New Scientist

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HOW VINTAGE COMPUTER CODE KEEPS THE WORLD RUNNING

WHAT'S BEHIND THE SURGE OF COLORECTAL CANCER IN YOUNG PEOPLE?

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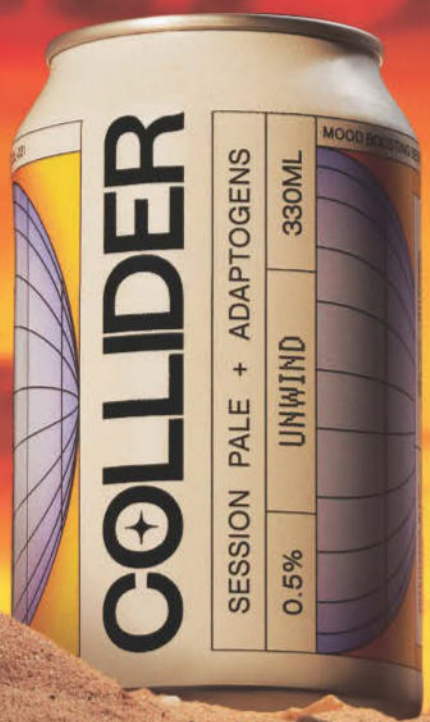

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Online event

Measuring the mind

Join biologist and neuroscientist Suzana Herculano-Houzel on an exploration of how the human brain became the marvel that it is without ever breaking the rules of evolution. Find out how her revolutionary method of counting neurons allows us to compare brains across species. This subscriber-only online event will take place on 1 April at 6pm BST/1pm EDT.

newscientist.com/events

Tour

Whale watching in the Azores: Portugal

Explore the lush flora and fauna, volcanic craters, lagoons and picturesque towns of the Azores. More than 20 species of whales and dolphins, including sperm whales and blue whales, visit this migratory crossroads. Learn about marine ecosystems, conservation efforts and animal intelligence on this seven-day tour, which starts on 13 May 2025 and costs £3499. Dates are also available in May 2027.

newscientist.com/tours

Podcast

Weekly

In this sleep special, the team devles into the issue of sleep debt and what constantly missing out on shut-eye does to you. Hear about how diet, and in particular your microbiome, influences your sleep. Find out if there really is an epidemic of sleeplessness. Plus, the surprising reason why people in industrial societies get more sleep than hunter-gatherers.

newscientist.com/nspod

COLLECTION CHRISTOPHEL/ALAMY

Big screen icons Were dinosaurs anything like their film depictions?

SCIENCE HISTORY IMAGES/ALAMY

Neuronal network Discover what makes the human brain so special

Video

Lost worlds of cinema

Dinosaurs have been stars in Hollywood from the earliest days of cinema, captivating audiences ever since. But just how accurate are these portrayals, especially given what we now understand about dinosaur physiology and behaviour? Palaeontologist Dave Hone at Queen Mary University of London looks at the surprising details the movies got right.

youtube.com/newscientist

Newsletter

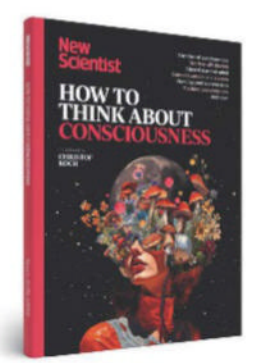
Lost in Space-Time

Physics reporter Karmela Padavic-Callaghan considers why quantum theory strikes so many people, researchers included, as plain weird. When quantum ideas are removed from their mathematical context they seem to stop making sense, so perhaps the key is confronting the limits of these tools?

newscientist.com/lost-in-space-time

Podcast

"When you try to catch up on sleep at the weekend, you often can't fully pay back the sleep debt"



How to think...

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Explore the mystery of ancient civilisations

Ancient caves, human origins: Northern Spain

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7 days

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- **Visit the stunning replica of Altamira, the Bilbao Archaeological Museum and the Archaeological Museum of Santander**
- **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**

Archaeological wonders of the Maya: Mexico and Guatemala

15 September 2025
10 days

Immerse yourself in the captivating world of the Maya as you explore key archaeological sites in Mexico and Guatemala, piecing together the fascinating history of this ancient civilisation. Discover the society, science and history of the Maya as you visit the ruins of once-great cities across the Chiapas region of Mexico and the Petén region of Guatemala.

- **Explore the key Maya archaeological sites of Tenam Puente, Chincultik, Palenque, Yaxchilán, Bonampak and Tikal, each telling an important piece of the civilisation's fascinating story**
- **Marvel at some of the best-preserved murals at Bonampak and the astounding architecture and carvings at Yaxchilán**
- **Spend time on the charming island of Isla de Flores, just off the shore of Lake Petén Itzá, with its cobblestone street and artisanal local shops**

Machu Picchu and the science of the Inca: Peru

16 September 2025
11 days

Journey to Peru, a land of stark deserts adorned with mysterious ancient geoglyphs, towering peaks that shelter lost cities and landscapes that leave a lasting impression. Become immersed in the legacy of the Inca civilisation, exploring its most iconic archaeological treasures, including the fascinating site of Machu Picchu.

- **Learn how the Incas used their extensive grasp of science and technology to expand rapidly**
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Scare stories for a new audience

As cancer cases rise in younger people, we need solid science, not online speculation

"Careless pork costs lives", wrote *The Sun* newspaper, a British tabloid, in a headline about the bowel cancer risks associated with eating bacon sandwiches. That scaremongering story was published almost a decade ago, but spurious claims about lifestyle choices and cancer – especially bowel cancer, also known as colorectal cancer – are still rife. The big difference? The alarmist claims are largely playing out on social media and are increasingly targeted at the young.

Why is this? In recent years it has become clear that rates of various cancers are rising in younger people. This is raising questions – and speculation – as to causes.

Of particular note is colorectal cancer, which was virtually unheard of in younger people last century. Today, under-50s make up 10 per cent of new cases globally, and that number is forecast to more than double by 2030, as we report on page 38.

The most intuitive explanation is a change in lifestyle in younger generations, as much of the social media frenzy purports. The strongest evidence so far points at obesity, type 2 diabetes and unhealthy diets. Conversely, there are signs that eating dairy products may be protective (see page 10).

> **"Colorectal cancer was virtually unheard of in young people. It is now 10 per cent of new cases"**

Ultimately, it is unlikely to be down to a single food or lifestyle choice, but real answers are sorely needed. The issue is so pressing that last year, the Grand Cancer Challenge, a global initiative focused on the toughest problems in cancer research, launched a project investigating the causes of early-onset colorectal cancer. It will look at the usual suspects, including alcohol and processed foods, as well as possible previously unknown causes, such as microplastics and specific ingredients common in ultra-processed foods.

Frustratingly, it will take four years to see the results, while misinformation on social media can spread in minutes. But this sort of slow, careful science is the surest way to fight unfounded and potentially harmful claims. This type of messaging isn't new, but in an era where the truth often feels under threat, such efforts are more important than ever. ▮

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Madeleine Cuff
Environment reporter

News

More cheese, please?
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The first water may have formed surprisingly early p11

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Throwing spears at prey began 300,000 years ago p12

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Physics "butterfly" is caught for the first time p14

Slow recovery
Marine life still feels seabed mining effects 40 years on p15

FIREFLY AEROSPACE

Space

A shadow selfie on the lunar surface

THIS ghostly image was taken by the latest craft to land on the moon. Firefly Aerospace's Blue Ghost probe touched down on 2 March at 0834 GMT, snapping this photo of its own shadow with Earth sparkling above. The craft carries 10 scientific instruments and is expected to operate for a lunar day – or about 14 Earth days – before darkness falls, shutting it down around 16 March.

Technology

Rules of time and space torn up

New insights into how long a computation takes relative to the amount of memory it requires have shocked scientists, reports **Matthew Sparkes**

AN ASTONISHING discovery about the relationship between the amount of memory a computation requires and how long it takes has wowed computer scientists – although it isn't clear if there are practical applications.

"It kind of shakes my world view," says Ryan Williams at the Massachusetts Institute of Technology, who made the discovery. "I'm still just shocked that it even exists."

Time and memory space are the two main constraints on what we can compute. Some problems require lots of memory, some lots of time, and many demand a lot of both. Studying these constraints is the domain of computational complexity researchers, who refer to time as the number of steps a computer takes to do a certain task, and space as the number of memory slots the task requires.

Intuitively these values are linked, because if a task requires X steps, in the worst-case scenario where the computer needs to access its memory for every step, it will require X memory slots.

But researchers have been able to lower the bar for the amount of memory needed in this worst-case scenario. In the 1970s it was discovered that, in fact, any computation that takes X steps could be done with X/log X of memory. So a program that took 100 time steps, for instance, could always run within 50 memory slots, as log 100 is equal to 2.

"That's the best that we've known until last week," says Lance Fortnow at the Illinois Institute of Technology. But then Williams showed that this can be reduced dramatically – to the square root of X log X. Instead of 100 or 50 memory slots, a 100-step task could be done with 15 slots.

"It was kind of a shocker when Ryan sent this paper around last week, and we were all like, 'wow'," says Fortnow. Williams himself was equally taken aback. "It took me months to convince myself that it wasn't just obviously false," he says. "It's still very difficult for me to wrap my head around it. I can go through all the steps, the proof, and verify every step is correct and that it's true. But at the end I'm still wondering."

"It took me months to convince myself that this finding wasn't just obviously false"

XUANYU HAN/GETTY IMAGES

Time and memory for computation are closely linked

The finding sounds unlikely, because it means that computers seem to need only enough space to hold a small part of a problem in memory – a bit like humans being able to solve a complex, multi-step maths problem without needing to write it down, relying only on our limited short-term memory.

Williams's approach hinges on what is known as the tree evaluation problem. This involves a series of linked calculations in a branching tree-shaped structure, where calculating the final result at the "root" of the tree first involves calculating the "leaves", then the "branches", and so on. Recent advances have shown that it is possible to do this with an algorithm that re-uses computer memory that is already full – itself an unexpected discovery.

To bring this to bear on the question of time and space, Williams created a model that can represent any computational problem, then applied the new tree evaluation algorithm, showing that it could drastically reduce the amount of memory required (arXiv, doi.org/n87p). It involves mathematical tricks and "magical cancellations" that ultimately provide valid answers, he says.

