory. But planetary defenders have more ambitious hopes: they want to send several spacecraft after Apophis to get the best look possible before, during and after the Earth flyby.

The first of the fleet is the successor to NASA's OSIRIS-REx mission. This spacecraft extracted pieces of rock from the asteroid Bennu in 2020, before returning to Earth in 2023 to drop a capsule containing them. This mission was primarily scientific, with those stolen shards being studied to understand the origin of planets and life itself. But OSIRIS-REx also helped anti-asteroid research efforts: it studied the geology of the asteroid and helped us better understand how this was being affected by sunlight, which can very gently but significantly alter an asteroid's orbit.

## Planetary defence

OSIRIS-REx has since been repurposed for planetary defence. While the spacecraft was on its way back from Bennu, its operators realised they could pilot it in such a way that it could also rendezvous with Apophis. It can no longer gather samples with its extendable arm, but it could examine the asteroid with its suite of cameras and sensors.

So, 20 minutes after the sample capsule was jettisoned towards Earth, the spacecraft fired its thrusters, sending it on a circuitous trajectory around the solar system to catch up to Apophis in 2029. The mission, now named OSIRIS-Apophis Explorer, or APEX, is taking a gamble: it wasn't designed to get as close to the sun as it has been. Fortunately, its instruments are


ALAMY, SHUTTERSTOCK, ESA-SCIENCE OFFICE

holding up to the scorching heat. "Everything appears 'go' for Apophis," says DellaGiustina, the principal investigator for OSIRIS-APEX.

The craft will begin observing Apophis on 2 April 2029, from 5 million kilometres away, closing the gap to just 50,000 kilometres during the 13 April Earth encounter. It will finally arrive alongside the asteroid on 5 June, and fly in formation with it into 2030, mapping out its surface. In September 2030, the craft will approach Apophis before firing its thrusters at the rock. Known as the Spacecraft Thruster Investigation of Regolith, or STIR, manoeuvre, this is designed to expose the pristine geology just under the surface of the asteroid.

OSIRIS-APEX's mission ends in December 2030. What happens then? "We're pretty interested in trying some daring things," says DellaGiustina. They may prod Apophis with OSIRIS-APEX's extendable arm or even try landing on the surface. "We would love to do something crazy, but right now, we're just hoping to get through our nominal mission plan." (See "Smashing asteroids", above.)

ESA's contribution to the fleet is the Rapid Apophis Mission for Space Safety, or RAMSES, spacecraft. Unlike OSIRIS-APEX, this is a work in progress. The preliminary design work has already been funded but awaits a critical go-or-no-go decision at an ESA gathering in late 2025. But there was considerable optimism in Tokyo that RAMSES would be green-lit.

Paolo Martino at ESA, the mission's project manager, says RAMSES will rendezvous with Apophis in February 2029, flying alongside it for at least six months. As well as monitoring it with cameras, RAMSES will deploy two miniature satellites called CubeSats. One will use ground-penetrating radar to probe the interior of Apophis, while another may land a seismometer on the asteroid, says Michel.

> **"This kind of approach of a body of Apophis's size occurs only once every few thousand years"**

"We can take more risks with CubeSats, while the mother spacecraft remains at a safe position," says Michel.

Beating OSIRIS-APEX and RAMSES to the punch – if it launches in 2028, as planned – will be JAXA's DESTINY+ mission. Although its primary target is another asteroid named Phaethon, which it will reach in 2030, it will make a flyby of Apophis in early 2029, taking photographs to aid the incoming RAMSES and APEX spacecraft, says Tomoko Arai at the Chiba Institute of Technology in Japan, the principal investigator of DESTINY+.

Assuming both RAMSES and DESTINY+ make it off the launch pad, the three-piece Apophis squadron must ensure it avoids an inadvertent destruction derby. "One coordination task is collision avoidance between spacecraft," says Michael Küppers, an ESA planetary scientist.

But if they succeed, NASA, ESA and JAXA will get to watch Apophis transform as it wrestles with Earth's gravity – revealing vital secrets to planetary defenders in the process.

"We have spent years considering what happens to an object when it makes such a close approach to a planet," says Cristina Thomas at Northern Arizona University. "We finally have the opportunity to see." ▮

## Smashing asteroids

**The Apophis flyby project is the latest in a series of planetary defence efforts. Like OSIRIS-REx, Japan's Hayabusa 2 mission also returned samples of an asteroid, named Ryugu, back to Earth in 2020. And in 2022, NASA's Double Asteroid Redirection Test, or DART, was the first ever deep-space planetary defence experiment: the spacecraft rammed into the (harmless) asteroid Dimorphos, deflecting it and proving that space rocks can be diverted away from Earth in an emergency. ESA's Hera mission, launched in 2024, is currently heading towards Dimorphos to examine it post-DART impact.**

**At April's Tokyo workshop (see main story), several other Apophis mission ideas were floated by institutions and universities. The most eye-catching was the Apophis Cratering Experiment, or ACE. "Our mission concept is pretty simple: we impact Apophis, and OSIRIS-APEX watches and studies the way the impact makes the crater and deflects its orbit," says Kevin Walsh at the Southwest Research Institute in Texas, one of the proposers of ACE.**

**Although it sounds like a miniature version of DART, ACE isn't going to majorly change the asteroid's orbit. By smashing into Apophis and watching it respond, the project would measure the asteroid's internal structure and mechanical strength – albeit in a fairly dramatic fashion.**

Health

# Digital devices may help ward off cognitive decline in older people

Michael Le Page

THERE is much concern about the notion of "digital dementia" – the idea that relying on smartphones and the internet reduces a person's cognitive abilities. But among those over 50 at least, these technologies appear to actually have the opposite effect.

An analysis of nearly 60 studies involving 410,000 people in this age group has found that those who spend more time using smartphones, computers and the internet are less likely to have cognitive impairment – and more likely to have slower cognitive decline – than people who spend less time using these technologies (*Nature Human Behaviour*, doi.org/g9fhw4).

While this analysis can't establish causation, it suggests that digital technologies encourage behaviours that help preserve cognition in the first generation of people to have access to them at an older age, says Jared Benge at the University of Texas at Austin.

There has long been concern about how the use of technologies is affecting our brains. To learn more, Benge and his colleague Michael Scullin at Baylor University in Texas searched the literature for studies involving the use of digital technologies in people over 50. Among other criteria, they excluded those focusing on gaming or brain training. "We were more interested in the everyday kind of experience of dealing with digital technologies," says Benge.

This left 57 studies, most from Europe or North America, but there were papers from all around the world, says Benge. "And the effects seem to be fairly consistent."

VALERY HACHE/AFP VIA GETTY IMAGES

**Sharing your holiday snaps could be good for the brain**

It is hard to boil down the results to simple numbers, says Benge, "but the effect sizes seem comparable to other established protective factors – things like education and blood pressure control – that we know are good for brain health".

One explanation could be that people with better education, healthcare or incomes are more likely to use digital technologies, as these factors are also linked with lower rates of dementia. But some of the studies controlled for these and still found the same effect.

There are three reasons why digital technology might slow cognitive decline, says Benge. The first is that digital activities are more complex and interactive than just watching TV. The second is that it can help people connect with others – for instance, via video calls. The third is that it might help people stay independent for longer, with satellite navigation ensuring they don't get lost even if their wayfinding abilities decline, for example.

Benge also points out that the people in these studies didn't have smartphones or internet access as children. "Does this play out for digital natives? This is a snapshot that's encouraging, but the story is not done being told."

"Current middle-aged people have been exposed to a very wide range of technologies since the turn of the millennium, and most of the focus of concern is on smartphones and/or social media, which haven't been around that long," says neuroscientist and science writer Dean Burnett.

**"This provides a counter for the usual knee-jerk stance that 'technology equals bad' for the brain"**

That said, while the results of the research are inconclusive, they suggest that long-term technology use can be beneficial for the brain and cognition, says Burnett. "It certainly provides a strong counter for the usual knee-jerk stance that 'technology equals bad' in terms of brain and mental health." ▮

Technology

# Simple wooden discs could be effective water filters

Matthew Sparkes

**SLICES of wood can act as water filters that remove bacteria and microplastics with more than 99 per cent efficiency.**

**Previous research has investigated more complex methods to make wooden filters involving complicated chemical treatments, but these would be impractical in lower-income countries where water-borne illnesses cause hundreds of thousands of deaths a year, say Antoni Sánchez-Ferrer and Jenifer Guerrero Parra at the Technical University of Munich, Germany.**

**To make more accessible water filters, they tested discs of wood that were 5 centimetres in diameter and 1 millimetre thick. The discs were effective at removing particles around 100 nanometres wide and upwards – enough to catch many microplastics and bacteria such as *Escherichia coli* (*Wood Science and Technology*, doi.org/phj2). While some smaller pollutants such as viruses may still be able to pass through, the wooden filters could still save many lives, they say.**

**Wood is made up of xylem vessels, which transport water from the roots of trees to the leaves. Each vessel is only millimetres or centimetres long, but water can pass into neighbouring vessels through small holes in their walls called pits. It is these pits that allow wood to act as a filter, says Sánchez-Ferrer. "They have this kind of net, which naturally works as a sieve," he says.**

**The researchers tested slices of yellow poplar (*Liriodendron tulipifera*), European beech (*Fagus sylvatica*), Douglas fir (*Pseudotsuga menziesii*) and silver fir (*Abies alba*). Two were clear leaders: European beech removed 99.7 to 99.9 per cent of nanoparticles and silver fir removed 99.3 to 99.7 per cent. But water flowed quicker through beech wood, so it was the researchers' preferred choice.** ▮

Human evolution

# Ancient humans faced radiation risk

Increased solar radiation in the distant past may have led to the first use of sunscreens

James Woodford

AROUND 41,000 years ago, Earth's magnetic field weakened to just a fraction of modern levels, leading to a huge increase in the radiation hitting the surface of the planet. Some researchers suggest the Laschamps event, as it is known, could have pushed Neanderthals towards extinction, while modern humans might have protected themselves using tailored clothing and ochre sunscreen.

Earth's magnetic field extends into space and acts as a protective shield against harmful radiation. The magnetic poles usually line up with the north and south poles, but they occasionally wander due to changes in the liquid outer core of the planet.

"Fluctuations in this system can lead to variations in the strength and orientation of Earth's magnetic field, such as those observed during the Laschamps event," says Agnit Mukhopadhyay at the University of Michigan.

By studying magnetic signatures preserved in volcanic rocks and sediments, Mukhopadhyay and his colleagues created a detailed 3D reconstruction of Earth's magnetic field during the Laschamps event.

They found evidence that the magnetic poles had shifted towards the equator and that the field strength had weakened to just 10 per cent of today's levels (*Science Advances*, DOI: 10.1126/sciadv.adq727).

A weakened magnetic field would have allowed more solar and cosmic radiation to reach Earth's surface, and may have altered regional climates. "These environmental changes may have driven adaptive behaviours in human populations, such as the increased use of protective clothing and ochre for UV shielding," says Mukhopadhyay.

The researchers argue that the production of tailored clothing and the use of the reddish mineral ochre as a sunscreen may have given *Homo sapiens* an advantage over Neanderthals, who are thought to have become extinct during this period.

"There's definitely a rough overlap in terms of timing between the incursion of ancient modern humans into Europe and the Laschamps event," says Amy Mosig Way at the Australian Museum in Sydney. "But it's probably a stretch to say modern humans had better sun protection in the form of tailored clothing than Neanderthals, and that this contributed to their ability to travel farther than Neanderthals and their subsequent dominance of Eurasia."

**"These environmental changes may have driven increased use of clothing and ochre for UV shielding"**

Veronica Waweru at Yale University says there is evidence for ancient humans using ochre around this time. For example, the Porc-Epic cave in Ethiopia records ochre use at 45,000 years ago, but this intensified 40,000 years ago, she says. They may have used it for sunscreen or other reasons such as making artwork or adhesives.

Ladislav Nejman at JCMM in the Czech Republic says we don't know if modern humans used ochre as a sunscreen. "If they did, it could've protected them more, but not necessarily saved them," he says. "Humans in Europe really had it stacked against them at the time."

Nejman points out that the Laschamps event coincided with an extremely cold period known as Heinrich event 4, as well as a major volcanic eruption in Italy called the Campanian Ignimbrite explosion. "The huge advantage that *Homo sapiens* had as a species compared [with] Neanderthals is that there were other large populations living in Africa and elsewhere, so new *Homo sapiens* could move into Europe after these events," he says.

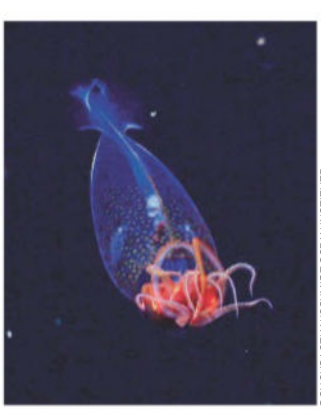
Zoology

## Live colossal squid caught on camera for the first time

**A COLOSSAL squid – the largest invertebrate on the planet – has been confirmed in video footage from the deep sea for the first time.**

**For decades, the colossal squid (*Mesonychoteuthis hamiltoni*) was more myth than reality: scientists had a vague sense of its appearance from fragments found in the stomachs of whales. Finally, in 1981, a live one was accidentally reeled up in a fishing net.**

**Last month, a vessel from the Schmidt Ocean Institute, a US-based non-profit organisation, was surveying the Southern Ocean near the South Sandwich Islands and live-streaming the footage from its remotely controlled deep-sea cameras, when an online viewer flagged that they might have just filmed a colossal squid.**



ROV SUBASTIAN/SCHMIDT OCEAN INSTITUTE

The baby colossal squid was just 30 centimetres long

**The researchers sent the high-resolution footage to independent squid experts, who confirmed that the squid had distinctive hooks along the suckers on its eight arms, which are a hallmark of the colossal squid.**

**While colossal squid are thought to reach up to 7 metres in length and 500 kilograms in weight, the squid caught on camera was a mere 30 centimetres in length: a baby.**

**A colossal squid may have been filmed in the wild in 2023 by a team from US-based organisation Kolossal – but the sighting couldn't be confirmed because the footage was too low in quality. The new squid recording might suggest the 2023 footage does capture a colossal squid. "It's the same size, same colour, similar depths, both in the Southern Ocean," says Matt Mulrennan at Kolossal.**

**However, there is no footage of an adult colossal squid in the wild, and the lives of these gigantic invertebrates are still mysterious, says Steve O'Shea, formerly at Auckland University of Technology, New Zealand, who coined the name "colossal squid". He once touted the animals as "seriously evil denizens of the deep", but is now convinced they are more like "giant gelatinous ticks, simply blobbing around in the water column near the seabed".**

Sofia Quaglia

Climate change

# Earth's frozen oceans in meltdown

Extremely low levels of sea ice in the Arctic and the Antarctic may accelerate global warming and disrupt ocean currents, on top of dire consequences for people and wildlife, finds **James Dinneen**

HUMAN-CAUSED climate change has ravaged sea ice at both ends of Earth in what may be a disturbing new normal. February this year saw the global extent of sea ice hit a record low, as its sluggish growth in the Arctic winter coincided with the fourth consecutive year of extremely low cover during the Antarctic summer.

"It's like a missing piece of a continent," says Ed Doddridge at the University of Tasmania in Australia.

The millions of square kilometres of lost sea ice spell disaster for people and ecosystems in these remote parts of the planet. Yet the extraordinary decline will also have global consequences, ranging from further disruption to Earth's energy balance and ocean currents to a boost in carbon dioxide released by ice-free waters.

The sea ice cover in both the Arctic and Antarctic is now far below historical average levels. But the story is different at each pole.

In the Arctic, where the ice floats in an ocean surrounded by continents, there has been a near-steady decline since the satellite record began in 1979. In every year since 2007, its minimum sea ice extent has dropped far below the long-term average, suggesting the region – which is warming nearly four times as fast as the rest of the planet – is experiencing "a new normal", says Walter Meier at the US National Snow and Ice Data Center. During its low point in Arctic summers, the area of missing ice is roughly equivalent to lopping off all of the continental US east of the Mississippi river.

Arctic sea ice is also declining in winter: in March this year, its maximum extent set a new record low, with more than 1.3 million square kilometres less cover than the long-term average.

In the Antarctic, where sea ice rings a continent surrounded by ocean, the change has been more complex. Until recently, "Antarctic sea ice wasn't playing along with the global warming theme", says Meier. Other factors, such as natural oscillations in ocean temperature and wind patterns, drove changes in sea ice year-to-year. Its extent had actually seen a slow increase since the beginning of the satellite record, until a precipitous decline in late 2016.

TONY SKERL/SHUTTERSTOCK

WIRESTOCK, INC./ALAMY

**Above: Arctic sea ice cover has steadily fallen in recent decades**

**Left: Emperor penguin colonies in the Antarctic, which rely on sea ice, have seen mass die-offs**

> **"In the Arctic, there has been a near-steady decline in sea ice since the satellite record began in 1979"**

In early 2022, cover during the Antarctic summer crashed below the previous record low, with nearly 2 million square kilometres less than average – equivalent to losing an area about the size of Saudi Arabia. Each of the next three summers got close to or beat that low, prompting researchers to suggest we are seeing a permanent "regime shift", like that in the Arctic. A recent reconstruction of Antarctic sea ice, based on a longer-term record of changes in the atmosphere, suggests the winter ice extent there is now lower than at any point in the 20th century.

However, the short satellite record and imperfect models mean some uncertainty remains about whether a regime shift has occurred in this region and to what extent global warming is behind the change, says Caroline Holmes at the British Antarctic Survey. But this streak of extreme lows "does imply that the Antarctic sea ice is responding to climate change in a way we hadn't seen previously", she says.