"It feels beyond exciting," says Ian Mertz at Charles University in the Czech Republic, one of the researchers who developed the new algorithm. "Definitely a counterintuitive result, although I'd say our tree evaluation algorithms were already pretty counterintuitive."

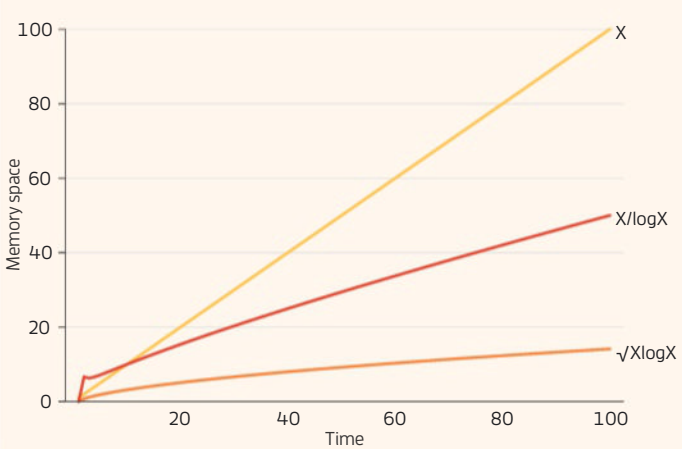
But while the magnitude of the discovery has shocked computer scientists, it won't necessarily change the way we use computers. The problem is that the finding shows that while you can shrink the amount of memory required to perform a calculation, it won't decrease the time taken. Computer memory is readily available, so reducing the amount we need isn't a priority.

A discovery that allowed the reverse would mean we could add more memory to computers and speed up computation as a result – which would be very helpful as advances in processor speed have begun to slow down – but whether this would be possible is unclear. "Now that we know time-efficient algorithms can be made space-efficient, we can look for tradeoffs which are pretty good for both time and space at the same time, and that's useful in a real sense," says Mertz.

Fortnow says he sees no immediate practical implications for the work, but adds that more surprises in computational complexity could still shake-up how we solve hard problems. "You're shocked once, you can be shocked again," he says. ▮

Shrinking space

A computational task that takes a "time" of X steps to do was once thought to require a maximum "space" of X memory slots, but over the years the space requirement has been shrunk and has now reached its lowest level yet (orange)



Archaeology

Ancient Roman's brain exploded and turned to glass when Vesuvius blew

Matthew Sparkes

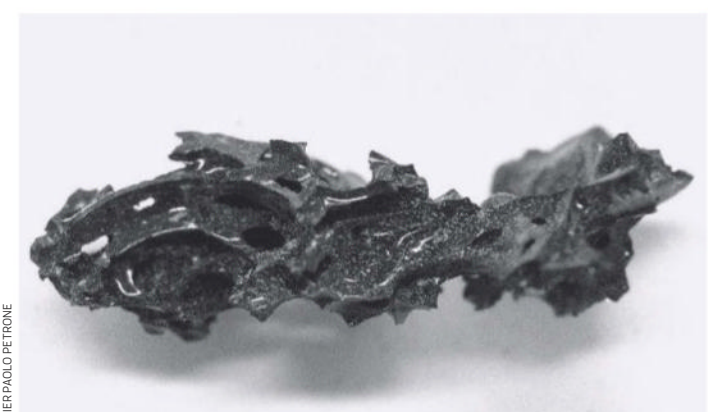
THE eruption of Mount Vesuvius around 2000 years ago caused one man's brain to explode and transformed the fragments to glass. The discovery is the only known instance of soft tissue turning to glass and sheds new light on how eruptions kill – and how we might protect people.

The volcanic disaster struck in AD 79, burying the cities of Pompeii, Herculaneum and Stabiae in thick layers of ash that eventually solidified. At least 1500 bodies and thousands of ancient papyrus scrolls have been found preserved in this material.

One of the remains belonged to a man lying in his bed, who had glass-like fragments inside his skull. When it was found in 2020, the material was thought to be an extremely rare organic glass formed from brain tissue. Now, Guido Giordano at Roma Tre University in Italy and his colleagues have confirmed this and worked out in detail how it happened.

Due to intense heat, the brain would have exploded as water in it rapidly evaporated, the researchers concluded. The fragments remaining in the skull turned to glass as a result of rapid cooling.

"We didn't find a brain. We found bits and pieces," says Giordano. "A few times [during the research] I really got into the human side: you're thinking about this person, and I was really affected by that."



PIER PAOLO PETRONE

This glass-like fragment was found inside a man's skull in Herculaneum

Although the brain suffered catastrophic damage, portions of it are extremely well preserved. Complex networks of neurons and axons can still be seen, and the researchers detected proteins common in human brain tissue.

X-ray and electron microscopy analysis revealed that the brain must have been heated above 510°C before cooling rapidly, in order to form a true glass with no crystalline structure. Because the pyroclastic flow of ash and detritus that buried the city is known to have only reached 465°C, this means that a super-hot cloud of ash and gas must have first engulfed the area, killing residents before it quickly dissipated (*Scientific Reports*, doi.org/n8wg).

"It's not the heating process that transforms things into glass," says Giordano. "The heating process would bake it, would transform it into charcoal, would vaporise it. But it's not going to make it glass. In order to make a glass, you need a fast cooling."

Giordano says the discovery paints a terrifying picture of how volcanoes kill, but also suggests new ways to protect people.

If evacuation isn't possible, and people are outside the physically destructive flow of ash and rock that flattens structures, there is still intense heat of the kind that killed the man from Herculaneum. But shelters with insulation could allow some people to survive.

"In the case of being engulfed within an ash cloud, what kills you is the heat – but there is also the potential to survive if you are sheltered from the heat," says Giordano.

Health

Dirtier spacecraft may help keep astronauts healthy

KEEPING spacecraft as clean and sterile as possible to ensure astronauts don't become ill may be a mistake. Our immune systems may need stimulation from certain kinds of molecules and microbes to stay healthy, say researchers who have been studying the International Space Station (ISS).

"The general notion is to try to have as few microbes as possible, but the question is if that is the best thing to do for long-term space travel," says Pieter Dorrestein at the University of California San Diego.

The main reason for sterilising spacecraft is that an infection that would be easily treatable on Earth could become a major issue on a spacecraft.

Dorrestein and his team have analysed more than 700 swabs of surfaces onboard the ISS and found it is indeed squeaky clean in terms of the diversity of the molecules and microbes present (*Cell*, doi.org/g86ks5). "The space station is just devoid of a lot of molecules and microbes," he says. "It is at the extreme end of human living."

NASA

Astronauts on the ISS live in a squeaky clean environment

The team thinks this lack of exposure could be one reason why there are significant changes to the immune system in space. On the space station, astronauts often get rashes, unusual allergies, fungal or bacterial infections, as well as activation of latent viruses such as Epstein-Barr, which was found in one of the samples. "We don't have a full understanding of that," says Dorrestein. "But the way I view this is that your immune system has to be periodically pinged."

The researchers say we need to find ways to make environments like the space station dirtier without introducing any pathogens. One approach would be to apply bacteria such as *Bacillus subtilis* to surfaces instead of disinfectants, says Dorrestein. *B. subtilis* is already widely used as an antifungal.

Michael Le Page

Analysis Health

Does eating dairy really reduce the risk of colorectal cancer?

There appears to be a link between dairy consumption and bowel cancer, but the true relationship is hard to untangle, finds **Chris Simms**

NEED an excuse to tuck into a cheeseboard? A handful of studies have recently suggested that dairy reduces the risk of colorectal cancer.

Also known as bowel cancer, this is the third most common cancer worldwide and the second leading cause of cancer deaths. If dairy can be protective, it might seem a no-brainer that we up our consumption, but is it so simple?

What clouds the situation is how confident we should be about studies that find a correlation between two things, rather than proving that one causes the other.

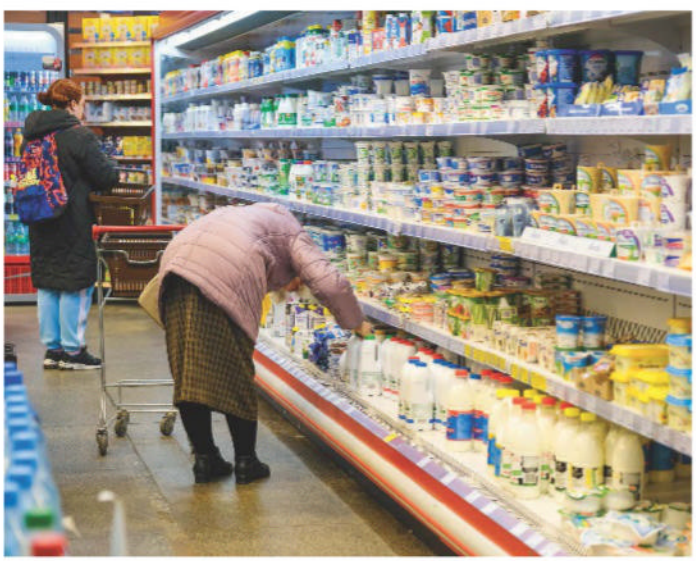
For instance, in a recent study, Keren Papier at the University of Oxford and her colleagues used 16 years of data on more than 540,000 women in the UK who had been regularly asked what they ate. During this time, more than 12,000 of them were diagnosed with colorectal cancer.

The researchers looked at 97 food or nutritional factors, such as vitamins and types of fat, extrapolated from those diets and linked the consumption of dairy, which is high in calcium, to protection against colorectal cancer. They also found that every additional 300 milligrams of calcium per day was associated with a 17 per cent reduction in risk.

"This is the most comprehensive single study ever conducted into the relationship between diet and bowel cancer, and it highlights the potential protective role of dairy, largely due to calcium, in the development of bowel cancer," says Papier.

Calcium "may protect against colorectal cancer by attaching to bile acids and free fatty acids in the colon, which helps reduce their cancer-causing potential", she says.

Papier's study chimes with another recent paper that followed more than 470,000 adults for over



DAMIAN LEMANSKI/BLOOMBERG VIA GETTY IMAGES

Calcium comes from many sources, including cheese, milk and yogurt

20 years. This similarly found an association between reduced colorectal cancer risk and higher calcium intake, from any source, including cheese, milk and yogurt.