## Penguin apocalypse

The fundamental shift at both poles is already affecting people and ecosystems. "It's a whole system change," says Twila Moon at the University of Colorado, Boulder. In the Antarctic, for instance, emperor penguin colonies that rely on the ice to raise their chicks have seen mass die-offs. In the Arctic, Indigenous communities that use the frozen sea as a hunting platform have seen the length of their hunting season and size of their catch shrink. In regions such as Alaska's northern coast, the loss of sea ice has accelerated erosion by exposing the land to waves. The structure and ecology of the Arctic Ocean in general has started to become more like that seen at lower latitudes in a process called Atlantification.

But the consequences of losing so much of this ice are hardly limited to the poles. One of the clearest global ramifications is a reduction in the amount of solar radiation reflected from Earth back into space. Sea ice reflects most of the sunlight that reaches it. When it melts, it exposes the dark ocean below, which absorbs most of the incoming solar energy. A recent study on this found that low levels of global sea ice since 2016 mean the cooling effect of the ice is now about 14 per cent weaker than in the 1980s. "This impact is large relative to what we already know we're doing to the climate system via greenhouse gases," says Holmes.

If gauged for the Arctic alone, the change is even greater, with the ice there losing a quarter of its cooling effect over that period.

This is fuelling the accelerated rate of warming in the north known as Arctic amplification. The warming, in turn, reduces the difference in temperature between Arctic air and warmer air to the south, which can disrupt the polar jet stream that controls weather across parts of the northern hemisphere. "That completely changes our weather systems over the US and Europe," says Andreas Klocker at the Norwegian Research Centre, leading to more persistent heatwaves, torrential rain and frigid outbreaks of polar air.

**"The loss of sea ice could switch the Southern Ocean from a sink for greenhouse gases to a new source"**

In the Antarctic, the loss of sea ice may also be contributing to an observed slowdown in the overturning circulation of the world's oceans. These powerful currents are driven by dense, salty water – left over from the formation of sea ice – sinking to the deep ocean. The currents driven by this "Antarctic bottom water" enable oceans to absorb more heat from the atmosphere and carry nutrient and oxygen-rich waters from the Southern Ocean to deep-water ecosystems across the planet.

Researchers have observed a slowdown in the formation of this bottom water since the 1990s, which they have mainly attributed to more fresh water pouring in from melting ice shelves. But a possible regime shift in the sea ice, along with more meltwater, adds to concerns that bottom-water formation could slow even further, with models projecting a 50 per cent decline over the next three decades under a high-emissions scenario. This would reduce the amount of heat the oceans can take up, says Klocker.

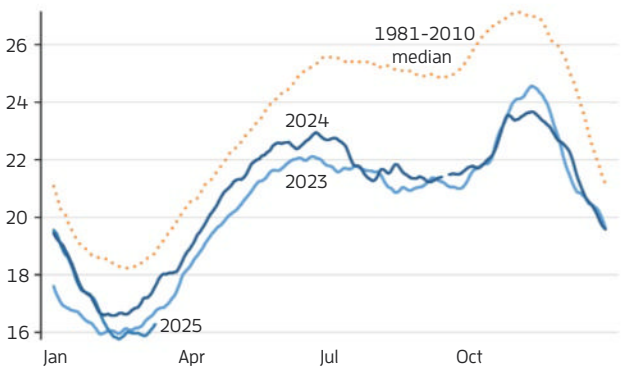
A slowdown could also affect other vital currents, including the Atlantic Meridional Overturning Circulation that warms Europe and the powerful Antarctic Circumpolar Current that isolates the continent from the rest of the world's warming oceans. "There are lots of delicate balances here and the sea ice is right in the middle of all of them," says Doddridge.

Other consequences of Antarctic sea ice loss are even more uncertain, but no less concerning. For instance, sea ice helps keep waves and warmer water away from the continent's ice shelves – the floating coastal structures formed as inland ice sheets flow into the sea. Loss of this buffering may increase the rate of icebergs breaking off those shelves, which would, in turn, speed up the flow of ice sheets into the ocean, adding to sea level rise. "We've only seen a few ice shelves disintegrate, but they have generally disintegrated after a period of low sea ice in that area," says Doddridge.

In winter, when carbon-rich deep water mixes vigorously with the surface, the Antarctic sea ice also acts as a lid on the Southern Ocean, preventing dissolved $CO_2$ from being released into the atmosphere. The overall effect is uncertain, as it is challenging to measure the flux of gases during the Antarctic winter, but the loss of sea ice could open that lid, switching the ocean itself from a sink for planet-warming greenhouse gases to a major new source, says Doddridge. "That is an absolutely terrifying impact that we cannot nail down at all." ▮

## 2025 has seen record-low sea ice levels

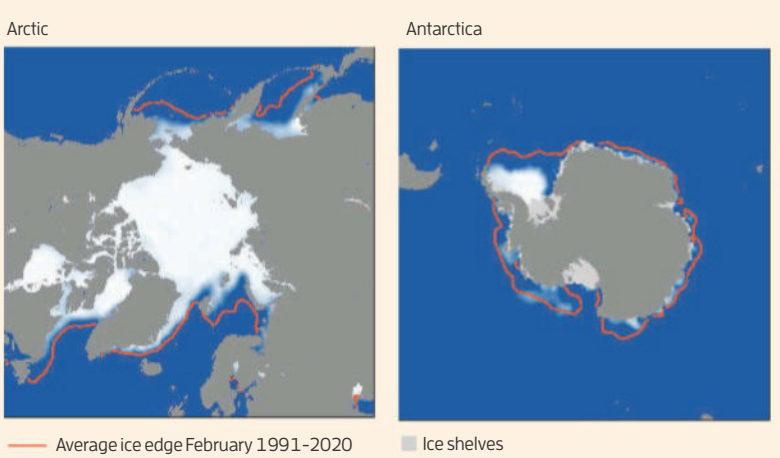
Global sea ice extent this February dropped below previous record lows set in 2023 and 2024 (in millions of square kilometres)




SOURCE: SEA ICE INDEX, NATIONAL SNOW AND ICE DATA CENTER

## Sea ice cover in retreat

The extent of sea ice in February is typically at its maximum in the Arctic and minimum in the Antarctic (shown on the maps below in white). This year, the Arctic maximum was the lowest on record, while the Antarctic minimum was close to the record low set in 2023




DATA: ERA5. REFERENCE PERIOD: 1991–2020. CREDIT: C3S/ECMWF

Environment

# Oldest ice cores yet hide climate clues

The hunt for the world's oldest ice cores could give us a glimpse into our planet's past and help model future climate change, finds **James Woodford**

MORE than a century ago, explorers from several countries raced to reach the globe's southernmost point, driven by fierce international rivalries. Now, a new race is under way in Antarctica, this time motivated by the need to understand one of the gravest threats facing humanity.

While other ancient climate records exist, only the ancient ice near the poles holds a perfect record of the atmosphere's carbon dioxide levels and temperature.

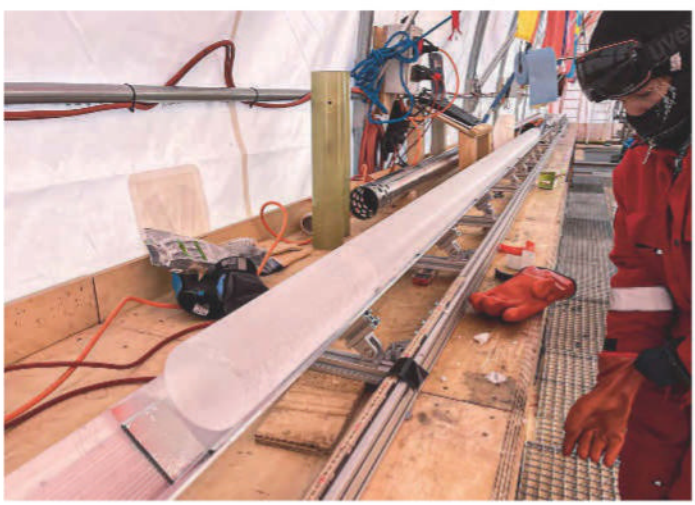
The oldest continuously layered ice anywhere on the planet is believed to have been laid down around 2 million years ago, on a 3300-metre-high ice plateau in the East Antarctic. It is also thought likely that it holds the secret to why the world's climate abruptly changed between 1.2 million and 800,000 years ago.

Until that time, Earth had glacial periods – commonly known as ice ages – roughly every 41,000 years, but suddenly, around 1.2 million years ago, something forced the climate to radically shift. By around 800,000 years ago, the planet had moved to a pattern of 100,000-year glacial cycles. No one knows why this mid-Pleistocene transition occurred, but understanding it is critical to modelling future climate change as greenhouse gases surge.

Separate teams from Australia, Europe, Japan and the US have all begun drilling ice cores that could hold the answer to this puzzle, while South Korean researchers and a Russian-Chinese team are exploring candidate sites and looking to drill in the coming years.

Currently in the lead is a European consortium called Beyond EPICA. In January, the project reached bedrock under 2.8 kilometres of ice at a location called Little Dome C in the East Antarctic plateau. Some of the ice the team has retrieved is thought to be 1.2 million years old.

PNRA/IPEV



**A team member at Beyond Epica logging an ice core in the field**

The Australian team was also planning to begin drilling at Little Dome C this summer, until new radar data indicated the possibility of 2-million-year-old ice 50 kilometres from the European drill site at a location called Dome C North, or North Patch.

When those findings emerged, the Australians had already established their camp at Little Dome C, but they hadn't begun to drill. Moving to a new drill site isn't done lightly in the Antarctic interior: temperatures in summer average -30°C (-22°F) and the weather is so inclement that the window for drilling is a mere month or two per year.

> **"Analysing this ancient ice is the best chance the world has of predicting the future"**

Still, the team re-established their camp and began drilling at Dome C North in January. The researchers managed to drill a 150-metre pilot bore and set up all the equipment needed to start deep drilling next summer. Team leader Joel Pedro at the Australian Antarctic Program says it will probably take until the Antarctic summer of 2029 before they are able to drill through the remaining 3 kilometres of ice and reach bedrock.

## Core problem

From Casey station, the nearest permanent base, it is a mere 6-hour flight back to Hobart in Tasmania, so the Australian team has already brought its cores home and will start analysing them in the coming months. Meanwhile, unwilling to take the risk of transporting ancient cores through multiple customs-stops by air, the European team faces a nervous wait while its ice cores are transported to Italy by ship.

Team member Carlo Barbante at Ca' Foscari University of Venice in Italy says he is losing sleep worrying about all the possible mishaps that could damage the cores. Once they are safely in the laboratory at the end of April, it will take at least two months to prepare sections of the ice cores for study, he says.

"The first thing is to establish an age scale," says Barbante. "So, we need to know how old the ice is. And then, in parallel, we'll do analysis to reconstruct the temperature of the past."

The researchers will study the isotopic composition of water molecules, the chemistry and the composition of gases in the ice.

Complicating matters, the last couple of hundred metres of ice above the bedrock at Little Dome C is what researchers call "stagnant". This means the stratification of the deepest ice has been destroyed by disturbances as the ice sheet has ground over the bedrock.

"For millions of years, you have disturbances in the bottom layer of the ice," says Barbante. "Because we don't see any more stratification, the oldest continuous ice record is not at the very bottom."

Radar imaging at Dome C North, however, appears to show that there is no stagnant ice layer there, says Pedro. "We're hoping that we preserve continuous stratified ice all the way to the bedrock."

For Barbante and his team, analysing ancient ice is the best chance the world has of predicting the future by understanding the past. "It is a gigantic work in very, very harsh conditions, and is a 20-year-long dream come true," says Barbante. "This is a huge, huge programme, like a space mission."

But he won't be disappointed if the Australian team surpasses his own in the hunt for the oldest ice, he says. "If, in the coming years, our Australian colleagues touch ground, and it will be 2 million years old, we will be super happy, as that is for science – it is not for a national or a personal record."

Technology

# A floating polar research station will uncover the secrets of Arctic winter

Madeleine Cuff

IN 1893, Norwegian explorer Fridtjof Nansen left Norway on a mission to drift across the North Pole. His vessel, the Fram, had been specially designed with a rounded hull so it would sit on top of the ice, gently ferrying its crew over the Arctic.

Nansen never made it to the North Pole, but after three years locked in the ice, the Fram emerged in the North Atlantic Ocean. The voyage was the first in history to complete a successful transpolar drift, proving the Arctic was one large ocean without a significant landmass.

Since Nansen's expedition, only a small handful of adventurers have followed in his footsteps, most recently a team of scientists who, in 2019 and 2020, spent a year locked in the ice aboard the German icebreaker Polarstern.

Instead, researchers have relied on data from satellites, summer expeditions and winter ice camps to track changes in the Arctic. But the rate of ice melt in the region (See, "Why vanishing sea ice affects us all", page 14) is making ice camps increasingly dangerous, with residents of one research camp north of Svalbard forced to evacuate several times in 2015 as the ice broke under their feet.

That leaves the Arctic largely unmonitored during the period running from November to February, says Chris Bowler at the Tara Ocean Foundation, a French NGO. "We have basically no information" for a large part of every year, he says. "Which is alarming, considering it is such a fragile place and it is changing so rapidly."

## Home comforts

Tara Ocean Foundation's solution is to build a drifting shelter for research teams – modelled on Nansen's designs for the Fram. Called Tara Polar Station, it is designed to withstand harsh Arctic winters, where temperatures can drop to -50°C (-58°F). At a cost of $23 million, the 26-metre boat features a domed living area, a rounded hull and a removeable keel, allowing the ship to rise and settle atop the ice.

Its crew members will live in relative comfort; Tara Polar Station features a gym, a sauna and fully equipped laboratories. There is even a "moon pool", which allows the researchers direct access to the ocean without having to drill into the ice.

The hope is that Tara Polar Station will function as a floating laboratory, allowing scientists to take continuous measurements from the deep Arctic throughout the winter, says Bowler. "The inspiration was really to build a shelter that could shelter scientists through the polar night, through an entire season in the Arctic," he says.

He describes the project as an Arctic version of the International Space Station: "We expect to develop Tara Polar Station like an international facility, that scientists can apply to use."

Construction, which began in 2023 and was funded mostly by the French government, is almost complete. The vessel is undergoing sea trials this year before embarking on its first planned transpolar drift in September 2026. The crossing will set off from the seas north of Russia and emerge east of Greenland.

Selection is underway for that expedition's crew. Tara Ocean Foundation is on the hunt for 12 people – six sailors and six scientists – willing to complete a seven-month stint aboard the station during the polar winter. A fresh team will relieve them for spring and summer.

> "Tara Polar Station is an Arctic version of the International Space Station"

The expedition isn't for the faint of heart, warns Bowler. "The people we select need to be psychologically very sound," he says. "They need to be strong, because it's pretty hostile – you are at the extremes of what humans can withstand in these conditions."

It isn't just psychological and physical strength that is needed. "The people on board will have to get the screwdrivers out, open things up, poke around and fix things," says Bowler. "We need people who are very good at DIY, very practical people."

If all goes to plan, the new station will complete 10 two-year drifts over the next 20 years, building a valuable database of observations and analysis describing this rapidly changing region. Researchers will focus on everything from the declining levels of sea ice to changes in cloud cover and microbiological disruption to Arctic food webs, says Bowler.

"On the one side, we will certainly be telling a very, very sad story, the loss of summer sea ice, potentially the loss of different kinds of organisms," he says. "But we will also be learning a huge amount about this amazing ecosystem, that we know very little about." ▮

TARA OCEAN FOUNDATION

LOU BENOIST/AFP VIA GETTY IMAGES

**Tara Polar Station is designed to drift on the ice and withstand harsh Arctic temperatures**

Energy

# The rush to unlock Arctic resources

Thawing ice and permafrost might not be the chance for industrial growth some nations hope for

**Madeleine Cuff**

CLIMATE change is transforming the frozen Arctic landscape at an astonishing rate. While devastating for wildlife and communities that live there, governments and businesses spy an opportunity.

The region is rich in resources, including untapped fossil fuel reserves and critical minerals necessary for the energy transition. Arctic nations have jostled for control of these resources for decades, and some exploitation – mostly fossil fuel extraction in the Russian Arctic – is already underway.

By the end of the decade, the Arctic Ocean could be ice-free during the summer, allowing ships to journey directly over the North Pole for the first time. This rapid melt is making the region more accessible than ever, fuelling expectations of fast industrial growth in the Arctic. Since taking office in January, US President Donald Trump has loudly declared his desire to take over Greenland, a Danish territory, as well as Canada. But will climate change really deliver an Arctic industrial boom?

KYODO NEWS STILLS VIA GETTY IMAGES


JONATHAN NACKSTRAND/AFP VIA GETTY IMAGES

**Above: Natural gas facilities in the Russian Arctic, Below: Members of the Indigenous Sámi community lead a climate march**

## Material interests

There is no doubt the region harbours valuable resources, including about 90 billion barrels' worth of oil and about 30 per cent of the world's undiscovered natural gas reserves, according to a 2012 assessment by the US Geological Survey.

Rare earth minerals are also plentiful. Greenland alone is thought to have enough reserves of metals such as neodymium and dysprosium, which are used in the manufacture of wind turbines and electric vehicles, to meet at least a quarter of future global demand. It also boasts significant quantities of cobalt, copper, graphite and nickel.

**90 billion**

**How many barrels' worth of oil there could be in the Arctic**

**30%**

**How much of the world's undiscovered natural gas reserves could be in the Arctic**

Demand for these materials is rising rapidly around the world as the energy transition gathers pace. China now dominates global supply chains, with other regions – most notably Europe – racing to secure alternative supplies.

"There is increased interest from [multinational mining companies] for exploring and mapping the deposits in the Arctic, due to the need for particularly critical raw materials in Europe," says Anne Merrild at Aalborg University in Denmark.

Merrild spent her childhood in Greenland and still has family living there. She says the interest from the US has "shocked" residents but also strengthened their resolve to develop the island's resources to bolster its case for independence. "Greenlanders are very proud people," she says. "Developing our resources is one way to strengthen our economy, to set the path forward."

But despite the hype, Greenland's actual mining industry is minuscule. The island has only two active mines, and while it has issued around 100 mining licences, mostly for exploration, it will be many years before any transition to commercial ventures.

This isn't a new issue; geologists have known for decades about the Arctic's potential riches. The problem has been accessing them.

Most of the Arctic is ocean, covered for most of the year by thick sea ice. But even though this ice cover is thinning and retreating (See, "Earth's frozen oceans in meltdown", page 14), open-water oil and gas exploration and drilling is still a hugely expensive and dangerous endeavour, justified only if the oil price is high enough. Even onshore fossil fuel extraction is more expensive in the Arctic, costing 50 to 100 per cent more in Alaska than in Texas, for example.

There is also the reputational and financial risk if something goes wrong. "The Arctic

environment is harsh but at the same time it is vulnerable; it is fragile," says Merrild. "The flora and fauna is delicate and it takes a long time to rebuild if it is damaged."

Western oil companies, for example, are wary of operating in such an environmentally sensitive region, where mistakes can be costly. In 1989, the Exxon Valdez, an oil tanker owned by Exxon Shipping Company, hit a reef off the coast of Alaska, draining almost 23 million litres of oil into the ocean in just a few hours. The disaster killed thousands of seabirds, otters, bald eagles, orcas and other wildlife, and destroyed marine habitat for hundreds of kilometres, with the impacts still apparent decades later. Exxon was forced to spend about $2.2 billion on cleaning up the spill and pay a further $1 billion in damages.

For critical mineral exploration, which primarily means land-based mining, companies have historically had to contend with huge glacial crusts or permafrost. Local infrastructure, such as roads and ports, is often sparse, and the available workforce is limited.

## Melting away

Rapid melting alleviates some of those problems, but also creates new ones. Melting permafrost improves accessibility to critical materials, but destabilises existing infrastructure and increases the risk of environmental disasters. In 2020, a fuel reservoir collapsed at a Russian power plant operated by a subsidiary of metals giant Norilsk Nickel, flooding local rivers with up to 21,000 tonnes of diesel oil. The spill, which caused $1.5 billion worth of environmental damage, was blamed in part on the collapse of the tank's foundations due to thawing permafrost.

"The melting permafrost will make life much more difficult," says Philip Andrews-Speed at the Oxford Institute for Energy Studies. Building new infrastructure – such as houses, operational buildings and roads that can cope with the thaw – is much more expensive, he points out.

Meanwhile, in Greenland, where the US's attention has been focused, melting glacier ice has exposed thousands of kilometres of new coastline. But this new land is precarious, vulnerable to landslides that can trigger huge tsunamis. "If you have infrastructure on land, say for mining or drilling or building, you would probably rather have permafrost where you can predict what the stability of the land will be, than going into a warmer surface that melts half the time," says Philip Steinberg at Durham University in the UK. "Climate change is not always, at least, the economic boon for Arctic extraction that it's made out to be."

The Arctic's Indigenous communities could also have a say in how much mining activity gets going. Often these communities mount strong opposition to development proposals, fearing new industrial activities will damage the local environment and cut off their traditional migration routes. In 2023, Swedish mining firm LKAB identified massive deposits of iron ore and phosphorus in the Swedish Arctic, which it says could meet 18 per cent of Europe's rare earth requirements, but the Indigenous Sámi people oppose the mine's development.

Such clashes will stymie industry in parts of the Arctic, predicts Andrews-Speed, limiting the role the region will play in bolstering global supplies of critical minerals needed for the energy transition. "Whether you are looking at Canada or Northern Europe, the Indigenous people of the Arctic are going to, at minimum, slow things down," he says.

> "Climate change is not always the economic boon for Arctic extraction that it's made out to be"

Taken together, the physical, environmental and social risks of developing industrial activities in the Arctic will deter many firms, despite the rapid melt underway in the region. "It's never going to be an easy operating environment for mining, for drilling, for shipping even," says Steinberg. Andrews-Speed says: "The projects will go ahead, but it will not make a big difference, with one or two small exceptions," he says. "The big difference will be in other parts of the world, where it is cheaper and easier to do business at a scale."

## The rise of Arctic shipping

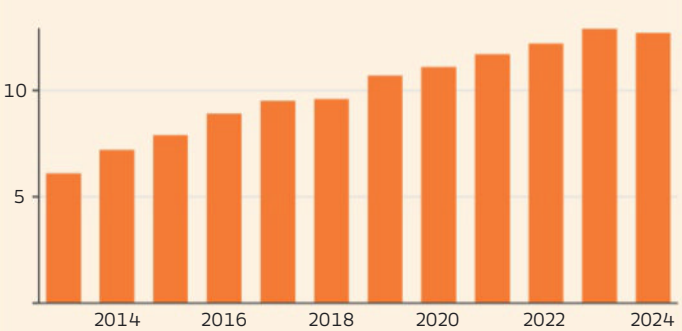
**As sea ice retreats in the Arctic, new shipping routes are opening up, allowing for the transport of goods and commodities into, through and out of the region.**

**Data compiled by Protection of the Marine Arctic Environment (PAME), part of the international Arctic Council, suggests that the number of unique ships entering the Arctic increased by 37 per cent between 2013 and 2024. Fishing boats are the most common kind of vessel in the Arctic, but there has been a surge in the number of crude oil tankers, gas tankers, cruise ships and bulk carriers, the data shows. The rise in vessels transporting cargo and fossil fuels points to increasing industrial activity in the Arctic, PAME notes, with the distance sailed by bulk carriers increasing by 205 per cent in the last 13 years.**

**Climate change enables the "easier transport of materials in and out of the Arctic region," notes Anne Merrild at Aalborg University in Denmark. But it may be the arrival of new transcontinental trading routes, such as the trans-Arctic passage, that really puts the Arctic on the map for global shipping activity.**

The distance sailed by ships inside the Arctic is increasing

Arctic shipping has more than doubled since 2013 (in million nautical miles)




SOURCE: PROTECTION OF THE ARCTIC MARINE ENVIRONMENT

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# Views



Comment

# Burning issue

The TV drama *Adolescence* is shaking things up in the UK. But where is the equivalent show for climate change, asks **Bethan Ackerley**

EVERYONE in the UK is talking about *Adolescence*. Created by Jack Thorne and Stephen Graham, the hit TV drama follows the investigation into a 13-year-old boy accused of killing a female classmate. It has sparked conversations about social media and the so-called manosphere, an online community of misogynistic influencers.

It has been so widely praised that UK Prime Minister Keir Starmer recently met the team behind *Adolescence* to discuss the online radicalisation of teenage boys. Meanwhile, the leader of the UK's Conservative party, Kemi Badenoch, endured a minor media firestorm after revealing she hadn't seen the series.

I am not here to give my view on whether plans to show *Adolescence* in UK schools will lessen misogyny among children. But what it did make me wonder is which other TV series our political leaders should be watching – and why the most pressing crisis of our times is yet to receive the *Adolescence* treatment.

Television, perhaps more than any other medium, is seen as a vehicle for change. Thorne has called it the "empathy box": it lives in our homes, evolving alongside us and making us better people.

Sometimes, it really does work like that. The 1960s drama *Cathy Come Home* led to the creation of homelessness charity Crisis, while a 2018 survey found that women in the US who regularly watched *The X-Files* were more likely to believe that women should study STEM subjects. And the 2024 drama *Mr Bates vs The Post Office* – about the hundreds of UK Post Office employees wrongly prosecuted due to a faulty IT system – led to more than 100 new potential victims seeking legal advice.

ADRIÀ VOLTÀ

But one issue where this hasn't happened is climate change. While documentaries have long played their part in informing the public about ecological crises, they don't seem to be enough. Take the 2017 series *Blue Planet II*. This is widely credited with raising awareness of marine plastic pollution, yet there is little evidence it caused enduring changes to consumer habits.

So could television really help save our planet? Fiction, not fact, may be key. We know storytelling is a prosocial behaviour and that acting for the collective good is vital for passing climate legislation. Heavy viewers of fictional TV have also been shown to more strongly believe in justice than do viewers of news and documentaries, which could prove crucial in stopping climate nihilism from taking hold.

We also know that awe – which encourages individuals to see themselves as small elements of a far larger world – is a powerful tool for preventing climate inaction. Science fiction may therefore be uniquely helpful: last year, researchers found that sci-fi was distinct in its ability to inspire awe and was linked to people identifying with all humanity. Even the act of imagining the future might encourage leaders to look beyond the next election and take long-term action.

What we need, then, is an *Adolescence* for climate change. If I could choose an existing series for politicians to watch, I would pick the 2019 drama *Years and Years*, which followed a British family living through the rise of fascism as the planet burns. *For All Mankind* – an alternate history of the space race, in which greater investment in new technologies slows down global warming – might also prove inspirational.

But some yet-to-be-adapted sci-fi novels would be even better. Who could watch a small-screen version of Octavia E. Butler's *Parable of the Sower*, Ursula K. Le Guin's *The Word for World Is Forest* or Kim Stanley Robinson's *The Ministry for the Future* and not be inspired to save our precious home planet? The opportunities are endless – we just need some fantastic writers to take them. Perhaps that could be Thorne and Graham's next project. ▮


Bethan Ackerley is *New Scientist*'s television columnist, and a subeditor

No planet B

# **Individual action** With corporations and governments playing fast and loose with environmental protections, are ordinary people fighting a losing battle to go green, asks **Graham Lawton**

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

## Graham's week

**What I'm reading**
Juice *by Tim Winton.*

**What I'm watching**
*The new season of* Black Mirror *on Netflix.*

**What I'm working on**
*A lot of stories about intestines...*

This column appears monthly. Up next week: Annalee Newitz

I HAVE been doing a lot of work recently on how narrow corporate interests are a seemingly insurmountable obstacle to making the changes necessary to stop the destruction of the environment. A few weeks back, I reviewed *A Climate of Truth* by Mike Berners-Lee, which makes a powerful case that dishonesty and obfuscation by climate-trashing industries are a major cause of environmental destruction. It reminded me of an interview I did a few years ago with Harvard science historian Naomi Oreskes, who has spent years exposing the tactics of corporate science deniers in the tobacco industry and oil and gas sector. I remember being dismayed by the depth of their deceit. Sadly, things have not gotten any better.

More recently, I've watched in horror as the new Donald Trump administration in the US strips away all environmental protections and slashes and burns related science, seemingly hell-bent on allowing private companies to do whatever they like in pursuit of profit. We are, it seems, fighting a losing battle.

It was against this disempowering background that some new research from the not-for-profit World Resources Institute (WRI) caught my eye. The headline read "The Most Impactful Things You Can Do for the Climate Aren't What You've Been Told". It would be, I hoped, a timely reminder that ordinary people are not powerless, plus some novel and actionable advice about how to live a climate-friendly life. So, I read the report.

First, the good news. By adopting pro-climate behaviours in just three areas of our lives – how we travel, how we power our homes and what we eat – it is theoretically possible for individuals to become carbon-neutral or even carbon-negative. The average person is directly responsible for 6.28 tonnes of greenhouse gas emissions a year, according to the WRI. Its analysis found that behavioural change can cancel that out completely, or even overshoot it by just under a quarter of a tonne.

What are these behaviours, I wondered, and why are they not what I've been told? Number one is to ditch petrol-powered cars and switch to electric vehicles (EVs), public transport or active transport such as walking or cycling. Going completely car-free

> **"The Trump administration wants to abolish tax credits that make home solar power more affordable"**

can cut personal emissions by 30 per cent. Hmm, I think I knew that.

Next on the list is flying less, which can achieve an 18 per cent cut. Number three is installing solar panels, insulation and a heat pump at home, which – along with moving to a smaller property – can reduce emissions by 16 per cent. Switching to a plant-based diet can cut your emissions by about 13 per cent. Meanwhile, familiar but less impactful actions include recycling, composting, cutting food waste and marginal reductions in household energy use by, for example, switching to more energy-efficient appliances.

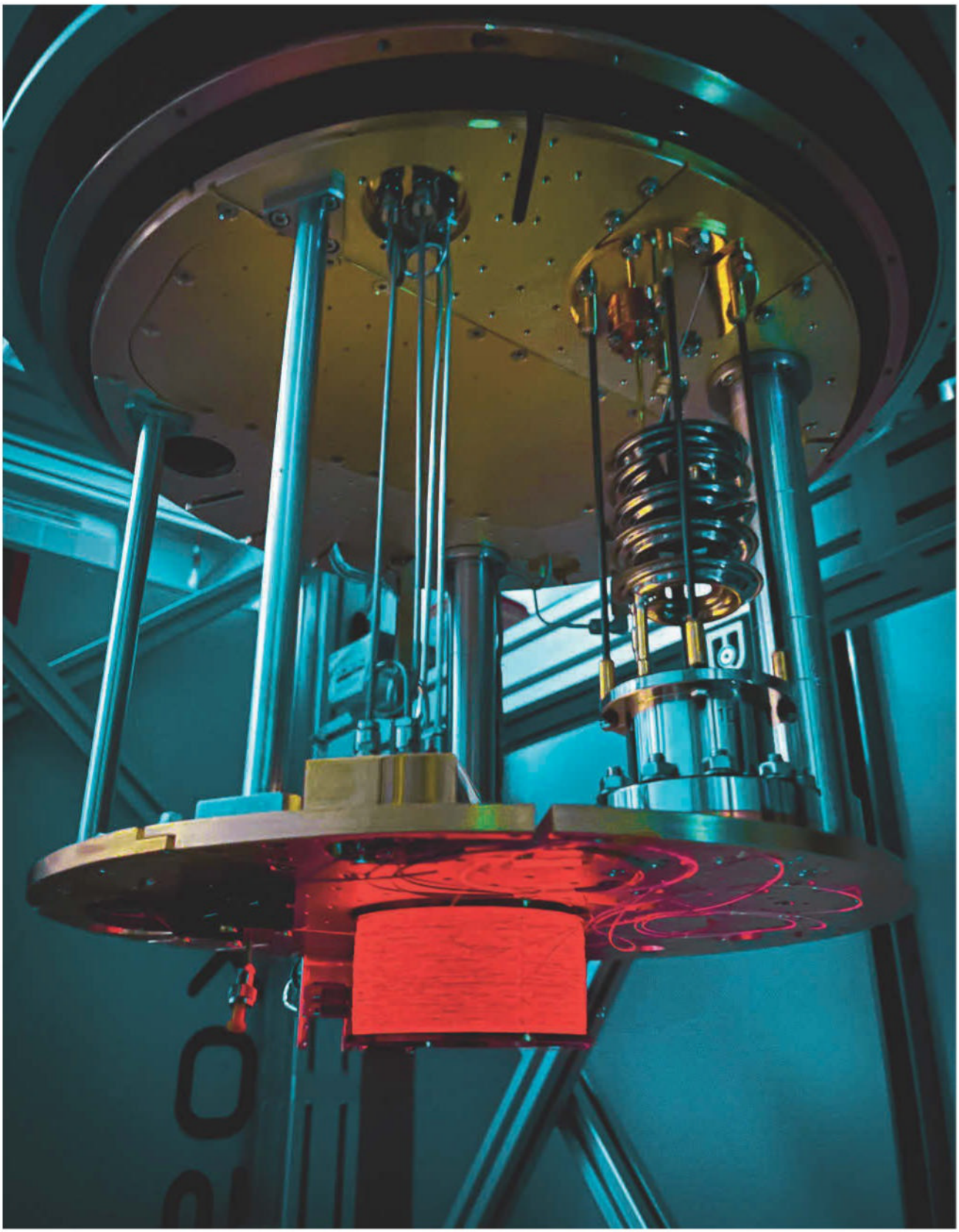
No obvious revelations there, but it is still good to know that individual behavioural changes can have a major impact. Right?

Here's the rub: even though these actions can theoretically wipe out the average person's carbon footprint (actually a concept invented by energy company BP in 2004 to divert attention from the hydrocarbon industry's impact on the climate and shift the onus onto individual actions), in the real world such actions typically make only a 10 per cent reduction. That is nowhere near enough to get to net zero.

To realise the full potential of behavioural change, people need the support of – wait for it – governments and corporations. That includes subsidising investments in heat pumps or cleaner vehicles, installing charging infrastructure for EVs, investing in public transport and bike lanes, and offering tasty plant-based meals in canteens. That appears to be the opposite of what is happening out there; the WRI report admits that the Trump administration, for example, wants to abolish tax credits that make EVs and home solar power more affordable. Governments are retreating from net-zero targets around the world.

That's not to say it can't be done, and the WRI report gives examples. The Netherlands introduced generous subsidies for home solar installations and allowed households to sell surplus electricity into the power grid, transforming a country that once had low uptake of home solar panels into the highest per-capita user in Europe. In Bogotá, Colombia, investment in cycling infrastructure has increased the number of journeys made by bicycle from 0.58 per cent in 1996 to 9.1 per cent in 2017.

I applaud the WRI for its timely reminder that individual behavioural change has a role to play in tackling the climate crisis. But I would rather they had told it straight: governments and corporations are failing us.