Both papers are based on people filling out questionnaires – a notoriously unreliable way of assessing diet. But they "add to and strengthen the existing evidence that consuming more dairy foods lowers bowel cancer risk and that it is the calcium in dairy products that appears to be beneficial", says John Mathers at Newcastle University, UK.

To bolster their results, Papier and her team did another analysis that used the genetic variation that occurs among people as a stand-in for how participants are randomly assigned to groups in experimental trials, so we can be more confident that trends represent causal links.

The researchers were interested in a gene called *LCT*, which can act as a proxy for consuming milk because it codes for an enzyme needed to break down the sugar lactose. The team found that a variation in a single nucleotide near the gene was associated with a reduced risk of colorectal cancer. This approach avoids some of the problems with conventional epidemiological studies of diet and cancer, says Mathers.

A third study, led by Shuji Ogino at Brigham and Women's Hospital in Boston, adds to the evidence, but turns the spotlight away from calcium. His team followed some 87,000 women for 40 years and

"There is a complex connection between diet and cancer risk, with no shortcut to health"

45,000 men for 30 years, asking every four years about their yogurt consumption. At least two servings a week of plain yogurt was linked to a 20 per cent lower rate of colorectal tumours that contained *Bifidobacterium* bacteria. This bacterium is found in yogurts and a strain has been linked to anti-tumour effects in the mammary glands of rats.

Muddying the waters further, a recent review stated that the link between dairy and various cancers is inconclusive. Instead, it emphasised familiar advice: that a Mediterranean diet rich in fish, fruits and vegetables, but with limited dairy, may be best.

Even so, Papier is convinced that calcium is key, and that other sources than yogurt can be beneficial. Her team looked at the impact of calcium regardless of whether it came from dairy or from other calcium-rich foods, such as tofu, canned fish and fortified plant-based milks. "Calcium was found to have a similar effect in both dairy and non-dairy sources," says Papier.

When it comes to calcium supplements, a 2018 report from the World Cancer Research Fund and American Institute for Cancer Research suggests that they decrease the risk of colorectal cancer, but another study found that they may increase the risk of polyps that are precursors to the condition. Given the widespread use of these supplements, further research is needed, says Papier. The benefits of *Bifidobacterium* probiotics are also unknown, says Ogino.

To him, these studies illustrate the complex connection between our diet and cancer risk, with there being no shortcut to health. "If people try to go to a supermarket and buy more plain yogurt, then that's good, but if they just stop in a day or two, there is no effect."

People should try to follow all the cancer prevention advice – such as being active and not smoking – and "not focus on the potential benefits of one food or one nutrient", says Mathers. ▮

For more on colorectal cancer, turn to page 38

Cosmology

The first water may have formed surprisingly early

Sophie Berdugo

THE first water molecules may have formed just 100 million to 200 million years after the big bang – before even the first galaxies.

Shortly after the big bang, most of the matter in the universe was hydrogen and helium. Heavier elements like oxygen didn't yet exist, making it impossible for water to form.

Those initial elements came together in the first stars, which then produced heavier elements through nuclear fusion including, crucially, oxygen. When the stars reached the end of their lives, they exploded as supernovae, releasing these heavier elements and allowing oxygen to combine with the pre-existing hydrogen to create H_2O – water.

Previous research has shown that the low amounts of oxygen formed in the earliest stars could have made water molecules, but nobody had simulated exactly what would happen when a primordial star went supernova and how the elements released would mix with the environment in which the star formed, says Daniel Whalen at the University of Portsmouth, UK.

To investigate, Whalen and his team used computer models to simulate the birth and death of the first stars in a realistic context. These early stars are thought to have ranged from 13 times as massive as the sun to 200 times as massive, so the researchers modelled both.

As you might expect, larger stars spewed out more oxygen, and so produced more water, in the form of vapour clouds about the mass of Jupiter, while the smaller stars made an Earth's mass of water, says Whalen.

Depending on the mass of the star, the team found that water took between 3 million and 90 million years to form after the supernovae, meaning that the first water molecules arrived 100 million to 200 million years after the big bang (*Nature Astronomy*, DOI: 10.1038/s41550-025-02479-w).

Importantly, the team found that this water didn't simply diffuse throughout the cosmos. Instead, gravity caused it and other heavy elements produced by the first stars to clump together. That, in turn, meant these clumps were the breeding grounds for the second generation of stars, and perhaps the first planets. "That was a huge result," says Whalen.

> "This overturns decades of thought about when life may have emerged in the universe"

"This idea that water formed even before galaxies did basically overturns decades of thought about when life could have first emerged in the universe," says Whalen. The team now plans to simulate if the water vapour could survive the destruction and harsh radiation of the formation of the first galaxies, meaning those early molecules may still exist – potentially even on Earth.

"The chemistry of life as we know it requires liquid water, and that you can get only on a planet or some object that has a surface with an atmosphere," says Avi Loeb at Harvard University. A lot of time would have passed before this first vapour condensed into liquid water, but searching for second-generation stars – and their planets – will help us find out whether these planets were habitable millions of years after the big bang, he says. ▮

Zoology

Stone tools are secret to monkeys' success

Colin Barras

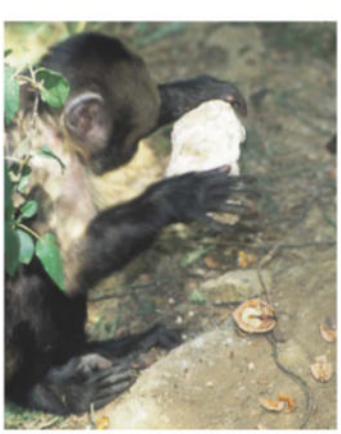
CRITICALLY endangered golden-bellied capuchins are more widespread than we had thought, and stone tools might explain why.

Although golden-bellied capuchins (*Sapajus xanthosternos*) are usually found in the humid Atlantic Forest of eastern Brazil, Waldney Martins at the State University of Montes Claros in Brazil found a population living outside the forest several years ago. "This stayed in my mind," he says.

He and his colleagues have now found golden-bellied capuchins at several sites in the dry forest south of their usual habitat. This has increased the monkeys' known geographical range by almost 20,000 square kilometres. "For an endangered species, any expansion of its limits, no matter how small, is very important for its conservation," says Martins.

The survey work also revealed something else: evidence that *S. xanthosternos* populations in the dry forest use stone tools to split open tough palm tree fruits. That is a significant discovery because the species doesn't seem to use stone tools in the Atlantic Forest, even when it has access to suitable stones (*International Journal of Primatology*, doi.org/n8v3).

Golden-bellied capuchins can use stone tools to access food



ROLAND SEITRE/NATUREPL.COM

This makes Martins and his colleagues suspect that stone tools allowed the monkeys to move into new territory. Easily accessible food is harder to find in the dry forest, so the capuchins may only be able to survive there because tools allow them to eat the flesh of palm tree fruits. The conclusion invites comparisons between the capuchins and our human ancestors, who may also have relied on tools and technology to expand into new environments.

Michael Gumert at Nanyang Technological University in Singapore says Martins and his colleagues still have work to do to strengthen their idea. "Did *S. xanthosternos* colonise the drier habitats and start using tools? Were they already there [using tools], and then the habitat dried?"

But Michael Haslam, an independent researcher in the UK, thinks the circumstantial evidence is enough to support the idea. He says earlier genetics research led by Jessica Lynch at the University of California, Los Angeles – who was also involved in the new analysis – suggests capuchins have been living in the Atlantic Forest for several million years but only moved into the drier forests within the past 750,000 years.

"It is a reasonable hypothesis that the expansion was made possible by stone tools to exploit the tougher foods found in those drier places," he says.

Whether this behavioural flexibility will help the species cope with ongoing habitat loss is unknown. "The kind of work in the new study is vital for understanding how the two primates – us and [golden-bellied] capuchins – can or will adapt to each other," says Haslam. ▮

Archaeology

Throwing spears got an early start

Spears from 300,000 years ago may have been used as projectiles, not just for close-range attacks

Michael Marshall

PEOPLE may have used throwing spears to hunt large animals 300,000 years ago – and perhaps as far back as 2 million years ago.

"Traditionally, you would say thrusting is more simple than throwing," says Dirk Leder at the Lower Saxony State Office for Cultural Heritage in Hanover, Germany. "You have to understand aerodynamics for throwing to be successful." For this reason, archaeologists have tended to assume that hominins first used spears for close-range attacks like stabbing, he says, and only later threw them like javelins.

For most spears, the wood has rotted away, leaving only the stone tip. However, a handful have survived, such as 300,000-year-old spears from Schöningen and a 120,000-year-old yew shaft from Lehringen, both in Germany.

In a pair of studies published in 2022, Marlize Lombard at the University of Johannesburg in South Africa and her colleagues examined the tips of these wooden spears alongside other spear tips and concluded that they were probably used as thrusting weapons. The implication was that throwing spears came later.

Leder, with Annemieke Milks at the University of Reading, UK, instead used a different measure: the point of balance. "Whenever you throw a spear, you want it to go down into the prey, rather than flying across," says Leder. Throwing spears therefore have their point of balance in the front half. On this measurement, the Lehringen shaft looks like a thrusting spear, but those from Schöningen were suitable for throwing (*Journal of Paleolithic Archaeology*, doi.org/n8vx).

The Schöningen spears may have been thrown 300,000 years ago

MINKUSIMAGES, MATTHIAS VOGEL, NLD

This means hominins were using throwing spears at least 300,000 years ago, says Leder.

Lombard says her more recent work supports this timeline. In November, with Yonatan Sahle at the University of Cape Town in South Africa, she published a new chronology of hunting with stone-tipped weapons in Africa. This suggests that, before about 464,000 years ago, "hunters used contact weapons whilst starting to experiment with throwing them over short distances of up to 10 metres", says Lombard. By 300,000 to 243,000 years ago, hunters started to throw spears up to 19 metres, she says.

For Lombard, the key distinction is between medium-range hunting over a distance of 10 to 20 metres – which is what Leder and Milks argue the Schöningen spears could have been used for – and long-range javelin hunting over 20 to 30 metres, which is what Lombard was assessing in her 2022 studies. It is hard to be sure when javelin hunting began because there isn't data for 243,000 to 191,000 years ago, she says.