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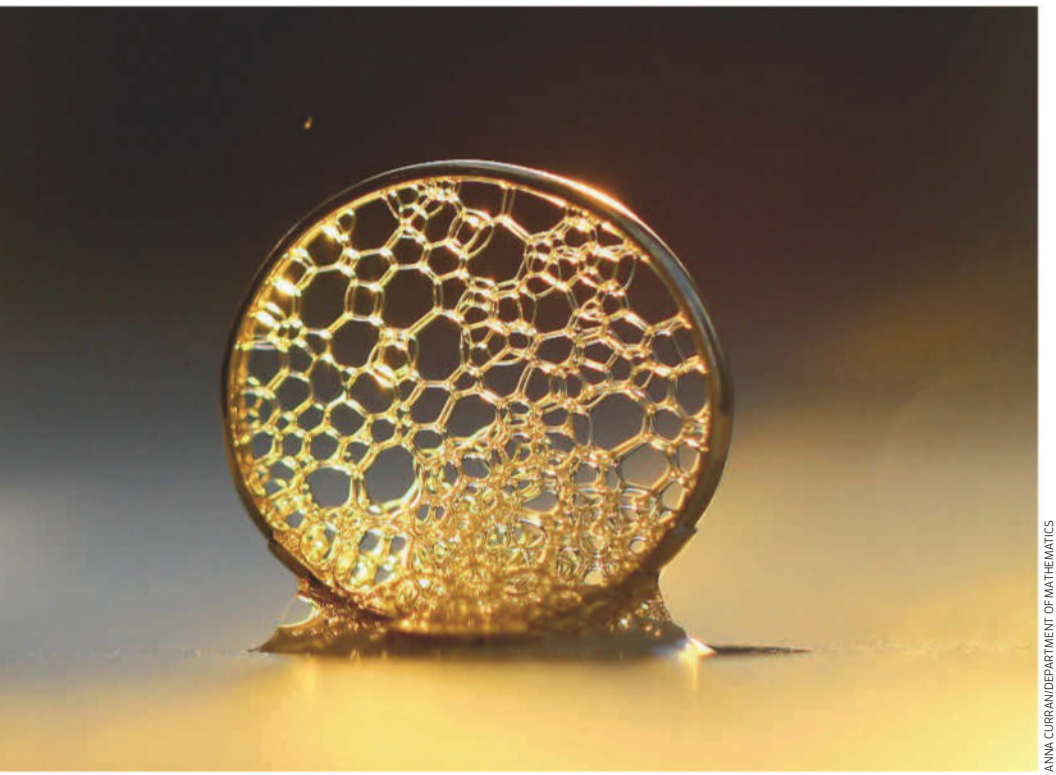
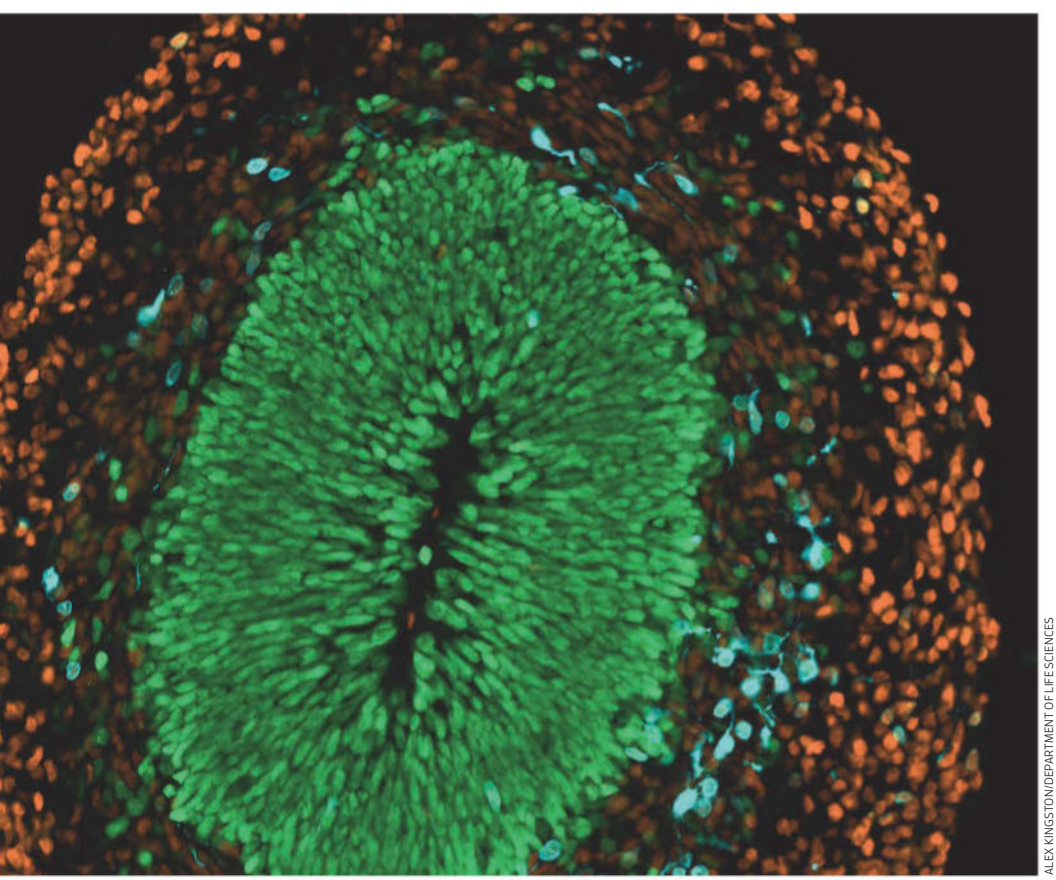


ANNA CURRAN/DEPARTMENT OF MATHEMATICS



ALEX KINGSTON/DEPARTMENT OF LIFE SCIENCES

# Lab lens

**Imperial College London**
**Faculty of Natural Sciences**

PHOTOGRAPHS accompanying most scientific papers might politely be called "functional". But this collection of images from Imperial College London's research photography competition proves that research can be beautiful.

The far-left image, by Harsh Rathee of the physics department, shows an optical fibre connected to a dilution refrigerator, a device that creates a temperature a thousandth that of the vacuum of space. By observing how light interacts with sound waves at this incredibly low temperature, researchers can explore the unique properties of matter at the quantum level.

The upper near-left entry is from Anna Curran of the maths department, who won a judges' choice prize in the PhD student category. Curran's research focuses on mathematically modelling the effect of molecules called surfactants, which reduce surface tension in fluids. It is this phenomenon that allows bubbles to hold their shape within the ring. "Surfactants are all around us – in our soaps and detergents, they are responsible for breaking down dirt and bacteria, but their effects also underpin many biological, medical and engineering processes, from inkjet printing to self-cleaning surfaces to the treatment of premature babies' lungs," says Curran.

At lower near-left is an image from Alex Kingston of the life sciences department. It depicts part of a cerebral organoid, also known as a "mini-brain". These lab-grown collections of cells are a microcosm of the earliest stages of human brain development.

**Matthew Sparkes**

# Ancestral voices

Hunting the origin of many of our modern languages is a huge feat, but a new book makes an excellent and elegant job of it, says **Peter Hoskin**

Book
**Proto**
**Laura Spinney**
**HarperCollins (UK)**
**Bloomsbury Publishing (US, 13 May)**

SAKKMESTERKE/ALAMY

**The now-extinct Tocharian language on a scrap of parchment**

A NEW book by Laura Spinney is rather tantalisingly called *Proto,* begging the question: proto-what? Prototype, the earliest version of a technology? Protoplasm, the stuff of our cells? Or even protoplanet, a small hunk of space rock with a big future ahead?

The answer, in fact, sits above and across those words: Proto-Indo-European. This is the great original language from which English, among many other tongues, both alive and dead, derives. As Spinney puts it: "Almost every second person on Earth speaks Indo-European." And the task she has set herself in *Proto: How one ancient language went global* is to explain how.

The story she ends up telling, through a mixture of reportage and beautiful prose, is one that spans millennia, dozens of civilisations and thousands of kilometres. It is a magisterial feat.

It starts around the swirling waters of the Black Sea, about 6000 to 7000 years ago, where ancient peoples started meeting, merging and mimicking each other's vocabularies to achieve goals such as trade.

Encompassing modern-day countries such as Ukraine and Bulgaria, this area was and is so rich in resources that it became a foundry for the Copper Age and many other developments. It is from here that the steppe folk reckoned to be the source of Proto-Indo-European – known as the Yamna in Ukrainian and the Yamnaya in Russian – struck out.

The Yamna are long gone, as is the language they spoke. They belong to prehistory, before written records began. This makes the early chapters of *Proto* a model of educated imagination. Here, drawing on the available evidence, Spinney allows the Yamna to live again. They aren't just skeletons, but fully fleshed people who stood around 1.8 metres tall, drank milk and smoked cannabis. They had, it is thought, a word for "wheel" (*k$^{w}$ék$^{w}$los*) and another for "honey" (*mélit*).

If all that makes *Proto* sound too much like a history book, then rest assured: there is a lot of science going on. Spinney, who has written features for *New Scientist*, explains that the study of Proto-Indo-European and its proliferation is a multidisciplinary pursuit. There is linguistics, enabling researchers to work backwards through various languages, grabbing on to roots of roots of roots, before having a go at reconstructing Proto-Indo-European itself (and those words for wheel and honey are reconstructions).

**"The Yamna, thought to be the source of Proto-Indo-European, are long gone, but live again in this book"**

Then there is archaeology, which enables us to see the Yamna's journeys through time and space. And there is genetics, by which we can track their advances through other populations. According to one study Spinney cites, "migrants had radiated east and west from the steppe around five thousand years ago, and in Europe their ancestry had replaced up to ninety per cent or more of the gene pool".

Migration is a huge part of Spinney's story. After the initial explications of Proto-Indo-European and the Yamna, the book effectively becomes a chapter-by-chapter account of migrations, large and small, violent and peaceful, by which the original language spread and split.

There are 12 main branches of Proto-Indo-European – from Greek to Germanic, Italic to Indic – all of which divide into branches of their own. Some of those have withered and died. As Spinney recounts in one of the most evocative passages of *Proto*, the disappeared Tocharian, found along the routes of China's Silk Road, may have been the result of an ambitious, one-off trek by the Yamna centuries before.

It is in these chapters that *Proto* can get a little knotty. You need to keep your brain switched on to distinguish between Hittites and Hattians or between one chromosomal group and another. Spinney shares every side of every argument to a fault: sometimes you are just getting to grips with a complicated idea when another is suddenly thrust upon you.

Yet such are the demands of the vanished past and its vanished languages. Any book that offers certainty on prehistory ought to be disregarded. *Proto* doesn't do that. It is clever, careful, expansive, insightful and a host of other fine Indo-European adjectives. ▮

Peter Hoskin is books and culture editor at *Prospect* magazine

# Existential Groundhog Day

An unusual speculative novel uses an old trope to new effect, urging us to be truly alert to the world, finds **Gerardo Bandera**

Book

**On the Calculation of Volume (parts I and II)**
**Solvej Balle, translated by Barbara J. Haveland**
**Faber & Faber (UK); New Directions (US)**

ON HIS 70th birthday, Albert Einstein received a manuscript from his friend, the logician Kurt Gödel, demonstrating mathematically something Einstein had conjectured, but never proven. According to his general theory of relativity, space-time could bend and close in on itself, creating a loop to the past.

It was an extraordinary development, but one that troubled many physicists – so much so that, years later, it led Stephen Hawking to make his "chronology protection conjecture", according to which the laws of physics prohibit time travel. This meant that time loops were relegated to philosophical experiments and science fiction, where they became a tired trope burdened by predictable plots and cheesy grandfather paradoxes.

*On the Calculation of Volume*, Solvej Balle's seven-part novel, is a welcome change of pace that slows down the temporal experiment and creates a meditative space where we can explore the illusory effects of time. The first two parts of the Danish novel are now available in English, with part I shortlisted for the 2025 International Booker prize.

For Balle's protagonist, Tara Selter, an antiquarian book dealer in France, the arrow of time is broken. Each day, she wakes up to 18 November, which repeats with no end in sight. By the time we meet Tara, she has lived 120 iterations of the same day, and the novelty has become claustrophobic ennui.

Unlike many time-loop experiments, Tara isn't subject to a daily reset – she can travel, begin the day in different places, repeat the same routine or change it slightly, and remember what she did on each 18 November. Everybody else, however, lives the day for the first – and only – time. Balle's innovative set-up isolates her character in a confounding, introspective experience while granting her enough agency to change her course – if she chooses.

The novel's contemplative prose (lucidly translated by Barbara J. Haveland) and slow, structureless plot lull the reader with their repetitiveness – but this is intentional, done to immerse us in Tara's stagnant world. For most of the first part, Tara spends her days observing details, finding patterns and writing them down with the dim hope of discovering a way out.

Ordinary events become a choreographed performance: she comes to know exactly when the birds will sing, the rain will fall or the tap will run. Sensory details turn into a rhythm she memorises and anticipates. "I find my way into a predictable world, a pattern that acquires more and more detail," she reflects in her journal. Like the narrator in Marcel Proust's *In Search of Lost Time*, habit begins to numb perception and impede the protagonist's self-discovery.

By the end of part I, we find Tara ready to break out of this monotony and take control of her days, even if whatever futile change she achieves will be reset the next morning. In part II, Tara attempts to recreate the sensation of time by travelling to places where the climate matches her internal calendar. On what feels like 25 December for her, she recruits her family to celebrate Christmas – even if it is only mid-November for them. The sensation of time passing, Balle reminds us, is critical to a sense of self.

*On the Calculation of Volume* calls our attention to the illusion of time's dulling effects. As a prediction machine, the brain quickly becomes habituated to repeated stimuli, expecting their recurrence while diminishing our emotional response to them. By making us aware of this numbing process, Balle encourages us to harness our powers of observation and remain alert to the world, which is never truly as constant as our minds would have us believe. ▮

Could reliving a single day over and over alert us to the numbing effects of time?

PUNEET VIKRAM SINGH; NATURE AND CONCEPT PHOTOGRAPHER/GETTY IMAGES

## New Scientist *recommends*

**Madeleine Cuff**
**Reporter**
**London**

I skirt the river Thames most days, usually in a packed train, though occasionally I stroll along its banks and admire the gleam of its water. But it is what lies beneath the river's waves that is

most fascinating, as I discovered at the London Museum Docklands's exhibition, **Secrets of the Thames**.

The show is devoted to mudlarking, the popular hobby that sees people scour the Thames at low tide for hidden treasures. From murky beginnings – tales of thievery and scams open the show – mudlarking is revealed as a vital archaeological resource. And London's riverbed has rich pickings.

From false teeth to Iron Age helmets, each cabinet holds fresh wonders, disgorged in near-pristine condition. On display are loaded dice, hunting knives, Viking brooches, eel spears and more, shed by the city's residents over the centuries.

These objects are a journey through London's history, telling stories of the rich and the destitute, warriors and enslaved. It made me want to hunt treasure myself.

JOHN CHASE/LONDON MUSEUM

# Nature's power to transform

From clams to crimson rose butterflies, a poetic account captures the rich wildlife that offsets the urbanity of Chennai, India, says **Graeme Green**

Book
**Intertidal**
**Yuvan Aves**
Ithaka

WHEN Yuvan Aves was a boy, a search party had to be sent out after he went missing. It turned out he had been so enthralled, sitting by a pond, watching a small bird of prey leap across the water to catch hovering dragonflies that he had lost track of time.

Decades later, the adult Aves is a naturalist, author, educator and environmental activist. He still spends hours watching wild creatures, and his observations of the natural world and the ideas they spark fill his new book, *Intertidal: The hidden world between land and sea*.

A diary account, recorded over two years from 2020 to 2022, it is a forensic look at the coastal city of Chennai, where he lives, on the Bay of Bengal's Coromandel Coast in the state of Tamil Nadu.

The "intertidal" of his title is defined as "the part of the shoreline that appears during low tide and is hidden during high tide", an area between land and ocean. Such transition zones are often populated with abundant life and diverse species. Readers are given a guided tour of beaches, rivers, wetlands and forests amid Chennai's "utter urbanity", where we are introduced to all kinds of residents, from clams to crimson rose butterflies.

According to nature writer Robert Macfarlane, who wrote the introduction, Aves "is flat out and hands down the best all-round naturalist with whom I have ever spent time in the field. Fungi, protists, plants, snakes, birds, fish, insects, mollusc, lichens, humans: his knowledge spans the many kingdoms and phyla of life."

The book is also about other in-between zones where elements meet or overlap: human and wildlife, nature and development, poetry and science, history and present, personal and political.

Aves's writing is captivating. Here he is walking on Urur Kuppam beach: "Early April wind blows feebly from the southeast. Crows sit airily along the sterns of boats facing the sea as if there is nothing for them to do that day. Waves curl south to north, stooping into question marks."

**"Aves is hopeful that more young people are moving away from values that proved ecologically disastrous"**

I particularly enjoyed Aves on ghost crabs, which live "on the foggy cusp of land, sea, sand and sky. They can hear and drink with the setae (hair) on their feet, speak in pincer signs, stridulations and gut rumbles. They have panoramic 360-degree vision, and the cylindrical retinas atop their eerie ghostly periscope eyes can see you coming from 50 metres away".

They also have a very clear role: as "the principal clean-up squad and public health officers of sandy shores – beaches would be less liveable and hygienic places for numerous life forms, including us". Their burrowing also reworks the soil, making the subsoil more inhabitable for other species.

Aves's relationship with nature is intensely personal. Growing up with a violent, uncaring father in a low-income household, then with a stepfather who beat him so badly his blood spattered the walls, the young nature lover's spirits would be lifted by the sight of a peregrine falcon, mongoose or snake.

Later, Aves recounts a story from when he was 14 and a wolf snake came in the house. His stepfather asked him to kill it. Instead, Aves left it safely outside in the grass, and ended up beaten until dawn, "thrashed with every piece of furniture in the house".

Aves has continued to take a stand against violence and to defend nature in India, one of the most dangerous countries in the world for environmental activists. He is the founder of the Palluyir Trust for Nature Education and Research, which provides outdoor, nature-based learning for the public, especially children and young people. Aves also supports environmental campaigns and conservation across Tamil Nadu, work detailed in *Intertidal*, including documenting the wildlife of Pulicat lagoon.

While the book's focus is on a section of India's east coast, its issues are global. Aves is hopeful that more young people are "moving away from the old political, religious and cultural values that have proved to be ecologically disastrous". His book will make that shift more likely.