Evidence of hominins hunting large animals for meat goes back to 2 million years ago. Leder says throwing spears may well be that old, but "we don't have the preservation of wooden spears for this very long time frame". He argues that thrusting spears are an impractical way to hunt large animals. "I would say throwing spears is certainly safer," he says. ▮

Technology

Knittable computer could make clothes to track your health

STRETCHY computers on threads that can be stitched into clothes could record whole-body data that most medical sensors can't pick up.

Wearable technologies, such as smartwatches, monitor signals from the body like heart rate, but typically only from a single spot. This can give an incomplete picture of how the body is functioning.

Now, Yoel Fink at the Massachusetts Institute of Technology and his colleagues have developed a computer that can be stitched into clothes, made from chips that are connected in a thread of copper and elastic fibre.

The thread has 256 kilobytes of on-board memory, around the same as a simple calculator, plus sensors that can detect temperature, heart rate and body movements. It also has Bluetooth so it can communicate with other threads.

This means they can collectively gather location-specific data on the body, which could theoretically be used by an artificial intelligence to monitor a person's health more accurately, says Fink. "We're getting very close to a point where we could write apps for fabrics and begin to monitor our health and do all kinds of things that a phone, frankly, cannot do."

To make the individual threads, Fink and his team folded the chips into a 3D structure and connected them in a copper wire. They then wrapped the wire in a protective plastic casing, which was pulled into a thinner tube that can be covered in fabric, such as cotton.

"We are getting very close to a point where we could write apps for fabrics to monitor our health"

To put them to the test, four fibres were stitched into the legs and arms of a person's clothes. The researchers found they could identify different movements the person made, such as lunges, squats and arm circles (*Nature*, doi.org/g86hvb).

As well as recording exercise, this could be useful for detecting when a vulnerable person has had a dangerous fall, says Theo Hughes-Riley at Nottingham Trent University, UK. ▮

Alex Wilkins

Physics

'Galloping' bubbles could act as tiny vacuum cleaners

Sophie Berdugo

BUBBLES can be made to "gallop" across the roof of a liquid-filled container simply by shaking it up and down – a surprise discovery that could be exploited as a cleaning technique.

Pedro J. Sáenz at the University of North Carolina at Chapel Hill and his colleagues were studying the behaviour of waves in a sealed container using vibrations when they made a chance finding. The team found that shaking the liquid-filled chamber up and down at particular frequencies caused a bubble that had mistakenly entered the container to move horizontally.

The researchers found that this movement was caused by the bubble changing shape. Left to their own devices, bubbles are normally spherical, but the team discovered that vibrating the chamber at the right frequency caused bubbles to become lopsided. Once this happened, the bubbles would start to "gallop" by cycling through a series of wiggling shapes, with one side fatter than the other in an alternating pattern. This wiggling pushed the bubbles against the surrounding liquid, moving them forwards (*Nature Communications*, doi.org/g86bzv).

"I think it's remarkable that we found such a beautiful effect in a field that has been studied so much," says Sáenz.

The bubbles could gallop in three distinct ways, depending on the frequency of the vibrations: forward in a straight line, spinning in place or moving in multiple directions through chaotic jolts.

Sáenz and his team showed that the chaotic galloping motion could be used to remove dust particles from surfaces by dislodging the particles and sweeping them beneath the bubble. In this way, galloping bubbles can act like tiny vacuum cleaners, says Sáenz. ▮

Climate change

Vital ocean current is unlikely to completely shut down this century

Madeleine Cuff

PASCAL HALDER/ALAMY

Melting ice in the Arctic is weakening a key ocean current

A CRITICAL ocean current is unlikely to shut down before the end of this century even under the most extreme climate scenarios, according to new findings that undermine doomsday predictions of an imminent catastrophic collapse.

The Atlantic Meridional Overturning Circulation (AMOC) transports warm water from the tropics northward helping to keep northern Europe temperate. Warming temperatures and an influx of cold water from melting Arctic ice are weakening the current and, scientists fear, could shut it down altogether. This would plunge oceanic ecosystems into chaos and rapidly cool Europe's climate by several degrees.

Some researchers say an irreversible shutdown could happen this century. But this worst-case scenario is unlikely, says Jonathan Baker at the UK's Met Office.

To explore whether a complete AMOC collapse before 2100 is possible, Baker and his colleagues used 34 climate models to simulate changes to the AMOC under extreme climate change, with greenhouse gas levels trebling from today's levels overnight. The team also modelled huge volumes of fresh water entering the North Atlantic at many times the rate of current ice melt.

They found that although the AMOC weakens significantly under these two scenarios, the ocean current would continue in its weakened state, supported

"Southern Ocean winds will continue to blow and that keeps the current running"

by upwelling of North Atlantic deep water driven by winds in the Southern Ocean (*Nature*, doi.org/g86gqz). "Southern Ocean winds continue to blow and this pulls deep waters up to the surface, which acts like a powerful pump," says Baker. "That keeps the AMOC running this century in the models."

The findings help to explain why climate models generally simulate a more stable AMOC in a warming world compared with research relying on statistical methods, which tend to suggest the AMOC is more fragile.

Niklas Boers at the Potsdam Institute for Climate Impact Research in Germany says the findings are "good news" for those worried about an imminent AMOC collapse. "All the state-of-the-art climate models agree on not showing a full AMOC collapse within the 21st century – because of the stabilising mechanisms induced by the Southern Ocean," he says.

But although the models don't foresee a full collapse, they show that quadrupling carbon dioxide concentrations would lead to a significant reduction in the current's strength, by 20 to 81 per cent. If the AMOC weakens by 50 per cent, the effects would be significant, Baker says, with rising sea levels on North Atlantic coastlines and changes to global rainfall. But this kind of weakening wouldn't bring rapid cooling to Europe, he says.

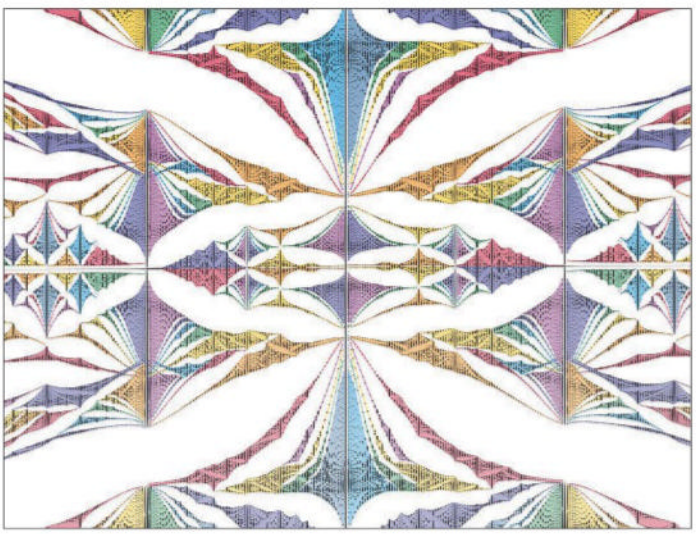
By comparison, an AMOC that is 80 per cent weaker than it is today would have catastrophic effects, says Boers. "That is of course an almost shutoff AMOC," he says. "That will give all the impacts in terms of cooling Europe and changing tropical monsoon patterns and everything we have been concerned about."

Stefan Rahmstorf, who is also at the Potsdam Institute for Climate Impact Research, agrees that the AMOC could weaken this century under extreme warming. Some studies even define an AMOC collapse as this kind of substantial weakening, he says. The study doesn't change the assessment of the risk and impact of future AMOC changes in response to global warming, he says. ▮

Physics

Strange fractal 'butterfly' caught for the first time

Alex Wilkins



YAZDANI LAB, PRINCETON UNIVERSITY

The fractal butterfly, as calculated from electrons in graphene

A FRACTAL "butterfly" pattern produced by an unusual configuration of magnetic fields, first predicted almost 50 years ago, has been seen in detail for the first time in a twisted piece of graphene.

While a physics student in 1976, Douglas Hofstadter predicted that when certain two-dimensional crystals were placed in magnetic fields, their electrons' energy levels should produce a pattern that looks the same no matter how far you zoom in, known as a fractal. At the time, however, Hofstadter calculated that the atoms of the crystal would have to be impossibly close together to produce such a pattern.

In 2013, researchers first saw hints of this pattern, which became known as Hofstadter's butterfly, in a flat sheet of boron nitride, a material similar to graphene.

Now, Ali Yazdani at Princeton University and his colleagues have measured Hofstadter's butterfly in detail for the first time, using two twisted layers of graphene (*Nature*, doi.org/g86h3k).

When one layer of graphene is rotated on top of another at a certain angle, called the magic angle, it produces unique repeating structural patterns and magnetic fields that can lead to unexpected properties, such as superconductivity. These conditions are similar to those in Hofstadter's original prediction, but the strong magnetic fields distort the graphene's electrons, making them impossible to measure in detail.

Yazdani and his colleagues were experimenting with a second magic angle, which leads to wider repeating patterns, when they realised it would produce weaker magnetic fields and leave the electrons free to measure, allowing the team to take detailed readings of their energies. "The fact that we could go to these very low magnetic fields, and do this experiment, was a sweet spot that people hadn't anticipated before," says Yazdani.

"I am always gratified when there are empirical confirmations of the structure that I predicted back in 1976," says Hofstadter. ▮

Archaeology

When were the first houses with corners built?

Colin Barras

BUILDINGS with corners have a much deeper history than we thought, adding an unexpected twist to a curious architectural mystery from the dawn of village life.

Archaeologists have long been aware of a global trend in early architecture. From south-western Asia to the Americas, the very earliest settlements typically contained buildings that had a round or oval-shaped ground plan. Then, usually a few thousand years later, these apparently went out of fashion, becoming replaced by rectangular structures.

But an analysis of early buildings in south-west Asia – home to the oldest settlements in the world – complicates things. "The round to rectangular [trend] isn't as straightforward as traditionally thought," says Hadas Goldgeier at Israel's Hebrew University of Jerusalem.

Goldgeier says archaeologists have a tendency to oversimplify things when describing building shapes, which means structures with an irregular shape may be classified in a qualitative sense as either round or rectangular.

"The round to rectangular trend in structures isn't as straightforward as traditionally thought"

With colleagues, she has instead used a quantitative approach to analyse the shape of 118 early buildings at 23 sites in south-west Asia, the oldest of which date back about 14,000 years and the youngest about 10,000 years.

The analysis revealed that the oldest buildings weren't universally round. Instead, they came in a variety of shapes including teardrops, D-shapes and irregular pentagons – and some contained 90-degree corners. The most ancient of these structures were built by a people known as the Natufians about 12,000 to 12,500 years ago. This means their architects were incorporating 90-degree corners into buildings about 2000 years before rectangular structures became the dominant style in the region (*Archaeological Research in Asia*, doi.org/n8sf).

The broader question is why the trend from round to rectangular buildings exists at all. "It's something that I have sat down and talked about with many different people," says Ian Kuijt at the University of Notre Dame in Indiana, who wasn't involved in the study.

"It's likely that the reasons are multiple and complex," says Goldgeier, suggesting it is difficult to explain the trend even in one region, let alone globally.

But Kuijt says we can at least speculate on the factors involved, and one in particular strikes him as important: rectangular buildings may just be more efficient and economical to construct than round ones. For instance, two adjoining rectangular buildings can easily share a wall, but round buildings can't. "The moment you go with rectilinear forms, the organisation and the construction of space is in some ways simpler," he says.

As such, incorporating 90-degree corners into buildings could be seen as a small step towards improving the efficiency of architectural design. But given that Natufians never constructed rectangular buildings with shared walls, they may have failed to appreciate the potential value of corners. ▮

Health

Modern life doesn't harm your sleep

People in industrialised societies actually seem to snooze for longer than hunter-gatherers

Michael Le Page

MUCH has been written about how modern lifestyles mean we are no longer getting enough sleep, unlike our ancestors who lived in less technologically advanced times. But an analysis of 54 sleep studies conducted around the world has found that people in small, non-industrialised societies actually get less sleep than those in more industrialised regions.

"Everyone I talk to in Canada and the US talks about how awful their sleep is," says Leela McKinnon at the University of Toronto Mississauga in Canada. "The numbers aren't showing that."

It is often assumed that the rise of gadgets like smartphones means that people today are sleeping less than in the recent past – the so-called sleep-loss epidemic. But many studies that report a decrease in sleep in the past few decades are based on asking people how long they sleep, which is an unreliable measure.

Research based on more reliable metrics, such as physical activity monitors or using electrodes to track brainwaves, hasn't found a decrease over recent decades. For instance, a 2016 review of 168 studies found no decline in sleep duration over the past 50 years.

But these studies were done in industrialised countries, leaving open the question of whether people got more sleep prior to industrialisation. The availability of wrist-based activity monitors has made it easier to study sleep in non-industrialised societies. Such studies have revealed short sleep durations. For instance, among hunter-gatherers, the San peoples in southern Africa sleep for 6.7 hours a night on average.

You may feel you need a nap, but you may be getting more sleep than you think

MARTIN PARR/MAGNUM PHOTOS

McKinnon and her colleague David Samson, also at the University of Toronto Mississauga, have been involved in several such studies. They have now compared sleeping habits in industrialised societies, including the US, Australia and Sri Lanka, with those in smaller, non-industrialised communities, including Indigenous peoples in the Amazon, Madagascar and Tanna Island in the Pacific.

Altogether, the analysis is based on 54 studies that involved direct measurements of sleep in people aged 18 and over who had no serious health conditions. While these involve only 866 people in total, the dataset is the most comprehensive yet, says Samson.

The pair found that in non-industrialised societies, the average was 6.4 hours, compared with 7.1 hours in industrial societies. They also found that people in non-industrialised societies were asleep for 74 per cent of the time they were in bed, compared with 88 per cent in industrial societies, a measure known as sleep efficiency (*Proceedings of the Royal Society B*, doi.org/g86gs4).

Samson attributes the higher sleep duration and greater sleep efficiency in industrialised societies to conditions more conducive to sleep. "We see that we've made some real gains in the safety and security of our sleep sites," he says. "We don't have to fend [off] rival human groups at night or predators." ▮

Environment

Deep-sea life is still recovering from mining 40 years ago

BIODIVERSITY is depleted and large furrows still lie in an area of seabed where deep-sea mining equipment operated decades ago.

Deep-sea nodules are packed with valuable metallic resources such as cobalt and manganese, critical components in electric car batteries and other devices.

In 1979, US firm Ocean Minerals Company carried out test runs for nodule mining in an area of the Pacific Ocean called the Clarion-Clipperton Zone. It was one of the first realistic trials and deployed a similar approach to plans set out by modern mining firms.

"This is one of the oldest disturbance events that's happened in the Clarion-Clipperton Zone," Daniel Jones at the UK's National Oceanography Centre told reporters in a briefing last week. "This was very much the early days, to see if it was technologically feasible to harvest these nodules. And they proved that it was."

Revisiting the site in 2023, Jones and his colleagues found that deep tracks from the machines remained. The team also used autonomous vehicles to assess biodiversity at the site. Some life had returned to the area, including larger animals such as sea cucumbers, but, overall, the site was still recovering, according to preliminary findings the team hasn't yet published.

Biodiversity was still lower in the ploughed area compared with nearby, undisturbed regions

"Biodiversity was still lower in the ploughed area compared with nearby, undisturbed seabed"

of seabed. "We started to see the first evidence of biological recovery," Jones said. "We have not seen communities that are very much back to their normal status."

But some mining impacts do appear to have dissipated. Based on model results, the team thinks the seabed would have been covered by a sediment plume in the immediate aftermath of the mining activity. However, this was no longer visible in 2023, Jones reported. "The impact of the plume after 44 years seems relatively limited, which is quite encouraging," he said. ▮

Madeleine Cuff

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Quantum PCs may hit store shelves one day p25

Comment

See you in court!

Our current justice system won't save island nations like mine – that's why we need a global environmental court, says **Anthony Carmona**

WITH temperatures set to dramatically exceed the critical 1.5°C limit of warming above pre-industrial levels, our planet is in a state of climate emergency. Our ability to withstand the environmental onslaught is being pushed to the brink, particularly in small island states like my home country of Trinidad and Tobago and other vulnerable nations.

Recognising this urgency, United Nations member states have requested an advisory opinion from the International Court of Justice (ICJ) on the climate obligations of individual nations. Governments could use its advice to understand and legislate their own moral duties, but they aren't legally bound to do so, thus the opinion alone is unenforceable.

It is a laudable move, but there is minimal force behind it, for there is no court in the world with jurisdictional authority to properly address climate change and biodiversity loss. Even the International Criminal Court (ICC), of which I have been a judge, only has jurisdiction over crimes listed in the Rome Statute, which triggered its creation. This doesn't include climate injustices.

What we need is an International Environmental Court (IEC). If this were created by statute, following in the footsteps of the ICC, then it could emerge as a permanent judicial body with the ability to impose penalties and sanctions against states that have violated environmental laws.

SIMONE ROTELLA

An IEC would provide a concrete deterrent and a way to implement remediation, while also building a body of case law and legal theory – empowering vulnerable people all over the world to demand climate justice. Cases of climate litigation have more than doubled in recent years, but their success rate remains woefully low.

Fixed legal frameworks could secure wins that are otherwise impossible. Currently, we have no such framework for enforcing rulings. In November 2024, for example, the Court of Appeal of The Hague in the Netherlands overturned a lower court decision that would have forced Shell to reduce its CO_2 emissions.

The creation of an IEC won't be easy. The Rome Statute was hotly contested during initial talks and only regained traction thanks to pressure from Trinidad and Tobago. By 2002, it had secured the 60 ratifications it needed for the court's creation. Now, its authority is recognised by 125 countries.

Today, we have the same impetus for climate justice, but our soft law instruments won't suffice. In 2023, for example, 197 countries plus the EU agreed to the momentous UAE Consensus at the COP28 climate summit. For the first time in history, they committed to "transition away" from fossil fuels. This unprecedented consensus can provide solid foundations for a new statute, declaring the need for an IEC to enforce its key terms.

COP28 empowered lower-income countries and Indigenous peoples to have their voices heard. Their demands for a "loss and damage" reparations fund were finally met, with an initial injection of $700 million.

A year later, however, momentum dwindled at COP29 in Baku, Azerbaijan. The loss and damage fund was left billions of dollars short and the fossil fuel transition agreement was referred for renegotiation in 2025. This is why we need a permanent judicial mechanism to ensure such promises are legally binding and cannot be backpedalled.

So I call on the UN to develop a statute triggering the creation of an IEC. Given COP28's consensus, we can surely reach whatever threshold the UN requires to edge a new statute over the line.

For vulnerable countries, an IEC is the last bulwark against rising sea levels, hurricanes, cyclones and devastating floods. Salvation of the global environment must begin somewhere, and the IEC is the panacea we seek. ▮

Anthony Carmona was the fifth president of Trinidad and Tobago and is a former International Criminal Court judge

This changes everything

The trouble with Moore's law

Back in the 1960s, it seemed like better communications could solve all our problems. Don't blame technology for the failure of that dream, says **Annalee Newitz**

Annalee Newitz is a science journalist and author. Their latest book is *Stories Are Weapons: Psychological warfare and the American mind.* They are the co-host of the Hugo-winning podcast *Our Opinions Are Correct*. You can follow them @annaleen and their website is techsploitation.com

Annalee's week

What I'm reading
One Day, Everyone Will Have Always Been Against This *by Omar El Akkad, a gorgeous manifesto.*

What I'm watching
I recently saw heavy metal cello band Apocalyptica play live, and my ears are still ringing happily.

What I'm working on
Making a website from raw HTML.

This column appears monthly. Up next week: Rowan Hooper

IF YOU cast your mind back over the past two and a half decades, a bizarre fact emerges: everyone from business investors to teachers has been planning for a future ruled by communications technology. If the 20th century was the age of atomics, then the 21st is the age of the internet.

Combining the power of radio, video and telephones, the internet is like a super-communication machine that completely upended our notion of what tomorrow would bring. Now, it seems that all our futures depend on how much we can say to each other, in zillions of different formats.

You might argue that artificial intelligence is the next new thing. But what do AI firms suggest we will do with their neoteric products? Write emails, make graphics for slide-show presentations and generate podcasts and movies. All of these uses – even shady deepfakes – are about communication. At this point, only spaceships can compete when it comes to signifying an advanced new world.