**An egret takes off at Pallikaranai marsh in Chennai, India**

MURALIDHARAN ALAGAR ARTS AND PHOTOGRAPHY/GETTY IMAGES

Graeme Green is a journalist and writer based in Derbyshire, UK

## Editor's pick

### Let's hear it for introverts, some of history's greats

**22 March, p 27**

*From Dominic Owens, Cambridge, UK*

**As a life-long introvert, I was taken aback by the advice in the book *Me, But Better*, which was reviewed in your pages. Forcing yourself to conform to perceived societal expectations around sociability is a recipe for disaster in the long term. Accepting yourself, on the other hand, fosters self-compassion that brings long-term happiness and, ironically, the change that many of us introverts desire.**

**I would like to point the interested reader to *Quiet: The power of introverts in a world that can't stop talking*, by Susan Cain. A gift from my university supervisor, that book helped me to understand and accept myself – and taught me that many of society's most celebrated figures, including Albert Einstein and Rosa Parks, were introverts.**

### Net carbon by banning fishing globally

**29 March, p 39**

*From John Kitchen, Kettering, Northamptonshire, UK*

If researcher Oswald Schmitz is correct about fish storing such large amounts of carbon, then we need to stop commercial fishing immediately. We know that world stocks of larger species have dipped to less than 10 per cent of what they were before industrial fishing took over. We could tackle the problem of excessive carbon dioxide in the atmosphere simply by banning commercial fishing.

### Little natural landscape left, even in countryside

**29 March, p 21**

*From Sam Edge, Ringwood, Hampshire, UK*

I loved Menno Schilthuizen's take on the (relatively) new urban natural history discoveries to be made. Unfortunately, he falls into the trap of thinking that only urbanites are living in landscapes that are "completely different from natural habitats". The rural landscapes of Europe (especially the UK), North America and many other places are artificial too, and also almost exclusively created by *Homo sapiens*.

### A flush-free way to reuse our own waste

**29 March, p 22**

*From Cheryl Hillier, Cribyn, Dyfed, UK*

Graham Lawton's article on the recovery of useful chemicals from sewage was excellent. I have long advocated for mainstream use of composting toilets – which can make use of our waste in situ – so it is helpful to put a value on the commodities we flush away.

Extracting chemicals at the source using composting toilets could cut water-treatment costs and domestic water use, making us more resilient to drought, as well as preventing sewage spills into rivers and flood water. Commodify the resources in sewage and you also potentially create emissions from their transport, which is a really strong argument to localise the process of dealing with them.

### Maybe dementia reduction had other factors at play

**15 March, p 14**

*From Paul Holt, Pitlochry, Perth and Kinross, UK*

There is an alternative explanation other than extra education for the reduced incidence of dementia in UK adults born four years after the cut-off birth date for the 1972 increase in the school-leaving age, from 15 to 16, compared with those born four years prior.

The older cohort were born in 1952 and the younger cohort in 1960. Post-war austerity probably affected the health of the older group (and their mothers during conception and pregnancy) because of poor nutrition and housing. Rationing in the UK didn't totally end until 1954, and the Clean Air Act in 1956 will also have benefited the younger group. These factors could also help account for the higher socioeconomic status of the 1960 group, which tends to correlate with better overall health.

### We give cows their own medicine cabinet

**22 March, p 34**

*From Iain Gordon, Townsville, Queensland, Australia*

I read with interest your interview with Jaap de Roode on self-medication in animals. My research focuses on domestic livestock self-medicating against gut parasites using medicinal plants. De Roode mentions that farm animals lack a varied diet for better health. At Lincoln University's Integral Health Dairy Farm in New Zealand, we introduced woodland strips with herbaceous plants, shrubs and trees, allowing animals to feed on aromatic plants for medication.

### Uncertainty in science is a great source of joy

**22 March, p 26**

*From Byron Rigby, Melbourne, Australia*

Your review of Adam Kucharski's book *Proof* refers to "truth" and "truth-seeking" in science. I don't know if Kucharski's book uses these terms much, but perhaps it should be added that indisputable truth isn't available in science, and that seeking evidence for something is less important than seeking evidence against it. Nowhere is this better illustrated than in Isaac Newton's theories of motion and gravitation being refuted from the beginning by anomalies in Mercury's orbit.

Once you get used to it, the perpetual uncertainty of science can be a great source of joy. There is no dead end; the journey is perpetual.

### Has population really been underestimated?

**29 March, p 17**

*From Scott McNeil, Banstead, Surrey, UK*

In their study on world population, the researchers used data from dam projects as the basis for their assertion that rural populations had been significantly underestimated. Could there be another explanation for the apparent discrepancies?

No doubt in many cases, people living in the area to be flooded were offered compensation. This could encourage false claims ranging from exaggeration and embellishment to outright fraud.

### An unfortunate case of nominative determinism

**29 March, p 10**

*From Dyane Silvester, Arnside, Cumbria, UK*

Reading "A wobbly start to radio astronomy on the moon" got me wondering: did NASA, in a spectacular case of nominative determinism, seal the lander's fate by naming the telescope mounted on it ROLSES-1? Perhaps someone should warn the agency not to use the name "Cosmic Radiation and Associated Solar Heating Interstellar Energy Sensor" (CRASHIES) for anything.

### For the record

**Andreas Hejnol is at Friedrich Schiller University Jena in Germany (5 April, p 13).**

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# Rethinking Parkinson's

We have fresh hope of treating the world's fastest-growing neurological condition – thanks to the surprising discovery that the disease might exist in two types, says **Alexandra Thompson**

PER BORGHAMMER'S "aha" moment came nearly 20 years ago. The neuroscientist was reading a paper from researchers who were examining whether REM sleep behaviour disorder (RBD), a condition that causes people to act out their dreams and is often found in people who later develop Parkinson's disease, could be an early form of the neurological condition.

Rather than starting with the brain, however, the team instead looked for nerve cell loss in the heart. Though Parkinson's is historically associated with nerve cell depletion in the brain, it also affects neurons in the heart that manage autonomic functions such as heart rate and blood pressure. And, says Borghammer, "In all of these patients, the heart is invisible; it is gone."

Not literally, of course. But in these people, the neurons that produce the neurotransmitter norepinephrine, which helps control heart rate, were so depleted that their hearts didn't show up on scans using radioactive tracers. This kind of neuron loss is associated with Parkinson's, but at the time, none of the people had been diagnosed with the disease and their brain scans seemed normal.

What struck Borghammer was that Parkinson's didn't seem to follow the same trajectory in everyone it affected: RBD strongly predicts Parkinson's, but not everyone with Parkinson's experiences RBD.

"I realised that Parkinson's must be at least two types," says Borghammer – when neuron loss starts outside the brain, eventually working its way in, and when neuron loss is largely restricted to the brain from the beginning. By 2019, Borghammer, at Aarhus University in Denmark, had gathered enough evidence to formally propose his theory of "brain-first" and "body-first" Parkinson's.

Now, with 14 published studies and more on the way, the idea is starting to gather steam. And if Borghammer is right, reframing the disease as existing in two discrete forms could dramatically transform how we treat or even prevent it.

"I think that we are getting to the heart of what causes Parkinson's disease," says Timothy Greenamyre, a neurologist at the University of Pittsburgh in Pennsylvania. "That will be a huge home run."

Getting to grips with the causes of Parkinson's disease can't come soon enough. Cases are skyrocketing, with a recent study estimating that by 2050, 25.2 million people will be living with Parkinson's disease worldwide, more than double the nearly 12 million people with it in 2021. Some researchers are even calling it a "pandemic" (see "Parkinson's on the rise", page 32). Meanwhile, the search for more effective treatments, not to mention a cure, has been littered with disappointments.

Parkinson's symptoms – tremors, unstable gait, muscular rigidity – were documented as far back as 600 BC. But it wasn't until the 19th century that the condition became known as Parkinson's, after London physician James Parkinson described six people's "involuntary tremulous motion" in his 1817 *An Essay on the Shaking Palsy*. Parkinson's was then rare, and it would take 100 years before the brain structures involved were identified.

## Losing dopamine

We now know that Parkinson's is associated with the loss of nerve cells in parts of the brain that help control movement, such as the substantia nigra. Some of these neurons produce the neurotransmitter dopamine, and the reduction in dopamine disrupts the normal signalling pathways that control motor function, leading to the "tremulous motion" Parkinson observed.

This neuronal die-off appears to be caused by the proliferation of a misfolded form of the protein alpha-synuclein. Alpha-synuclein is found throughout our bodies and plays a critical role in controlling the release of neurotransmitters, including dopamine, at synapses, the junctions between neurons where communication happens. But for proteins to function within cells correctly, they need to assume the right shape. When alpha-synuclein misfolds, it can form clumps called Lewy bodies inside neurons. The Lewy bodies slowly kill the neurons, whether by disrupting signalling, puncturing cells or accumulating in the mitochondria, inhibiting cells' ability to produce energy.

What causes alpha-synuclein to misfold is still unclear, but the irregular proteins seem to then spread the disease from cell to cell. "One of the mechanisms that cells have to defend themselves against bad proteins is to get rid of it by kicking it out of the cell with exosomes – a small balloon of bad material," says Borghammer. "And then the neighbour is stupid enough to import it, and then you have kick-started the process in the next cell."

Trying to understand why and how alpha-synuclein goes wrong, researchers began to search for the places in the body where the misfolding could originate. In the 1990s, neuroanatomist Heiko Braak at Goethe University Frankfurt in Germany observed that the proliferation of the Lewy body clumps resembled "a falling row of dominoes". This led him to suspect that the disease might originate outside the central nervous system ›

SUNNU REBECCA CHOI

## Parkinson's on the rise

**Parkinson's is the fastest-growing neurodegenerative condition in the world. The question is: why? Initial rises in disease rates were attributed to increased life expectancy – diagnoses generally occur among people aged 60 or older and "as more people get old, there'll be more people with Parkinson's", says Dario Alessi at the University of Dundee, UK. But that can't be the whole answer. Rates of Parkinson's are rising faster than would be expected even if people are living longer, says Filip Scheperjans at Helsinki University Hospital in Finland.**

**Many point the finger at pesticides, which have been the subject of dozens of Parkinson's-related studies over the past 40 years. They enter cells and damage mitochondria, which provide cells with energy, says Alessi. "You get to that level where the body can't compensate anymore and you start getting symptoms." Much of this research is observational and cannot prove cause and effect, but the sheer volume of evidence makes the idea increasingly convincing. "It is very robust, very consistent across studies," says Alastair Noyce at Queen Mary University of London. Studies of agricultural workers also show that greater pesticide exposure is linked to greater likelihood of diagnosis. "If you sprayed more [pesticides] and were protected less, that seemed to increase your risk even more," says Lee Neilson at Oregon Health & Science University.**

**Air pollution is also increasingly under scrutiny. Traffic exhaust fumes release particles known as PM2.5. These measure just 2.5 micrometres across and contain even smaller particles that can cross the blood-brain barrier, the membrane that keeps harmful substances in the blood out of the brain, triggering inflammation that may damage dopamine-producing neurons. In a recent study, people who had the greatest PM2.5 exposure, determined by their home address, were 23 per cent more likely to have a Parkinson's diagnosis than those with the lowest exposure. However, the scientific consensus isn't unanimous – defining PM2.5 exposure is difficult, as is quantifying an individual's exposure over their lifetime.**

and somehow find its way in. In 2003, Braak proposed that some kind of pathogen could trigger local inflammation in a network of nerve cells within the gut called the enteric nervous system and initiate the corruption of alpha-synuclein. Neurons in the vagus nerve, a conduit that connects the gut and brain, would then carry the misfolded protein to the vulnerable brain regions.

Braak's hypothesis has gained ground in the years since. However, critics note that it doesn't describe the development of Parkinson's in all cases. In a small but pivotal 2020 study, Borghammer, Aarhus University PhD student Jacob Horsager and their colleagues assessed 37 people with Parkinson's, of whom 13 also had RBD, as well as 22 people with only RBD. The team showed that, on average, people with RBD had more neuron loss in the heart and gut than those with only Parkinson's, hinting that the disease originated there before making its way to the brain.

But crucially, the team also found that those without RBD "lose the dopamine system first but have more normal hearts and guts", says Borghammer, implying that for them, the disease started in the brain.

Borghammer realised that, though Braak might have been correct in thinking that neuronal degradation starts "body-first" in some people with Parkinson's, that didn't describe everyone. There are other people for whom the dopamine-producing structures in the brain are affected from the start, "brain-first". "It is completely two separate categories with no overlap," says Borghammer.

### Brain-first, body-first

Borghammer's post-mortem analyses of people who died with Parkinson's offered yet more evidence that the disease followed at least two trajectories: some people had misfolded alpha-synuclein only in the centre of their brain, supporting the brain-first idea, but for others, it was found only at the bottom of the brainstem, as if it had just reached the brain from somewhere else. "When you've got several hundred brains [showing this], it starts to get pretty convincing," says John Hardy, a neurologist at University College London.

Borghammer's team isn't alone in pursuing this idea. Married neurologists Valina and Ted Dawson at Johns Hopkins University in Maryland have tested the body-first theory by injecting misfolded alpha-synuclein into mice's guts. "It just seemed like a reasonable experiment to do, to formally test the hypothesis," says Ted Dawson.

One month later, the misfolded protein was in the mice's brains, killing off their dopamine-producing neurons and inducing the onset of symptoms such as movement difficulties and loss of smell. "They got the whole spectrum of disease," says Valina Dawson.

Crucially, this didn't occur for mice that had their vagus nerve cut shortly after the injections. "I think that the data is very persuasive," says Dario Alessi, who researches Parkinson's genetic pathways at the University of Dundee, UK.

Such research cannot ethically be done in humans, but scientists can study people who had their vagus nerve cut as a last-resort treatment for peptic ulcer disease. In one study, those who had the nerve cut at the junction between the oesophagus and the stomach – the "trunk" of the nerve tree that communicates with digestive organs – were 15 per cent less likely to develop Parkinson's 20 years later than people in the general population who hadn't had the procedure. In a separate study, Borghammer and his team uncovered more evidence for a gut connection. They analysed gut tissue samples taken from 57 people up to 20 years before they were diagnosed with Parkinson's disease and found misfolded alpha-synuclein in more than half of them, at significantly higher levels than in people who never developed the disease.

Though much of the research focus in body-first Parkinson's has been on the gut, some scientists have gone looking for and found misfolded alpha-synuclein in other places in the bodies of people who don't have neuron loss in the brain, including the appendix and the nasal cavity. "I think that it is plausible that an initiating event in a Parkinson's disease cascade can occur in the periphery and then move centrally," says Alastair Noyce, a neurologist at Queen Mary University of London.

The two subtypes also align with how differently the condition can manifest in people. "We are confronted with a very broad spectrum of what we call Parkinson's disease that can be very differentially expressed in different patients," says Filip Scheperjans, a neurologist at Helsinki University Hospital in Finland.

For example, people with signs of body-first Parkinson's – exhibiting misfolded alpha-synuclein in peripheral tissues outside of the brain – are more likely to experience disruption to autonomic systems. In such people, RBD, unexplained drops in blood pressure, urinary dysfunction and constipation

can occur years before their movement is affected. "When you see them in the street, you wouldn't know that this is a sick person," says Borghammer. "And in 70 per cent of these cases, when you do a dopamine scan, it is normal, [but] sooner or later it becomes abnormal."

For brain-first Parkinson's disease, movement-related symptoms dominate from the start. "These are the people who are more likely to have tremor," says Camille Carroll at the University of Plymouth, UK.

## New paths to treatment

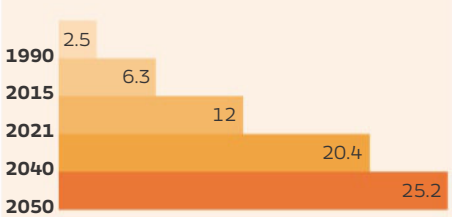
Knowing that Parkinson's might actually be two different types of disease can offer new pathways to treating it. "The point is: why the hell is there a brain-[first] and body-first type?" says Borghammer. "If there are some differences – molecular differences, genetic differences, cellular differences – these might constitute treatment targets, but we have no idea, because nobody has studied Parkinson's disease in this framework."

At the moment, says Borghammer, only a handful of medical centres around the world have the scanning equipment needed to differentiate between body-first or brain-first forms of the disease. However, future studies could divide trial participants into these two groups, so drugs are tested on those who have the best shot of benefiting from them This could be particularly important when targeting the gut microbiome, which can be dramatically altered in people with Parkinson's disease.

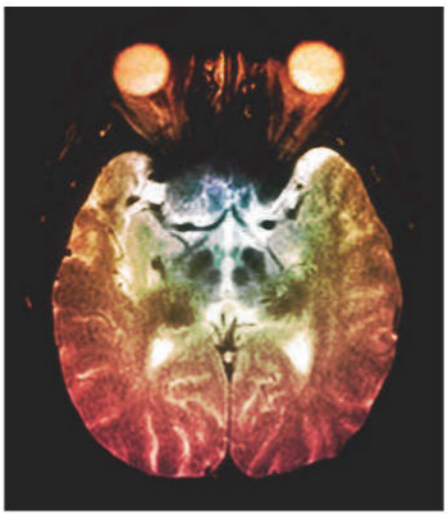
Several teams are already working on this. In a study published in 2020, neurologist Haydeh Payami at the University of Alabama at Birmingham examined the gut microbiomes of 490 people with Parkinson's and 234 people without the condition. She found that 30 per cent of the species of gut microorganisms in people with Parkinson's were either

**Global estimates of people living with Parkinson's in millions**

The incidence of Parkinson's is expected to rise dramatically in the coming years.