In my previous two columns about futurism, I talked about 19th- and 20th-century ideas of the future. Now, we are coming up to the present day, and it's time to talk about… well, talking. What happens to the present when we assume the future will be shaped by conversation machines?

To get to the answer, we need to travel briefly back to the year 1965, when Intel co-founder Gordon Moore formulated his now-famous "Moore's law", which held that the number of components on a microchip would double every year. He revised this calculation many times, as technology changed. In 2025, the law is mostly considered dead. Even so, the idea of exponential growth behind Moore's law was infectious, influencing predictions about the rate of innovation in fields as diverse as biology and space exploration.

Most futurism contains two ingredients: a plausible, evidence-based observation and a mythical narrative. Moore's law has both. Moore's original observation was factual: in 1965, microchip efficiency was absolutely accelerating at an exponential rate. But his accurate prediction morphed into a kind of industrial fairy tale. The rapid growth of the computer industry – and, by extension, the internet – became an aspirational story about civilisation itself. Thanks to computers, humans would become more productive, our cultures would transform and amazing new inventions would arrive faster than ever.

> "Gordon Moore's accurate prediction about microchip efficiency morphed into an industrial fairy tale"

It was a very seductive way to imagine the future – as long as Moore's law held true. By the 21st century, forecasters were predicting a world where everyone lived and worked via the internet, which would bring together international teams of geniuses to solve all our problems (aided by AI, of course).

Meanwhile, Twitter-fuelled protests during the Arab Spring in 2011 and Donald Trump's Facebook-enhanced 2016 election campaign made it seem like social media could accelerate political change, too. Chatting with each other was going to change everything! Investors responded by dumping billions into internet companies, especially ones with social or AI components.

You can see the results in nearly every product. I own a coffee table that has an associated social network. Apple offers iPhone owners the exciting prospect of getting AI summaries of their text messages. Communications technology is being smeared everywhere, even when that causes things to break.

The myth of Moore's law suggested that one nifty form of technology would set the pace for everything else in our civilisations. When you anticipate the future using that narrative, it leads to overinvestments in very niche tech. This isn't to say there is no place for social media and AI in our future – of course there is. But we also need to invest in better sewage systems, malaria treatments, aeroplane safety and science education itself. AI won't solve the looming climate crisis. We need to cultivate a diverse ecosystem of technologies and political institutions to do that.

Back in the 1960s, when *Star Trek* wowed audiences with the crew's communicators and sci-fi legend Ursula K. Le Guin dreamed up the ansible (instant messages across thousands of light years), it seemed better communication would be the answer to all our problems. Especially because the microchip would put electronic communication in the hands of ordinary people. But now that dream has become a nightmare, with AI chatbots generating lies and authoritarian leaders using social media to control nations.

This isn't the fault of our technology. It's ours, for believing a single form of rapidly improving tech could make humanity improve rapidly, too. Sometimes, futurism prevents us from seeing what is actually coming next. ▮

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Spacebound

Rhiannon Adam
Sony World Photography Awards

THIS ghostly image of a Soyuz MS rocket at Baikonur Cosmodrome in Kazakhstan, shot the night before it took off for the International Space Station in December 2021, has a particularly poignant resonance for its photographer, Rhiannon Adam.

Around a month earlier, she had been told that she would be one of eight crew members in the dearMoon project. Set to be the first civilian mission to the moon, it was scheduled to launch in 2023 using a rocket developed by SpaceX, but was later cancelled.

Adam was part of a large crowd taken to see the Soyuz rocket that evening. As others started leaving, she hung back to get her shot before she was escorted away by security. "Before firing the shutter, I held my breath and closed my eyes, as I didn't have a cable release," she says. "It was an eerie kind of alien green light, the flood lights mixing with the mist, and I knew it was a sight I may never see again."

Adam captured two frames before she was ushered onto waiting buses and had to cross her fingers that her photo would come out. "Luckily for me, it did. The image is a little bittersweet now, for what it symbolises for me, but when I can disassociate it from my own life, I still think it is a beautiful monument to human achievement," she says.

She is one of 30 finalists in the professional competition at the 2025 Sony World Photography Awards, making the cut in the "creative" category for her photo series about the mission's cancellation. The overall winner of Photographer of the Year will be named on 16 April.

Alison Flood

Parenting to perfection

Flimsy neuroscience is creating a culture that pushes parents to optimise their child's brain. **Penny Sarchet** welcomes a critique of "intensive mothering"

Book
Motherdom
Alex Bollen
Verso (UK, out now; US, pending)

SVETIKD/GETTY IMAGES

How mothers handle their baby's every move is now subject to "expert" advice

RELAX, but be on constant alert. Enjoy your baby, but take them very seriously. Follow your instincts, but do exactly what the scientists and health professionals say. Amid such a deluge of "expert" advice, is it any wonder that the experience of modern parenting – motherhood, in particular – can often feel exhausting and impossible?

Thankfully, a handful of well-researched books are questioning this stress-generating situation and, in the case of *Motherdom: Breaking free from bad science and good mother myths* by Alex Bollen, revealing the role bad science has played in creating it.

The term "intensive mothering" defines the expectations I didn't realise I was up against until I read about it. Coined in the 1990s by sociologist Sharon Hays, author of *The Cultural Contradictions of Motherhood*, it describes a parenting ethos centred on the ideas that children need very large amounts of a mother's energy and resources, and that mothers need to be sharply tuned in to their children's cognitive, psychological and emotional needs.

Intensive mothering is child-centred, labour intensive, financially expensive and – notably – highly guided by experts. Think costly baby sensory classes and toys, play that is designed to "optimise" an infant's brain development and worrying you aren't providing the "right kind" of stimulation.

I first came across the concept in Lucy Jones's important 2023 book *Matrescence*, in which she investigated what she called "the metamorphosis" of becoming a mother. That book was a welcome reality check, explaining why this transition can feel so difficult.

But what I didn't fully appreciate until reading Bollen's *Motherdom* is the extent to which science – especially neuroscience – has shaped modern expectations of parenting, and the degree to which it has been overextrapolated and misapplied.

Before providing support to new mothers as a postnatal practitioner with UK childbirth charity the NCT, Bollen was a director of market research company Ipsos MORI. She therefore brings an outsider's perspective to academic research, marvelling at the small sample sizes used to draw conclusions when, in her former line of work, polling much larger cohorts was standard practice.

Like the economist and parenting author Emily Oster before her, Bollen brings a critical eye to the science used to justify child-rearing recommendations. But while Oster's 2019 book *Cribsheet* is more of a manual, assessing the evidence in order to inform decisions on issues such as breastfeeding, sleep-training and discipline, *Motherdom* isn't a guide to parenting. Instead, it is a dismantling of the myths, moral judgements and shaky science that have led to today's prescriptive guidelines.

Its extensive survey of research, policy reports, parenting manuals, social criticism and more can become a chore to follow. But its critique of the undue emphasis placed on the need for a mother to shape her baby's brain makes compelling reading. Bollen unpicks the scientific evidence that has been used to bolster claims, such as that a mother's support can increase the growth of a baby's hippocampus, or that stress can have toxic effects on a child's brain.

She reveals how the evidence used to make assertions about baby brain development is often flawed – whether it is a result of small samples that are more likely to turn up weird results, contrived experiments in lab animals, the findings of which are implausibly extended to humans, or studying children who have experienced extreme neglect and then inferring more general lessons from this.

Bollen doesn't hide her anger: "When I began to understand the flimsy scientific foundations of neuroscience narratives, I became incensed." You can feel this as she traces the short path such research takes to becoming public policy.

Take *The Best Start for Life: A vision for the 1,001 critical days*, a UK government report published in 2021, which states that the infant brain "becomes hardwired

by the baby's earliest experiences, having a lifelong impact on their physical and emotional health".

Bollen describes how similar narratives have been adopted by various charities and campaigns that frame a mother's interactions with her baby as a crucial window for shaping that child's future life. These often ignore the profound

"If brain development needed such coaching, it is hard to imagine our species being as successful as it is"

impact of poverty on children's cognitive development, as well as decades of research that show brains are plastic and continue developing significantly into our early 20s.

The end result, argues Bollen, is that parents "are expected to build their babies – and their brains". This is evident in a 2007 report from the National Scientific Council on the Developing Child, a collaboration of researchers in North America. It states that "the quality of a child's early environment and the availability of appropriate experiences at the right stages of development are crucial in determining the strength or weaknesses of the brain's architecture, which, in turn, determines how well he or she will be able to think and to regulate emotions".

Bollen writes that such statements are now used to justify all sorts of prescriptions, especially in the way parents and carers interact with their children. One example is "serve and return", the advice that appropriately responding to your children's gestures, babbles and facial expressions plays an important role in shaping their brains. As the Harvard Center on the Developing Child puts it, "responsive, attentive relationships with a caring adult" not only shape brain development, but also "all future health and well-being".

What I dislike about all this is that it turns many of parenting's pleasures – such as cooing and smiling along with your baby – into critically important work which, if not performed adequately, puts that child's future health and happiness in danger.

Many of the studies behind this kind of advice focus on so-called primary carers, rather than family life as a whole. The result is that mothers – who most often are the primary carer – now shoulder the daunting responsibility of "optimising" their children's development.

The pressure is cranked up further by a "the-more, the-better" approach. "Right from birth, every time you talk, sing or play with your baby, you're not just bonding, you're building their brain," the NSPCC, a UK children's charity, has said.

"The implication," writes Bollen, "is that every time you don't do these things, your baby's brain is not being built."

Must every outing involve turning fun into an enriching experience?

CAVAN IMAGES/ALAMY

Of course, there is a place for science in understanding child development and parenting. I was unsurprised that towards the end of *Motherdom*, Bollen looks to psychologist Alison Gopnik, at the University of California, Berkeley, and her excellent 2016 book *The Gardener and the Carpenter*.

What is so refreshing about Gopnik's approach is that, rather than dissecting the parent-child relationship, she studies how babies and children really learn. Her conclusion is that they do so from everyone (not just their mothers) and are doing it all the time – through watching, listening and playing. Rather than attempt to shape infants into a particular type of person, Gopnik suggests that parents just need to provide a safe and stable environment in which they can develop.

Where does all this leave those of us wanting to take an evidence-based approach to raising our children? Unsatisfyingly, and in the absence of better studies, some of it has to come down to what feels right for you.

I will continue to "serve and return", but I won't feel guilty if my family's main activity today is simply running errands instead of something special and child-focused. Pressure on mothers will remain for as long as governments continue to view intensive maternal input as an easy way to compensate for big problems like poverty and inequality.

But I really hope a better understanding of the science can reassure parents that we don't need to meticulously shape our children's brains to some perfect ideal. If brain development really did need such intensive coaching, it is hard to imagine that our species could have been as successful as it is. ▮

New Scientist *recommends*

Eleanor Parsons
Magazine editor
London

Winter is a time for me to wrap up in blankets and read. Among the books I have enjoyed so far is **Orbital** by Samantha Harvey, which won the 2024 Booker prize. It follows six astronauts on the International Space Station over the course of an Earth day (16 orbits of our planet) and is a poetic meditation on everyday life on board, punctuated by moments of awe.

The main character is our beautiful, fragile planet, and I loved getting a different perspective on my home.

As the weather slowly improved, I ventured out

to see the sun – **Helios**, that is, the latest giant sculpture (pictured) by Luke Jerram. It is based on detailed photos of the sun's surface, stitched into a sphere 7 metres in diameter. I got lost in its sunspots and streaks of plasma that look like brushstrokes, thrilled to encounter our star so close up.

I saw the sculpture in the large ballroom in the Bath Assembly Rooms. But if you missed it there, it is on tour across the UK this year – look online for a venue near you.

NATIONAL TRUST IMAGES/JAMES DOBSON

The TV column

After David Lynch

The death of someone who shaped decades of film and TV is bound to hurt. Rediscovering a show called *The OA* helps, with its *Twin Peaks*-style echoes of small-town US and other Lynchian themes, finds **Bethan Ackerley**

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

JOJO WHILDEN/NETFLIX

Prairie Johnson (Brit Marling) returns home with secrets to tell

LIKE many film fans, I was heartbroken by the recent death of David Lynch. A trailblazing director and painter, he was perhaps the most influential visual artist of the past 50 years, responsible for haunting works of film and TV like *Mulholland Drive*, *Lost Highway* and, of course, *Twin Peaks*. "Visionary" seems too small a word to describe him.

While reading tributes to Lynch, I stumbled across a list of TV shows influenced by his work. One of those was a series I had been meaning to check out for a while: *The OA*, a Neflix science-fiction drama from 2016 about a woman called Prairie Johnson (Brit Marling) who goes missing for seven years. Blind when she disappears, she returns to her adopted parents' Michigan home with her sight restored and a universe-altering secret to tell.

Her confidants are four troubled teenagers and their teacher, drawn together for reasons they can't quite fathom. Prairie – who comes to refer to herself as "the OA" – recounts her life and her time spent as a captive in the hands of a man known as Hap (Jason Isaacs), a doctor with a dangerous fixation on people like her. *The OA*'s story shouldn't be spoiled, beyond it involving prophetic dreams, doppelgängers, parallel worlds and near-death.

If that all sounds a bit *Twin Peaks* to you, you aren't alone. That is exactly what drew me to the show – and made me suspect I'd dislike it, for being so reminiscent of something I love.

> **"*The OA* is about a young woman facing abuse, whose image reverberates through a small town"**

There are plenty of similarities. Like the short, tragic life of *Twin Peaks*'s homecoming queen Laura Palmer, *The OA* is about a young woman facing unspeakable abuse whose image reverberates through a small town, the subject of more misinterpretation than understanding. It shares the same sincerity, with a full-throated belief in love, dreams and other phenomena transcending death. There are wildly implausible plot developments, mystic rituals, out-of-nowhere dance scenes and lapses into melodrama. In other words, it's Lynchian to the core.

I craved these similarities, but I began to see *The OA* on its own terms: a singularly weird show of a kind that doesn't often get made these days. This is particularly true in the second season, where a kaleidoscopic expansion of the narrative leans further into sci-fi, building a tone reminiscent of a superhero comic series.

Crucially, we visit another world, where private investigator Karim Washington (Kingsley Ben-Adir) searches for a missing teenager in San Francisco. In the process, he learns about *Q-Symphony*, an augmented-reality puzzle game where advanced players can win hundreds of thousands of dollars.

This noirish plot adds yet another layer to an already mind- and genre-bending series, but these threads are surprisingly well-balanced overall. And if *The OA* shows scant interest in the mechanics of its multiverse-hopping events, that's something I can overlook in favour of its awe-inspiring view of a reality where death isn't always the end.

When an artist you love dies, you see their influence everywhere. It has been tempting to live in David Lynch's work for a while – and I will certainly be revisiting some favourites. But it is also important to find your way back to the new and undiscovered. I am grateful to have found *The OA* at a time when I needed something in between – familiar but altogether different, like a friend from some alternate plane. ▮

TV

The OA
Brit Marling and Zal Batmanglij
Netflix

Bethan also recommends...

TV

Twin Peaks
Mark Frost and David Lynch
Parmount+
Practically every TV show of the past 30 years has been shaped by this uncanny series. After a high school student is murdered in a small town, the FBI sends in Special Agent Dale Cooper.

A Murder at the End of the World
Brit Marling and Zal Batmanglij
Disney+ (UK); Hulu (US)
The minds behind The OA *created this mystery where hacker Darby Hart is invited to a billionaire's Arctic retreat.*

Editor's pick

From the mouths of children

15 February, p 38

From Mark Jones, Reading, Berkshire, UK

In researching infant consciousness, has anyone sought input from people who were themselves recently babies? I no longer have direct memories of being a baby, but do recall as a 4- or 5-year-old, reviewing my infancy, including my cot and pram. I would have been a willing interviewee. Moreover, until about age 10, I had recurring nightmares, a synaesthetic melange of rhythm, colours and base emotions, which I later felt might have been a reconstituted recollection of my birth.

Quantum PCs may hit store shelves one day

Leader, 15 February

From Sam Edge, Ringwood, Hampshire, UK

The same sentiment that "you will probably never own a personal quantum computer" was felt about conventional computers in the 1950s, 60s and 70s. Current quantum computers are still nothing but proofs of concept. But once commercially viable and useful ones become available to buy, the pressure will be on to make them more powerful and cheaper. This may spur innovation in miniaturising confinement and cooling systems and in room-temperature superconductors, which may eventually lead to devices the size of today's gaming PCs and perhaps eventually even smaller. At that point, why wouldn't we all have one at home?

Perfect boiled egg is an imperfect solution

15 February, p 19

From Isidore Margaronis, London, UK

As an engineering student decades ago, I was taught that a simple empirical formula that gave a "good enough" result was more useful than a perfect, correct analysis with too many variables.

A case in point is the "best boiled egg" method you reported. It was fascinating and illuminating and involved nuclear magnetic resonance and spectroscopy, complex energy flow calculations and more. However, it requires more than half an hour of cooking. Other methods for the "perfect" egg require far less time.

Spreading rock dust to save climate is a problem

1 February, p 14

From Malcolm Black, Middle LaHave, Nova Scotia, Canada

You report the idea that the use of crushed rock on agricultural land to capture carbon may also alter Earth's reflectivity. However, this geoengineering proposal isn't practical. A millimetre-thick layer of rock per hectare weighs around 20 tonnes. Extended to 1.5 billion hectares of cropped land in the world, and that is a lot of rock dust. I shudder at the carbon emissions from crushing it, trucking it to distant fields and spreading it.

Other potential negatives include wind erosion of the dust, which would cause pulmonary problems for humans and animals that breathe in the particles, and potentially fatal effects on insects when they are coated by the dust.

From Richard Black, Belchford, Lincolnshire, UK

I wonder if any change in reflectivity due to spreading crushed rock on farmland would only occur where there was no crop cover. And would the rock deplete carbon dioxide where crop seedlings grow, reducing viability? I suspect this method would be only for areas with no plant cover.

This is the real hallmark of alien intelligence

8 February, p 28

From Hillary Shaw, Newport, Shropshire, UK

The problem with recognition of alien intelligence raised in your review of Adrian Tchaikovsky's book *Shroud* was also tackled in a short sci-fi story from the 1970s, in which some humans get stuck on a very warm and humid planet where every artefact they have rapidly rusts or rots. Aliens arrive, assume they are indigenous animals and take them back to a zoo. Now the humans must convince their captors they too are intelligent. Making artefacts is no good; the bowerbird does that. Then the humans find the alien equivalent of a mouse in their zoo cage, and befriend and cage it. Instantly the aliens set them free with profuse apologies. You see, only intelligent creatures imprison and feed other creatures.

Some history on new visions of the future

8 February, p 22

From Xavier Duran, Barcelona, Spain

While Filippo Tommaso Marinetti is said to have founded futurism in 1909, the word was actually created in 1904 by Catalan writer Gabriel Alomar at a Barcelona conference.

His was an aesthetic movement, but also a political one, in a sense opposite to Marinetti's. Alomar was unequivocally democrat, Catalanist and leftist and, probably, agreed with the Italian futurists only in their anticlericalism.

Alomar's theses were echoed in the *Mercure de France* magazine in 1908. Perhaps this is how Marinetti learned of the term and took advantage of it.

We see evolutionary mismatch all around

Letters, 15 February

From Denis Watkins, St Just in Roseland, Cornwall, UK

Beth Morrell makes the excellent point that the modern world is grossly mismatched to the one in which we evolved. The restraints of our evolution on our thinking are there to be seen in our actions. We continue to wreck the planet, render its air toxic, pollute rivers, destroy wildlife and slaughter our own kind. Questions on, for example, the structure of space-time may be beyond us. Another order of intelligence, with means and methods unimaginable to us, may be needed.

Never mind the horses, what about the bullocks?

15 February, p 16

From Alex Jones, Sydney, Australia

You reported a study providing evidence of the origins of the Yamna culture that spread across Europe. One contention for which there is no evidence, however, is that the expansion of this cultural group involved carts pulled by horses. There is no evidence for the use of horses as draught animals in the areas concerned so early. What we do have is evidence for bullock wagons, and the word "yoke", for the technology for harnessing bullocks, is widespread in subsequent languages.

Another view on cosmic pauses

15 February, p 30

From David Bacon, Hove, East Sussex, UK

Isn't it more likely that the possible pauses in the evolution of the universe discussed in your look at a new cosmological model are for installing software updates?