SOURCE: GLOBAL BURDEN OF DISEASE STUDY 2021



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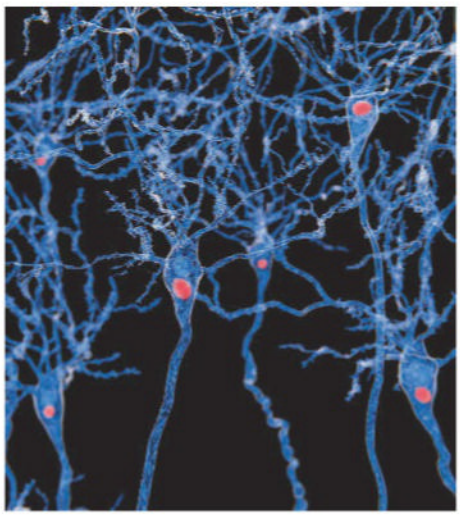


JUAN GAERTNER/SCIENCE PHOTO LIBRARY/ALAMY

**Left: the black areas show the degradation of neurons in a person with Parkinson's; right: illustration of Lewy bodies (in red) clumping in neurons**

abnormally elevated or depleted, compared with those without the condition. One species that was elevated was *Escherichia coli*; some kinds of *E. coli* have been found to induce alpha-synuclein misfolding in the gut. Some bacteria can also stimulate inflammation, which could damage dopamine-producing neurons in the gut, says Scheperjans.

But these findings throw up the age-old dilemma of correlation versus causation. Is the gut microbiome intrinsically different in people who will go on to develop Parkinson's or do symptoms such as constipation lead to changes? To investigate this question, a team led by microbiologist Sarkis Mazmanian at the California Institute of Technology transplanted faecal samples from people with Parkinson's disease into germ-free mice bred to overexpress the normal alpha-synuclein protein, seeding the rodents with bacteria from the patients' guts. Within six weeks, the mice developed signs of impaired movement, including being unable to perform mouse-specific motor function tests as well as before. "That is a nice step in the direction of causation," says Carroll.

That raised the tantalising idea that the reverse procedure – transplanting healthy bacteria into the guts of people with Parkinson's – could treat symptoms. The prospect has shown promise in animal studies and in at least one 2024 human trial that found "mild, but long-lasting beneficial effects" on motor symptoms in people with early-stage Parkinson's.

Other research, however, has shown mixed results. In July 2024, Scheperjans and his colleagues gave 45 people with mild to moderate Parkinson's either a faecal microbiome transplant (FMT) from a healthy donor or a placebo infusion. Six months later, there was no difference in movement-related symptoms between the two groups. However, those who had a transplant went on to need a lower dose of levodopa, a drug that helps replace the lost dopamine, than those in the placebo group. The transplant may have improved their body's ability to use levodopa, so they required a smaller dose even if their symptoms progressed as much as those who had a placebo, says Scheperjans.

Researchers aren't yet done investigating the link between the gut microbiome and Parkinson's symptoms: two more FMT studies are under way, as well as a trial testing the antibiotic rifaximin's effects on symptoms via its action on the gut microbiome. And though the July 2024 trial wasn't quite the bullseye researchers might have hoped for, it could nevertheless lend further support to the idea that Parkinson's exists in two types. Because the trial didn't separate participants into subtypes, it's unclear whether the treatment could be beneficial solely for individuals whose Parkinson's originates in the gut, for example. "It could be that there are some mechanisms that we try to attack with new treatments, [but] they only work for one subtype," says Horsager, who was not involved in the trial.

And that, say researchers, is an incredibly important step in the direction of more effective treatment. "We need to be able to give tailored treatments to subgroups of patients that really benefit from them," says Borghammer. "How do we get there? We get there by subtyping."

But more than that, says Horsager, "It has revolutionised our understanding of the disease, if it is correct. We have to start thinking about the disease in whole new way." ▮

Alexandra Thompson is an assistant news editor for *New Scientist*

# Solid, liquid, gas... life?

Redefining life as a strange state of matter might finally help us grasp what it is – and how it started, finds **Elise Cutts**

LIKE many young children, Sijbren Otto was fascinated by the history of life and wanted to dig up dinosaurs when he grew up. But life doesn't always go to plan, and he ended up becoming not a palaeontologist in the field, but a chemist in the lab. Still, maybe that wasn't such a departure from his childhood dream. Thanks to a surprise discovery, his work would take him closer than any fossil ever could to the heart of one of the most profound questions about life on Earth.

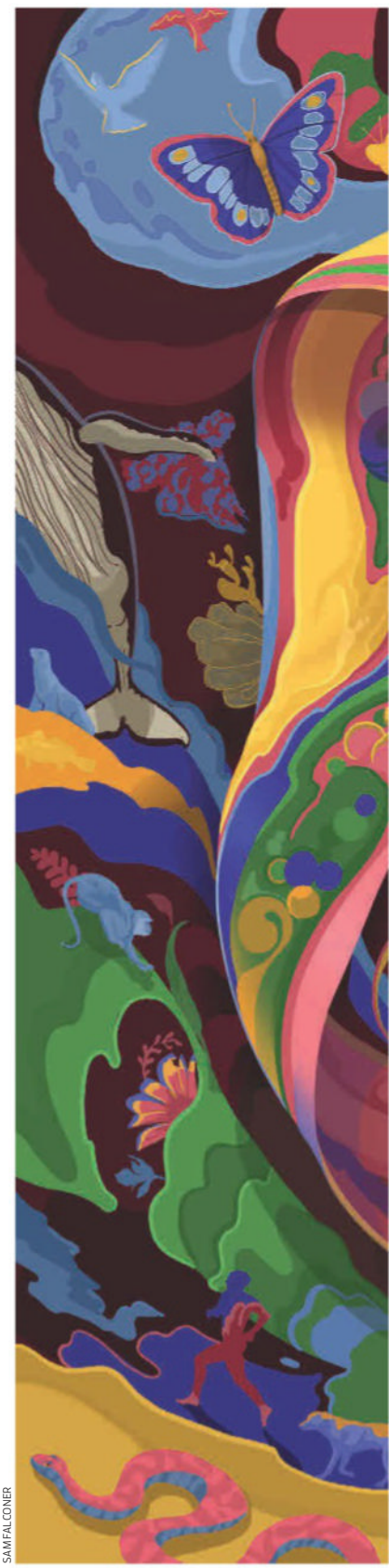
In 2010, Otto stumbled upon some of the first synthetic molecules that could self-replicate. Since then, he has been trying to coax them into states that look intriguingly like life. "We've been building on them to make them do more and more lifelike things – not only replicate, but also metabolise and evolve," he says.

That simple chemicals can behave in this way is startling enough. But recently, Otto's experiments have also offered tentative evidence that life may best be described as a novel state of matter, an idea proposed by Addy Pross, a chemist at Ben-Gurion University of the Negev in Israel. "It's a bridge that brings the physical and the biological worlds together," says Pross.

The hope is that studying the physical processes that underpin life may explain how it originated and illuminate its nature. Already the results are suggesting that Darwinian evolution may be just one facet of a more general evolutionary principle that also applies to the non-living world. In which case, researchers argue, evolution may have begun before life did.

You may think you have an intuitive sense of whether something is alive. But the search for a clear-cut, scientific definition of life in all its diversity has long been fraught. A decade ago, biologist Edward Trifonov tried to count all the proposed definitions and found no fewer than 123. In this chaotic definitional chorus, he identified two universal features: self-replication and evolution. Despite these common themes, the definition of life remains stubbornly slippery.

Scientists' ideas about what life is are often tangled up in their theories of how it began. Traditionally, origin of life researchers tend to fall into one of two camps, says astrobiologist Michael Wong at Carnegie Science in Washington DC. The first and oldest camp is the genetics-first camp, sometimes also called replication-first or information-first. In this view, the formation of self-replicating molecules like DNA or RNA was the defining moment in life's origin. The second camp argues life started with metabolism; that is, the networks of chemical reactions that break



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down and build up the stuff of life. Both of these origin stories smuggle in their own definitions of life. Information-first theories define life in genetic terms as chemical systems that replicate and evolve, while proponents of metabolism-first theories define life more like an engine that burns chemical fuels to keep on running. "These conceptions for what life even is in the first place are very different from one another, which is, I think, at the heart of why there are so many heated debates in the origins of life field," says Wong.

To try to make sense of this muddle, Pross set aside the specific chemical details of life's origin and focused on fundamental principles that could bridge chemistry and biology. Starting in 2003, he developed an idea he calls dynamic kinetic stability (DKS), which paints life as a new state of matter. And it tells a different origin story – one that might be called "evolution-first". Pross argues that Darwinian evolution can be reduced to a deeper kind of evolutionary behaviour obeyed by living and nonliving matter alike: it's not survival of the fittest, but survival of the *stable*. "The ultimate logical principle of nature is that things that persist, persist, and things that don't, don't," says Pross.

## Balancing life and death

This might seem painfully obvious, but it suggests a different kind of stability from that with which chemists and physicists usually work. In thermodynamics, the framework that describes how heat, energy and work relate to each other, the stability of a state is determined by its energy. Higher-energy states are less stable than lower-energy ones, and the non-living world evolves in one direction: down the energetic slope, towards equilibrium – at which point there is no net flow of material or energy between the system and its surroundings. Balls roll downhill, not uphill, and they stay put once they reach the bottom if left alone. "Chemists do most things at equilibrium or in systems that go there. It's the default," says Otto.

If the energetic landscapes of the real world were smooth slopes, everything would slide to equilibrium and nothing interesting would ever happen again. But it's not that simple: systems can get stuck in local valleys uphill from true equilibrium. When that happens, chemical reactions become incredibly slow. This is called kinetic stability, and it's why woodpiles don't spontaneously combust and why diamonds are "forever" even though, thermodynamically, they are uphill of graphite.

But life defies both kinds of stability. For life, whether it's resting at the bottom of a mountain or stuck in a high-altitude ditch, ›

**"Evolution can begin in systems that we wouldn't normally consider to be alive"**

Self-replicating synthetic chemicals can be coaxed into life-like behaviours

ELIE BENCHIMOL, KAYLEIGH VAN ESTERIK, LUKAS HEROLD/OTTOLAB

standing still means death. "Life is a dynamic system. It is never in equilibrium," says Wong."

It is this refusal to comply with the usual thermodynamic order of things that has long made life so indigestible for the physical sciences. Pross made biology easier to swallow by divorcing the concept of stability from static states. Stability of the dynamic kinetic sort isn't about sitting at the bottom of the hill, but about consuming energy and material to stay on top of it. Like the paradoxical ship of Theseus, systems in such a state persist by changing. Left alone, the ship would eventually fall apart and into equilibrium. But supplied with a steady flow of new parts and the energy to assemble them, it can be maintained. "That regime of formation versus breakdown is the norm in biology, but it has been the exception in chemistry for most of its history," says Otto.

The idea that systems can sometimes, somehow, maintain themselves out of equilibrium isn't entirely new. In his 1944 book *What is Life?*, physicist Erwin Schrödinger pointed out that life maintains itself far from equilibrium by dissipating energy. Later, in 1977, physical chemist Ilya Prigogine won the Nobel prize in chemistry for his work on the thermodynamics that allows complex physical systems like hurricanes to self-organise. Pross's insight was to take these ideas about out-of-equilibrium systems and write them in the language of chemistry: specifically, he turned to kinetic rate laws, which describe how quickly reactions occur. "[DKS] is a very useful framework because it's a lot more concrete than Darwinian evolution," says Otto.

Pross argues that kinetic rate laws are crucial to understanding why life persists. In one sense, this all boils down to probability: if there is a lot of something now, it is more likely to exist a moment from now. Bacteria are a good example of this logic. Individually they are rather easy to kill, but there are a lot of bacteria. If even one survives, it can make a million copies of itself by dividing just 20 times. For *E. coli*, that would take about 6 hours.

This exponential runaway is the "incredible kinetic power" of molecules that can copy themselves, says Pross. Unfettered, a self-replicating reaction is its own worst enemy: without anything to stop them, *E. coli* cells would quickly overrun the planet, consume everything and then die in equilibrium. But if the rate of birth is balanced by death, replicating populations can linger high on the energetic slope instead of sliding down it. Individual organisms die, but life as a whole is far older than most rocks on the surface of Earth.

In theory, what is true for *E. coli* should be true for self-replicating molecules, too. In chemical systems, self-replication balanced by destruction should produce a DKS state with the kinetic power to resist falling into equilibrium. And once the system is in such a state, Pross's guiding principle of "survival of the stable" should favour replicators that maintain that stability. In fact, Pross has calculated that the best replicators will drive others to extinction, in a process that looks a lot like what happens in evolution when multiple species compete for finite resources.

## Towards complexity

Dynamic kinetic stability could even explain why evolution seems to drive life towards ever-increasing diversity and complexity. Generally speaking, that's because increasing DKS doesn't have a final destination the same way that increasing thermodynamic stability does. If you climb out of a crater, you could end up anywhere along the rim, but going the other way always lands you at the bottom. "Make a system in this dynamic state, make it replicative, and I'm telling you, it'll move in the direction of greater complexity," says Pross.

But are any of these ideas testable? That is where Otto comes into the story. In 2010, he was studying questions around how proteins work. Along the way, he accidentally created some of the first synthetic molecules that can self-replicate. These molecules can react with each other to form rings that stack themselves into tube-like structures. And these tubes then spur more of the original molecules to form into further tubes. It took many years for Otto and his team to perfect the art of working with and studying these molecular wonders. But as they did so, they realised these were the perfect tools for exploring principles that might transcend the specific biological components of life on Earth.

Otto's team began experimenting with balancing the kinetics of "birth" and "death" to keep the replicators far from equilibrium. Once Pross had coined DKS, Otto finally had a name – and a useful set of equations – for what they'd been working with.

Armed with the DKS framework, in 2021, Otto's team validated one of Pross's key predictions: that chemical systems in DKS states can evolve towards complexity, not simplicity. To do it, they experimented with two different-sized replicators made of the same building blocks – a sort of primitive ecosystem with two "species" in competition for the same resource". These replicators were subject to chemical decay at different rates. The smaller replicator multiplied faster, but

**(Above) Synthetic chemicals can behave in a similar way to species of finches competing for the same resources**

**(Below) Unrestrained *E. coli* cells would overrun Earth, exhausting their food supply and driving themselves to extinction**

TOP: OLE JØRGEN LIGODDEN/NATURE PICTURE LIBRARY/ALAMY; BELOW: EYE OF SCIENCE/SCIENCE PHOTO LIBRARY

the bigger replicator better resisted chemical attack, so it stuck around for longer. Taken together, these birth and death processes struck a balance that favoured the bigger, more complex replicator. While it formed a stable population, the smaller replicator went extinct. In other words, survival of the stable drove the system out of equilibrium and towards complexity.

Otto's experiment was the first time that anyone had used DKS to propel synthetic chemical replicators towards complexity. But there was more to come. In 2024, Otto's team showed that similar systems can obey a key pillar of evolutionary theory called the niche exclusion principle. This says that two species can't occupy the same ecological niche. For instance, two species of finches living on the same island and eating the same food can't co-exist, so these species must develop different feeding strategies if both are to survive. Similarly, in Otto's chemical systems, trios of competing replicators that would usually drive each other extinct could co-exist if endowed with different preferences for chemical building blocks.

The results suggest a new answer to the question of how inanimate chemistry becomes biology. "You need some kind of evolutionary dynamics," says Charles Kocher, a physicist at Memorial Sloan Kettering Cancer Center in New York state who builds computer simulations of more complicated DKS states to explore their evolutionary behaviour. In other words, evolution can begin in systems that we wouldn't normally consider to be alive. This means that, as Pross says, life wasn't evolution's beginning but rather its product – a chemical system that had climbed up and away from equilibrium in a DKS state . Pross describes the kinetics that push towards complexity as a "driving force".

## Primitive awareness

However, while Pross argues that dynamic kinetic stability should drive increasing complexity over time, this argument is qualitative: no one has yet figured out how to measure the growth of complexity in DKS systems. There is also no widely accepted definition of complexity, and it is not clear that ever-increasing complexity really is a hallmark of life. After all, certain cave fish have lost their eyes and bacteria slim down their genomes when they can get away with it.

So where does that leave Pross's ideas around DKS states? Well, thanks to Otto's experiments, we can say for sure that non-living systems can evolve towards complexity. That has vindicated one of Pross's key predictions. Beyond that, it remains unclear just how influential the idea will be. It is a new language for revealing the nature of life, but it remains unclear if it will lead to further insights.

There are already ideas that build on Pross's work that may end up being more useful. Inspired in part by Pross, Wong and his colleagues devised an alternative framework based on the more rigorously defined concept of "functional information" rather than nebulous concept of "complexity". They've proposed that in evolving systems functional information always increases over time, as they accumulate information about how to persist in their environments. For instance, a bird's wing implicitly contains lots of information about aerodynamics and Earth's atmosphere. And unlike complexity, functional information still goes up even when evolution simplifies organisms – if that simplification helps it persist in its environment.

For Pross, though, DKS states have a lot more to give. One of the key lessons he takes from the hypothesis is that life can never be considered in isolation. In fact, this has led him to a radical thought: he interprets the dependence of DKS systems on their environments as a kind of primitive awareness. "That dependence, to me, is the beginning of a mental dimension," he says. "Once you're aware of an outside, you start to become aware of yourself."

Ascribing awareness to chemical systems is controversial, to say the least. Kevin Mitchell, a neurogeneticist at Trinity College Dublin in Ireland who studies the evolution of agency, is sceptical that cognition should be reduced to chemistry this way. "It's absolutely right to think of living organisms as this persisting pattern of dynamic chemical processes at one level," he says. "But that doesn't mean everything the organism does is usefully understood at that level."

Pross still argues that mental processes must ultimately be understood as physical processes – so where better to start than dynamic kinetic stability? "Mind doesn't just sort of float in the air. It has to emerge from a physical system," he says. "The door to resolving that mystery has just opened." ▮

Elise Cutts is a science journalist based in Graz, Austria

# Lunar labs

The time is ripe to start building groundbreaking astronomical observatories on the moon, says **Rebecca Boyle**

WHEN Michael Collins floated above the far side of the moon during the Apollo 11 mission in 1969, he knew he would be remembered as the loneliest human in history. He recalled feeling unafraid, almost exultant, thinking about everything on the other side of the moon: Neil Armstrong and Buzz Aldrin on the lunar surface and, beyond that, every creature on Earth and everything humanity had ever built. On his side, as Collins wrote in his memoir, was "one plus God only knows what".

A half-century later, the famously empty lunar landscape is starting to get busier. Not only are NASA and other space agencies preparing to send humans to the moon for longer periods of time, researchers around the world are working on blueprints to turn it into the most powerful astrophysics laboratory in history. This could address the deepest questions we have ever asked. How did the first stars ignite? Why has the universe evolved the way it did? Is there anyone else out there?

"On the moon, we can think about concepts that, here on Earth, are completely impossible to realise," says Jan Harms, an astronomer at the Gran Sasso Science Institute in Italy. The conditions there seem nearly purpose-built to house cutting-edge observatories that could answer some of the most perplexing questions about the cosmos. The moon's unique peace and quiet, especially on the side that never faces Earth, could make it a portal to the history of the universe, from the first galaxies to the mysterious dark energy that stretches the universe apart at an ever-accelerating rate. But first, we have to build the observatories.

"It was silly to think about this 10 years ago, even. There was no real, believable path to having large equipment placed on the moon, so essentially every astronomer, including me, dismissed the idea," says Martin Elvis at the Harvard-Smithsonian Center for Astrophysics in Massachusetts. "Now, it's worth thinking about. And once astronomers start thinking, they are very creative." Some of those creative ideas are starting to become reality.

One of the most audacious involves placing a radio telescope on the far side of the moon – the quietest place in the solar system. Human technology has been spewing out radio signals for more than 100 years, and the far side is the only place they can't reach. That means it may be the only location in the solar system where the weak radio waves from throughout the cosmos aren't drowned out.

## Lighting the dark ages

Radio waves are a key tool for measuring faint and very distant cosmic objects. We can see faraway stars and galaxies in all wavelengths of light, but only in radio waves can we "see" the universe before there was any light at all. Cosmologists want to understand this epoch before the first stars, called the cosmic dark ages, because it set the course for all that was to come, including where and why galaxies formed. To study it, we must look for particles of light, or photons, ejected from the first hydrogen atoms, formed about 380,000 years after the big bang.

"That is the only way of doing it. You have no other information for cosmology," says Nivedita Mahesh, an astronomer at the California Institute of Technology.

The problem is, these first photons can only be spotted in the form of low-frequency radio waves – the same frequencies as FM radio on Earth. Observing them from our planet is all but impossible, because they reflect off the atmosphere, but the far side of the moon could be the perfect vantage point. By studying the distribution of the photons emitted by those early hydrogen atoms, astronomers can potentially build a map of the cosmic dark ages.

A far-side radio telescope could even study the auroras and magnetic fields of distant exoplanets, the signals from which would be absorbed by Earth's atmosphere and drowned out by our own noise. This could help us understand how an alien planet – and any life on it – would be affected by its star. "Then it's a very profound question it can answer," says Mahesh. "If an exoplanet has a magnetic field, is it protecting that planet from incoming stellar flares? [If so], it could be a nice planet to follow up, to look for signs of life."

The moon would also be the best place to go to improve the viewing power of the Event Horizon Telescope (EHT), the network of radio telescopes that took the first images of black holes. Better black hole imaging could help astrophysicists understand these strange cosmic denizens and test theories of gravity. Extending radio observations to the lunar surface and linking them with Earth-based telescopes would turn the EHT into a monstrously powerful observatory.

The work towards these goals has already begun. The first lunar radio astronomy experiment, NASA's Radio wave Observation at the Lunar Surface of the photoElectron Sheath (ROLSES-1), landed last year on the near side of the moon, close to its south pole, aboard a craft made by private company Intuitive Machines. The lander tipped over shortly after touching down, limiting its lifespan and the data gathered. But the team was nevertheless able to collect some radio waves from Earth and ›


ALLAN SANDERS

Jupiter. As a demonstration, the experiment succeeded, showing that a small instrument on the moon can indeed detect radio waves. Now, scientists are clamouring for more.

The next lunar radio experiment is set to be NASA's Lunar Surface Electromagnetics Experiment, LuSEE-Night, which is scheduled to launch for the far side of the moon in 2026. Its radio receivers will measure low-frequency light from our galaxy, taking a small step towards studying the faraway photons from the first hydrogen atoms. Once astronomers understand the "white noise" of the galaxy, they can figure out how to separate the signals necessary for cosmology experiments.

NASA engineers are also working on the proposed Lunar Crater Radio Telescope, which would be a large antenna inside a crater on the far side of the moon. It is still in the planning stages, but some designs call for a fleet of wall-climbing robots to be sent to a large crater. After landing, the robots would string wires across the crater rim, constructing a spiderweb-like mesh antenna. A radio receiver would then be suspended from the antenna's centre. Though the proposed diameter varies from 350 metres to a kilometre, even a lunar crater telescope at the bottom end of this range would still be among the largest radio receivers ever built.

## Ripples in space-time

The moon could also be used to investigate gravitational waves, the shuddering of space-time itself in the wake of gargantuan collisions. Adding these ripples in space-time to more traditional, light-based observations is like gaining a whole new astronomical sense, like being able to hear as well as see.

So far, astronomers on Earth have caught the reverberations of merging binary black holes and neutron stars. But future observations could yield even more information about the nature of cosmic objects and gravity itself. The problem is Earth – a seismically active world with moving tectonic plates, not to mention wind, water, tides, elephant herds and humans. The lasers that detect gravitational waves in the Laser Interferometer Gravitational-Wave Observatory (LIGO) must cancel out all that Earthly noise, and be supercooled and kept in a vacuum to boot. But on the moon, there is minimal seismic activity, no water or wind, no elephants and no human presence, at least not yet. Plus, the pressure there is only 10 times higher than that in LIGO's carefully evacuated laser tubes. The entire project would be much easier to construct and use, says Harms.

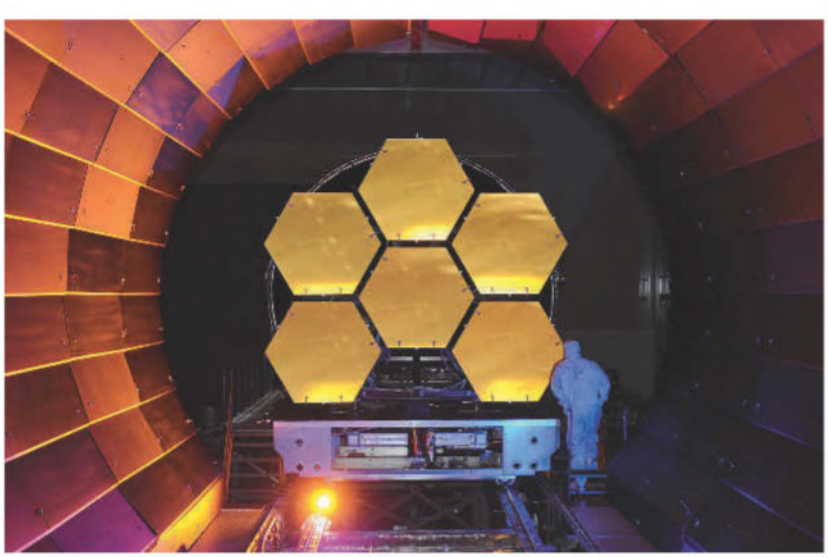
"Even with the same concept as LIGO, we could extend to lower frequencies and see sources LIGO could not see, such as larger-mass black hole binaries. That would be really a new science you could do with a [lunar detector]," says Harms. "And once you have a detector like LIGO on the moon, then you could essentially let them observe together."

The power of interferometers like LIGO comes from having multiple detectors that work together as a single, enormous instrument – the further apart they are, the more powerful the overall observatory. With such a huge distance between observing stations on Earth and the moon, astronomers would be able to anticipate a gravitational wave's arrival and point optical, infrared and X-ray observatories at the source, says Harms.

Detecting gravitational waves from a moon-based detector would also enable astronomers to study different exotic objects, says Jasmine Gill at the Harvard-Smithsonian Center for Astrophysics. The moon could help us see the cores of collapsing supernovae and better understand how these exploding stars become neutron stars or black holes.

"We still can't catch those final moments of collapse or the final moments afterward," says Gill. There is simply too much noise on Earth, and it is too unpredictable. "But if you head to the moon, you are able to do it," she says.

**"The moon could help us see the cores of collapsing supernovae"**



BALL AEROSPACE

**The moon could host telescopes bigger than JWST (pictured being built below)**


INTUITIVE MACHINES

**An artist's impression of the lander carrying ROLSES-1, the first radio telescope on the moon**

Work is already under way on the Laser Interferometer Lunar Antenna, a proposed LIGO-like observatory on the moon. In the current concept, three landers would settle on the edge of a large crater, a few kilometres from one other. Each would hold lasers, mirrors and a vibration-isolation system to cancel out any lunar quakes – a simple enough set-up that it could be launched in the next decade, according to the team behind it at Vanderbilt University in Tennessee.

Other lunar development could be a problem for this proposal, though. Exploration of the moon has ramped up over the past decade and space agencies have various plans for long-term settlements and increased activity there. Although still a long way off, any lunar age of industry could be accompanied by some of the Earthly conditions that astronomers want to go to the moon to escape. "Once we start mining or building railroads, we are immediately going to kill that pristine environment," says Gill. "But we can just boost up the laser power and make sure our detectors still work well." Upgrades similar to those regularly performed on LIGO's instruments, along with maintenance, would require astronauts to visit the detector regularly, she says – but there may be a simpler way.

The Lunar Gravitational-wave Antenna (LGWA) is a European Space Agency project that aims to use the moon itself as a detector by measuring gravitational waves passing through its entire bulk. Near the moon's poles, sunlight streams onto the surface at extreme angles, so some crater floors never see the light of day and stay at a temperature of -246°C or even lower. The extreme cold and low pressure would make it easier to catch a passing gravitational wave. By installing a set of simple vibration sensors in one of these permanently shadowed craters, the LGWA might be able to observe gravitational waves from objects and phenomena that are too faint to spot from Earth, such as the very first black holes.

The idea even has precedent: Apollo 17, which landed on the moon in 1972, carried a prototype gravitational wave experiment called the Lunar Surface Gravimeter. In the end, it didn't work properly, but designing something similar with greater sensitivity wouldn't be hard, says Harms. "Apollo 17 did the tough part," he says. "Now we have to repeat it."

The moon is also a prime location for more traditional astronomy. Over the past few years, the international astronomy community has been agog over images from the James Webb Space Telescope (JWST), which are revolutionising our understanding of cosmic history. The moon's natural craters could provide a cosy home for an even more powerful infrared observatory.

## The biggest telescope

Jean-Pierre Maillard at the Paris Institute of Astrophysics is leading an effort to conceive of an infrared telescope in a dark lunar crater, which would keep it as cold as required. Such craters naturally have a circular, concave shape that is just right for a telescope. Power could be supplied from the crater's rim, where the sun always shines along ridges known as peaks of eternal light. And the moon's weak gravity could make it possible to deploy a truly colossal mirror – impossible on Earth because the planet's gravity would warp the mirror's glass. On the moon, "a lot of problems go away", says Elvis. Maillard's work has shown that a huge infrared telescope on the moon could be more sensitive than any of the similar observatories we have ever built before, on the ground or in space.

But more than the other proposals, an infrared telescope would have one major issue to contend with: lunar dust. Many scientists and even geologists don't fully appreciate how difficult moon dust can be to deal with, says Mihály Horányi, a physicist at the University of Colorado Boulder.

After walking on the surface of the moon during Apollo 11, Aldrin and Armstrong rejoined Collins absolutely coated in dust. Its electrostatic charge made it impossible to brush off. After two or three moonwalks, the astronauts on all the Apollo missions were so thoroughly dusty that further outings could have threatened their lives – dust caked in every buckle and latch of their suits and landers could have prevented perfect seals, causing air leaks. Future missions have to consider this pervasive threat, too, says Horányi. After all, what good will a perfect, concave telescope mirror be if it turns into a giant, dust-collecting cup?

Dust on the moon levitates at lunar sunrise and sunset, for reasons scientists don't totally understand, and this behaviour could also interfere with sensitive gravitational wave-detecting lasers or even radio instruments. Horányi and others are hoping for missions to study moon dust and its strange behaviour before anyone builds a lunar observatory.

Beyond dust, future astrophysics outposts will also have to contend with intense cosmic radiation, along with dramatic temperature differences between lunar day and night. LuSEE-Night gets the latter part of its name from this effort: it will be one of the first spacecraft built to withstand the two-week-long lunar night.

A lot has changed since Collins was the only human on the moon's far side. The lunar surface now teems with landers and rovers, and they could soon be joined by telescopes, gravitational wave detectors and radio dishes. The question isn't whether this will happen, but when.

"There will be a human presence on the moon in a decade or less," says Richard Green at the University of Arizona, who chairs the International Astronomical Union's working group on moon-based astronomy. In the meantime, scientists need to start thinking about areas they want to reserve for future research. "We aspire, in the next year or less, to have a list of actual physical sites that we think should be candidates for exploration for astronomy," says Green.

Future lunar orbiters might glimpse a surface criss-crossed by power lines, dotted with radio antennae tuned to the distant beginnings of our cosmos and inky black craters full of infrared sensors soaking up far-flung starlight. These new projects may finally help us answer the same question Collins posed to himself as he floated alone above the moon: what else is out there? ▮

Rebecca Boyle is a science journalist based in Colorado. She is the author of *Our Moon*, a history of humanity's relationship with Earth's satellite

# The back pages



Debunking gardening myths

# Put that on ice

Should you water your orchid with ice cubes? **James Wong** looks into the fierce debate raging in the horticulture world


James Wong is a botanist and science writer, with a particular interest in food crops, conservation and the environment. Trained at the Royal Botanic Gardens, Kew, in London, he shares his tiny flat with more than 500 houseplants. You can follow him on X and Instagram @botanygeek


**New Scientist video**
**Watch James investigate whether you should water your orchids with ice cubes**
**newscientist.com/video**

*Debunking gardening myths appears monthly*

**Next week**
The science of exercise

WITH such a wholesome image, the world of horticulture can have some surprisingly passionate debates. So while it is probably extremely unwise, I thought I would wade into one of the most heated questions in gardening in recent years: should you really water tropical orchids with ice cubes? Bear with me...

I first came across this idea over a decade ago at a horticultural trade fair in the Netherlands, where giant commercial orchid growers were unveiling a glossy new campaign. Oversized retro fridges and fake ice sculptures were festooned with live orchids, under a neon cocktail bar sign that said "Just Add Ice". Aware that one of the most common reasons for beginners to fail when growing moth orchids (*Phaleanopsis*) is overwatering, nurseries were advising that adding three ice cubes to a plant each week was an easy way to provide a measured dose of water, released slowly as the ice melts.

However, moth orchids (pictured) are tropical plants that don't possess adaptations to help them survive sub-zero temperatures. So: cue a furious online backlash from the orchid-growing community (yes, there is one), who say this advice would cause crippling damage to these delicate plants that would far exceed any of its supposed benefits. And yet, many years later, the campaign still endures, as does the fiery controversy. So what does the evidence actually say?

Considering how long this argument has been raging, it is surprising that only one published scientific trial seems to exist. And even to a botanist like me, its results were unexpected.

SHUTTERSTOCK/SONELLY

Researchers set out to directly compare flowering moth orchids watered with ice to a control group given an identical volume of water. It was a well-designed experiment too, using multiple cultivars, two different test locations and a decent number of subjects. What it found is that, perhaps counterintuitively, the ice had no measurable effect on how long the flowers lasted, nor how well their leaves or roots grew – a set of findings the "Just Add Ice" campaign is keen to publicise.

I would point out that the trial only lasted for a few months, from the day of purchase until the flowers faded. As orchid growth is comparatively slow, this is really a very short snapshot of time, and gives us no indication as to how it may effect reflowering. Not to mention that, as it was just a single trial, we have no idea whether the results are replicable. Most importantly, while it didn't seem to harm plant growth in the short term, the ice didn't seem to actually have any benefits either.

The bottom line? The evidence so far suggests we have been making a bit of a fuss about nothing. Right now, it seems you can do whichever you find easiest, without any clear consequences. So let's put the pitchforks down. ▮

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**Delilah Gates,**
Postdoctoral fellow, Center for Astrophysics, Harvard & Smithsonian and Black Hole Initiative, Harvard University

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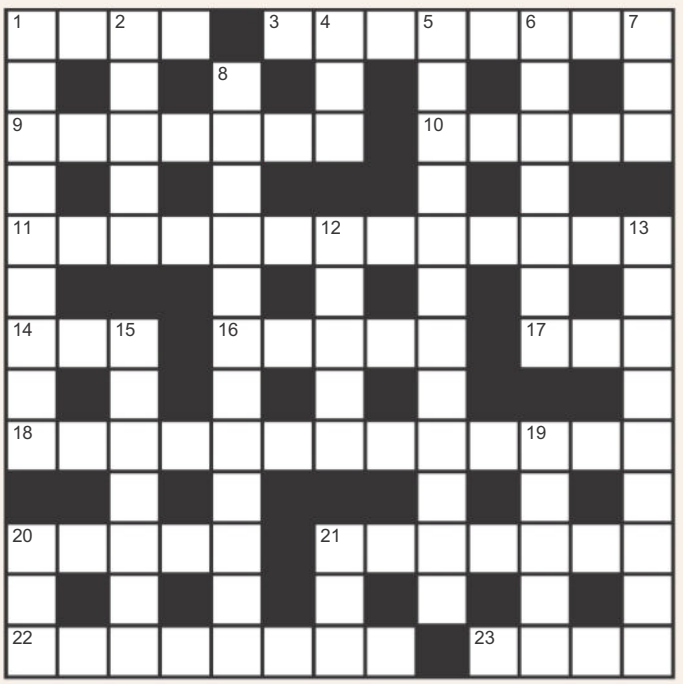
## Cryptic crossword #160 *Set by Trurl*



Scribble zone

Answers and the next quick crossword next week

**ACROSS**

**1** Should that be true, seen in turning over Galileo's findings? (2,2)
**3** Former president in league with Lib Dem leaders, unfortunately (2,6)
**9** Crikey – King Charles's mistress found in US research centre... (7)
**10** ... by newspaper (5)
**11** Fizzing blue stuff ends uncontrolled fever – our subject doesn't have one (13)
**14** Bit of work for European Research Group (3)
**16** Oddly, coders of Microsoft initially used this for storage (2-3)
**17** Detach terminals of output channel to get RAM? Quite the opposite (3)
**18** End of sponsored silence? That's not the half of it! (2,3,3,5)
**20** In open, capsize, losing vessel (5)
**21** Lively muppet dancing with Oscar (2-5)
**22** Vampire, perhaps, drinking bodily fluid in cellar (8)
**23** Hacks X, Y and Z (4)

**DOWN**

**1** Not kind to switch side for a small uplift (9)
**2** Rising, dismisses feature of Georgia character (5)
**4** Lack of phosphorus makes skin into something slippery (3)
**5** Comet exploding with Pluto within limits of atmosphere – does this end things for us? (12)
**6** It's refreshing, not having a newspaper in Europe (2,5)
**7** Deity: entity of sunrise, originally (3)
**8** Way of measuring in mm, etc? Yessir – ultimately, it works (6,6)
**12** Er, that's a rare one, where we live! (5)
**13** "Vote Reagan!"? Seeing, at first, only basically negative things (9)
**15** Request to be put in bags for seals (7)
**19** Work together, finishing paperwork early, by 10 (5)
**20** Globe offering alternative to A? (3)
**21** Reportedly win Ashes here (3)

**Our crosswords are now solvable online**
newscientist.com/crosswords

## Quick quiz #299
*set by Corryn Wetzel*

**1** What type of cloud is associated with severe thunderstorms?

**2** How many moons was Saturn recently discovered to have?

**3** What was the first vegetable grown in space?

**4** Which plant hormone plays a key role in fruit ripening?

**5** Which species went extinct in 2000 after a tree fell on its last living member?

*Answers on page 47*

## BrainTwister
*set by Colin Beveridge*
### #70 Powerful years

**Mathematician Augustus de Morgan turned n years old in the year $n^2$. Given that he died in 1871, when was he born?**

**Young Carrie turned a square number of years old this year (2025). She wasn't born in a square number year, but her age will be a power of 2 in the next year that is also a power of 2. When was she born?**

**When was the last time someone born in a square year would reach a square age in a different square year?**

*Solution next week*

## Cosmic sprint

**How long would it take to accelerate a spacecraft to 99 per cent light speed without major injury to the astronauts inside?**

***Ron Dippold***
*San Diego, California, US*
It wouldn't be long if you had infinite energy! Let's lock down our units – 99 per cent of the speed of light, or 0.99c, is 1068 billion kilometres per hour. Normal Earth gravity acceleration, 1 *g*, is equivalent to 9.8 metres per second squared – every second, you go about 10 metres per second faster. You have to take time compression into effect: time passes slower for people on board because they are going faster (explained by general relativity).

The time it takes to get to 99 per cent light speed is about 81 million seconds per *g*, or 2.6 years on-board time. To someone watching on Earth, it would be 6.8 years. So if you could accelerate infinitely without worrying about fuel or running into anything, it would only take you two and a half years to get to 99 per cent light speed at a perfectly comfortable 1 *g*.

How high can you crank up the acceleration? There have been a few studies on the long-term effects of high gravity on people, and they suggest people can comfortably tolerate 1.25 *g* to 1.5 *g*. Above that, the fluids in your body start draining to places they aren't supposed to before too long. At 1.5 *g*, it would take 1.7 years on-board time to reach 99 per cent light speed. A normal person without special training or equipment can withstand about 5 *g* without passing out if in a chair. That would be half a year of misery though! Trained people with special compression suits can do 9 *g*, which would only take 0.3 years. So perhaps if you strapped your hypernauts into a compression vat and kept them fed and hydrated with hoses and amused in virtual reality, you could get there in three and a half months at 9 *g*.

> **"If you could accelerate infinitely, it would only take you two and a half years to get to 99 per cent light speed at a comfortable 1 *g*"**

The real problem is that there is no technology that would let us accelerate at a constant 1 *g* for two and a half years. Besides the obvious collision issues (even a speck of dust could be lethal), you have to carry enough fuel to accelerate the fuel you are carrying, which means you need more fuel, and so on. This is why the Saturn V rocket was so gigantic, and that would be nothing compared to this. A Falcon 9 rocket masses about 550,000 kilograms at launch – a back-of-the-envelope calculation suggests that you'd need about $4 \times 10^{115000}$ kilograms of standard rocket fuel to get it to 0.99c, which is 4 followed by 115,000 zeros. Our entire galaxy is only estimated to be $3 \times 10^{42}$ kilograms! This is why science fiction with travel between stars needs warp drives or external propulsion sources.

***Mike Follows***
*Sutton Coldfield, West Midlands, UK*
The safest acceleration would mimic the gravitational field strength we experience on Earth's surface – essentially, free-fall acceleration. Rather than being pulled downwards by Earth's gravity, we would feel the same force (our weight) if we stood on a surface accelerating upwards at the same rate as free-fall.

A spacecraft with an upward acceleration of 1 *g*, taking relativity into account, would take about 2.6 years to reach 99 per cent of the speed of light. Once the spacecraft reaches a constant speed, it could be converted into an O'Neill cylinder, which generates artificial gravity on its inner surface by spinning about its axis of symmetry. The required rearrangement of the internal layout of the spacecraft brings to mind *The Twits* by Roald Dahl when Mr and Mrs Twit were led to believe that their house had been turned upside down.

***Pat French***
*Longdon-upon-Tern, Shropshire, UK*
The questioner wishes to avoid injury to the occupants of the craft. This would be difficult, not to say impossible. As the vehicle approached light speed, those occupants would find themselves in a hole, and quite a deep one.

As they neared the speed of light, their mass would approach infinity relative to the bodies by which they passed. Planets and stars would be drawn into the abyss in space-time created by such a mass. This near-infinite mass would collide with dust and particles, with near-infinite, catastrophic impact. It would not be a comfortable journey.

TIM BOODY

Would it have changed our technological development if glass was not transparent?

## This week's new questions

**Seeing clearly** **What difference would it have made to our species' technological development if glass wasn't transparent?** ***Justin Baker****, Elsternwick, Victoria, Australia*

**Hot meal** **Can you reheat food without additionally cooking it? Is there a threshold temperature that begins the re-cooking process?** ***David Bloomquist****, Venice, Florida, US*

## Ancient mixtape

**Is it known when humans or our ancestors first started to sing?**

***Joshua Bamford***
*Jyväskylä, Finland*
Identifying the exact moment when humans began to sing is a difficult task. Unfortunately, songs don't fossilise or leave many artefacts, at least until the invention of written musical notation and audio recordings.

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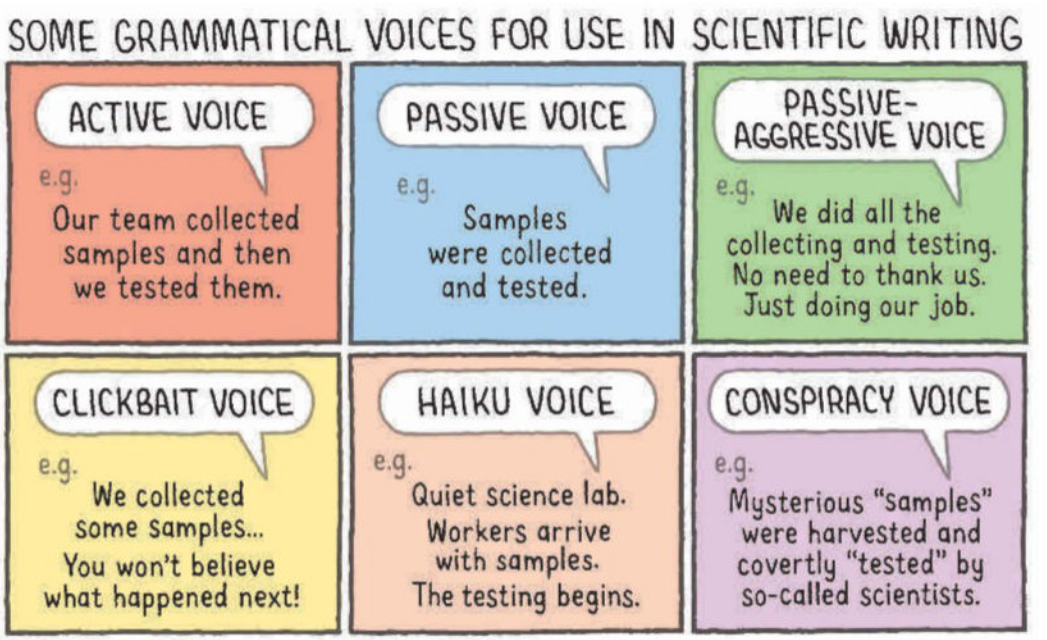
*for New Scientist*




The best we can do is give an estimated range in which singing first emerged. Similarly, it is difficult to know exactly why our ancestors started to sing, but there are some good theories.

The earliest evidence of crafted instruments are bone flutes from around 40,000 years ago, and paintings found in the same caves as those first bone flutes depict human figures that appear to be dancing. However, humans were probably singing and dancing long before they were crafting instruments or depicting dance rituals on cave walls.

Studies of chimpanzees, our closest living relatives, show that they don't have the vocal control required to sing. This means that our singing abilities probably developed after early hominins diverged from our last common ancestor with chimpanzees, around 5 million to 7 million years ago. Fossil remains of heads and jaws suggest that some hominins may have had the required anatomy to control their voice up to 1 million years ago, so it is possible that they could sing, although we don't know if they actually did. So our best guess is that singing, in our evolutionary lineage, first emerged sometime in the past 1 million years but before 40,000 years ago. Singing is now found in all contemporary human cultures, albeit with great variation in the nature of the music being performed.

**"Our singing abilities probably developed after early hominins diverged from our last common ancestor with chimpanzees"**

Why did we start singing? Speculation goes right back to when Charles Darwin first proposed his theory of evolution through sexual selection and suggested that singing might be a sexually selected trait in humans, as well as birds. A later theory, developed by Robin Dunbar (who came up with Dunbar's number – the notion that most people have around 150 relationships), suggests that singing and dancing allow humans to bond efficiently with many people at once, which helped human group sizes to get so much larger than the group sizes of other primates.

Others have suggested that singing is most important for parent-infant bonding and see the origins of song in infant-directed speech. Also known as "parentese", infant-directed speech emphasises the musical aspects of spoken language, with heightened pitch and rhythm. Whether to refer to this as "singing" is a matter of debate.

Unfortunately, we can't (yet) observe all of human evolutionary history in the lab, so we will never know exactly what the reason was. It does seem plausible that both singing and speaking evolved from a common proto-musical language, somewhat like parentese, which may have initially been used to communicate with infants but later developed into a means of bonding with other adults, both in groups and with romantic partners. ▮

## Answers

### Quick quiz #299 *Answers*

**1** Cumulonimbus

**2** 274

**3** Potato

**4** Ethylene

**5** Pyrenean ibex (*Capra pyrenaica pyrenaica*)

### Quick crossword #181 *Answers*

**ACROSS 6** Aorta, **7** Earlobes, **10/11** Cassini-huygens, **12** True rib, **13** Toluene, **14** Epigastrium, **19** Buttock, **21** Locknut, **23** Scotoma, **25** Trinity, **26** Bakelite, **27** Polyp

**DOWN 1** Pressure, **2** Xavier, **3** Men in black, **4** Arch, **5** Ketene, **6** Arcate, **8** Onyalai, **9** Aspen, **13** Totalities, **15** Iron ore, **16** Mandible, **17** Obese, **18** Stay up, **20** Thorax, **22** Chirps, **24** Axis

### #69 Backward drops *Solution*

The next drop is after 19, which is followed by 2.

In the first 100 terms, the biggest drop is 99 followed by 1, a drop of 98.

Drop sizes in the first 1000 terms are 8, 89, 98, 890, 989 and 998.

## New kind of microscope?

Science is one of the most fruitful sources of new terminology. There's nothing like a surfeit of terms like "mitochondrial synthesis" and "quantum fluctuations" to make your writing sound authoritative Recently there has been a spate of scientific papers containing the phrase "vegetative electron microscopy/microscope". The term suggests a device for scanning broccoli, but it is utter nonsense. There are scanning electron microscopes and tunnelling electron microscopes, but not vegetative electron microscopes.

One possible explanation was proposed by Alexander Magazinov, a software engineer who moonlights as a watchdog for scientific publishing. He pointed to a 1959 article in *Bacteriological Reviews*, the text of which was formatted into two columns. Towards the bottom of page 4, the words "vegetative" and "electron microscopy" appear next to each other, in the left and right columns. Old papers have often been scanned using optical character recognition, but such software sometimes struggles to deal with complicated formats. "Vegetative electron microscopy", according to Magazinov, is "an artefact of text processing".

However, the journalists at Retraction Watch spotted another possibility, which had been flagged on Reddit. In Farsi, the phrases "scanning electron microscope" and "vegetative electron microscope" sound extremely similar and, crucially, they use near-identical characters: the only difference is a single dot, a diacritic known as a *nuqta*. This means a tiny mistake in translating a paper from Farsi to English would suffice to create "vegetative electron microscopy".

These explanations aren't mutually exclusive, and Feedback is satisfied that we can account for the emergence of this phrase. The bigger question is why it persists in published studies. Are these papers not rigorously peer-reviewed and checked, to ensure a high degree of accuracy and thus preserve the integrity of the scientific literature? Perhaps such "tortured phrases" should be included in a checklist of warning signs that a paper may be plagiarised or fraudulent.

Readers who have encountered similar tortured phrases in their perusals of the technical literature are invited to submit them to the usual address.

## 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

## A nun too far

Sometimes, Feedback receives a story that feels too good to be true. The set-up is so neat, and the payoff so simultaneously surprising and inevitable, that we doubt ourselves. Is reality ever so neat? And then we remember that the Titanic was the largest ship ever at the time it was built and on its maiden voyage when the bad thing happened. Sometimes, reality is melodramatic. So, maybe we believe this story happened exactly as described, and maybe we don't.

It comes to us from Charlie Wartnaby, whose late father John was a curator at the Science Museum in London. It relates, inevitably, to the Scunthorpe problem: the difficulty of banning offensive words in online discussions when the same letter strings can appear in harmless words like "peacock" and "Sussex".

John's story isn't, strictly speaking, an example of the Scunthorpe problem, but it's definitely adjacent to it. As Charlie explains: "In the earliest days of the computing gallery, a machine was set up such that members of the public could type and see their words on a large screen, a great novelty for its day."

This may seem like an invitation to misbehave. Readers will thus be pleased to learn that staff anticipated the inevitable attempt to write torrents of filth on the large screen for all to see. They drew up "a long list of profanities", all of which were blocked.

"All was well", Charlie says, until the system was taken down by the most dangerous person possible: a computer expert. Trying to use the machine, he noticed that some keystrokes didn't do anything. "Investigating, he managed to pull up the entire list of offending (or offensive) words on the big screen for all to see – allegedly including a visiting party of convent school children and supervising nuns."

Feedback is prepared to believe 90 per cent of this story, but in the absence of independent verification, we draw the line at the nuns. However, we are also willing to be wrong about this. If any convent school children were in the Science Museum on that fateful day – and we suspect you'd remember – please get in touch.

## Yodel-eh-oh

Senior news editor Sophie Bushwick draws our attention to a press release titled "Monkeys are world's best yodellers – new research". It describes a study that looks at "special anatomical structures" in the throats of apes and monkeys, called vocal membranes. These membranes allow the monkeys to perform "the same rapid transitions in frequency heard in Alpine yodelling", but over "a much wider frequency range", sometimes "exceeding three musical octaves".

After a build-up like that, Feedback went, with bated breath, to find the accompanying audio recording of a tufted capuchin monkey. We anticipated an ululating call that evoked *The Sound of Music* or Dutch rock-yodellers Focus. What we got was, approximately, "skroark rark eek". And now we understand why Sophie told us that she "can't stop laughing".

However, a closer look reveals a missed opportunity. By all means, show us a tufted capuchin "yodelling", but the study also included howler monkeys.

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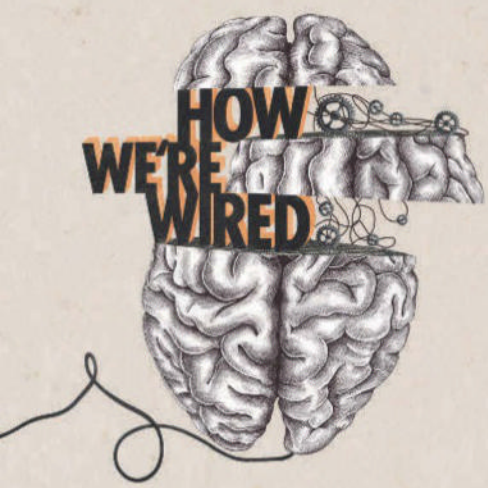


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# locommotion?

Every mechanical watch has a balance wheel, but not all balance wheels are created equal. The **C12 Loco's** 'free sprung' balance wheel (and hairspring) isn't merely a part of the watch. It's the star. Placed below the time-telling dial, on the artfully coloured and stepped platine, its mesmeric oscillations are driven by a new in-house movement – Calibre CW-003, whose hand-wound, hand-finished architecture delivers a six-day power reserve and chronometric accuracy. And because we want to tell the story of how we got here – and because we're a little *loco* ourselves – we've made a feature-length documentary about it. Just make sure you're sitting down when the price is revealed.

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Christopher Ward

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