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The dark energy illusion

A new conception of how time varies across the universe suggests we can get rid of cosmology's most mysterious entity, says **Stuart Clark**

IMAGINE looking out over a beautiful vista. The sun glances off the snowy peaks of distant mountains, a river winds through rolling hills. There is something wonderful about beholding the contours of a majestic landscape.

It might not be obvious when you look at the night sky, but the universe has a landscape of its own – filaments of galaxies separated by near-empty voids. We have long known this much. But now one group of cosmologists is taking things further and proposing that the universe possesses not just a landscape, but a timescape, too. The idea is that the very flow of time varies from place to place.

To say this goes against the grain would be an understatement: we have always thought that on large scales, time runs at the same speed throughout the universe. But in this picture – known as timescape cosmology – there are large patches of the universe where time has been ticking for billions of years longer than we usually assume.

It may sound strange, but what entices some physicists is the simple elegance of this idea. There is no freaky physics involved, it springs naturally from established theory. "It is part of the structure of general relativity," says its inventor David Wiltshire at the University of Canterbury in New Zealand. "It's just not a part of the structure that

ALAMY/RYAN WILLS

people thought about before." His proposal could explain one of the biggest puzzles in physics and overturn the standard way that astronomers model the universe. Now, as results from new sky surveys trickle in, there are hints that there might be something in it.

Astronomers have known for nearly a century that space is expanding. Everything that isn't gravitationally locked together is flying away from everything else. You would expect as much, given that the universe began in a big bang that kicked off the expansion. But in the mid-1990s, two independent research groups made a discovery so fundamental and surprising that it won them a Nobel prize.

It isn't just that the cosmos is expanding, it is doing so at an increasing rate. Since there is no easy way to explain this, cosmologists suggested that space is filled with a mysterious "dark energy" pushing the universe apart faster and faster. The trouble is that there is no natural explanation for what this dark energy might be, despite decades spent thinking about it. With nothing better to fall back on, dark energy has become a key tenet of cosmology.

That is also the status of an assumption known as the cosmological principle. Introduced in 1933 by the British astrophysicist Edward Arthur Milne, this states that there are no special places in the universe, so conclusions drawn from our vantage point on Earth are universally true across all of space.

Take, for example, the age of the universe. Astronomers estimate that this is around 13.8 billion years. Even though it has been calculated using measurements taken from Earth, the cosmological principle states that we should get the same answer if we did the same thing from some distant, random locale in space. This is because, according to the cosmological principle, the universe is both isotropic and homogeneous on large scales. Isotropic means that it looks the same in all directions, whereas homogeneous means that it has the same properties throughout. "If I look at the distribution of galaxies on large scales, I see roughly the same number of galaxies when I look north as when I look south or east or west," says Joshua Frieman, a cosmologist at the University of Chicago.

With this principle in place and coupled with Einstein's general relativity – the theory of how gravity warps space and time – we end up with a model of cosmology that needs extra ingredients to explain our universe, namely dark matter and dark energy. The standard version of this model assumes that dark matter is made of heavy, sluggish particles known as cold dark matter (CDM), while dark energy is a constant energy field represented by the Greek letter lambda. That gives the standard cosmological model its name, lambda-CDM – and this is the lens through which most astrophysicists and cosmologists consider the universe. "It gives us a framework for understanding how structure formed and evolved in the universe which is consistent with observations," says Frieman.

The trouble with the cosmological principle, however, is that the universe is only isotropic and homogeneous on scales of around 400 million light years or more. Below this, things are very different from place to place. There are clusters of galaxies, which contain so much matter that they hold themselves together, detached completely from the expansion of the universe, and ›

"More time will have passed since the big bang in a void than in the Milky Way"

there are voids. These are vast, almost empty areas in which expansion is proceeding as normal. It's a bit like how Earth resembles a perfect sphere from space. Yet, zoom in and the landscape of mountains and valleys disrupts the curvature.

In the mid-2000s, Wiltshire became aware of the work of Thomas Buchert, then at the CERN particle physics laboratory near Geneva, Switzerland, who was struck by this inhomogeneity. With voids thought to make up as much as 95 per cent of the volume of the universe, Buchert had set about calculating a better way to deal with them, rather than simply assuming the cosmological principle held. Wiltshire took Buchert's methods, applied them to general relativity, and in 2007 the timescape model was born.

The trick behind it is an odd phenomenon called gravitational time dilation: the gravitational pull of massive objects warps space-time, resulting in time passing more slowly near such objects than it does further away. The stronger the gravitational field, the slower time passes. This concept itself is far from new, but cosmologists have generally assumed that the effects tend to smooth out over large scales, because the cosmological principle dictates that matter is roughly evenly distributed across the universe.

Throw out the cosmological principle, as Wiltshire and his colleagues advocate, and you can no longer assume this is so. If you want a model of cosmology that is consistent with this view of things, you have to get into the nitty-gritty of Einstein's equations relating the properties of space-time to the amount of matter and energy situated within it. Those properties determine whether that part of the universe is expanding and if so at what rate, and also how fast time is passing in that region.

Because there is hardly any matter in a void, time can progress very differently there. "Voids can be as much as 4 billion years older than [clusters of galaxies]," says Ryan Ridden-Harper, one of the team at the University of Canterbury. In other words, more time will have passed since the big bang in a void than in the Milky Way, and so the universe's age will vary hugely depending on where you are located within it. There is no such thing as a single age for our cosmos.

This also means the space inside the voids has been expanding for up to 4 billion years more than we would think if we simply used the age of the universe calculated from within the Milky Way. Once we correct for this difference between locations, using the timescape model, the researchers claim that the need for dark energy disappears.

The idea has been a tough sell since it was first introduced – and not just for Wiltshire's group. There had been earlier, different approaches to deal with the obvious inhomogeneities in cosmic structure, and none of those could move the needle of mainstream opinion either.

Expanding voids

Frieman is among those who remain unconvinced. "There's been a whole literature on [inhomogeneous cosmologies]," he says. "When you include these large structures, could they actually affect the expansion of the universe in a way that mimics the effects of dark energy? To my mind, the preponderance of the literature indicates that that's not happening."

He isn't alone in this view. Wiltshire, however, says that early efforts to construct inhomogeneous cosmologies by other groups only told half the story, because they continued to assume a constant age for the universe. What many haven't realised, he says, is that timescape is different because it includes a varying age. This is what makes it all work, by allowing the voids to expand for billions more years than expected from our local calculation. "If you integrate these effects over billions of years, you get large differences," says Wiltshire.

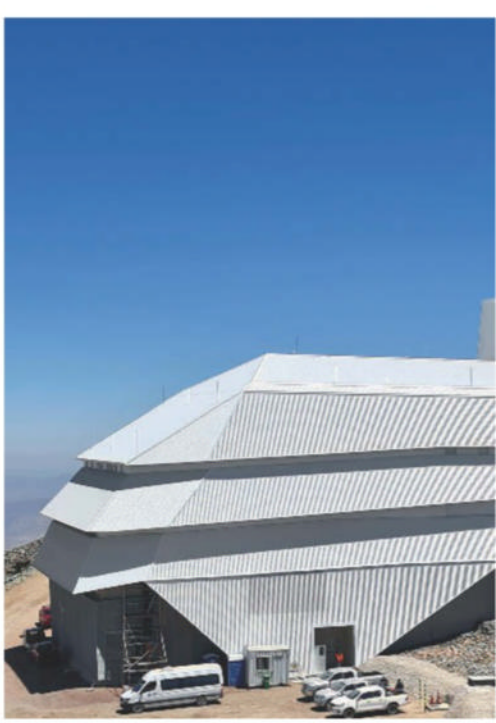
He may now have another opportunity to persuade his peers, thanks to a new dataset called Pantheon+. This contains observations of 1535 supernovae, or exploding stars, of a particular type, known as type 1a. All release essentially the same amount of energy, so any variation in their brightness is the result of their distance from us. This makes them an excellent way to measure the universe.

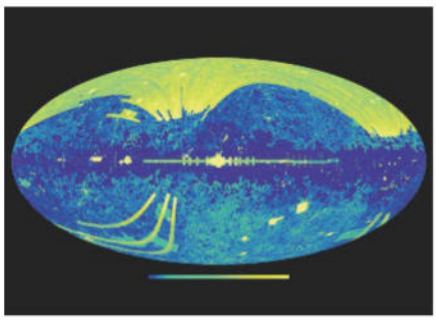
But the true value of the dataset for Wiltshire is that all of the observations have been calibrated to remove potential errors introduced by the supernovae being recorded with different telescopes. Such a large, accurately calibrated dataset finally allows a meaningful comparison between timescape and lambda-CDM.

Wiltshire and his colleagues' latest analysis, published in January, takes the supernovae of the Pantheon+ dataset and compares how well the lambda-CDM model of cosmology fits the data compared with the timescape model. They claim that their statistical analysis yields "very strong evidence in favour of timescape over lambda-CDM".

However, this latest development still hasn't convinced Frieman, who is director of the Dark Energy Survey (DES), a collaboration of more than 400 scientists from across the world. This is despite DES having its own collection of supernova data gathered between 2013-2019 that, when analysed alone, also favoured the timescape model over lambda-CDM. The reason for Frieman's continued scepticism lies in measurements of different cosmological phenomena called baryon acoustic oscillations (BAOs). These measurements were also taken by DES and, when added to the collaboration's supernova data, see the exact opposite conclusion reached about timescape.

BAOs can be thought of as ripples in the large-scale structure of the universe and are related to sound waves moving in the primordial plasma, the bath of super-hot particles that filled the universe in its early





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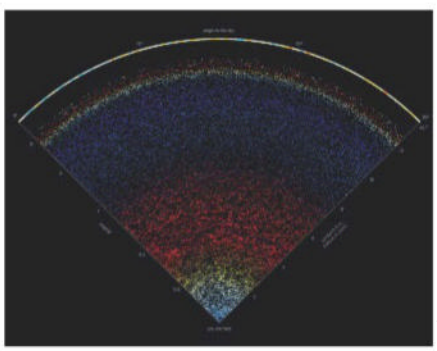


B. MÉNARD & N. SHTARKMAN

Detailed maps of the structure of the cosmos (above) are key, and the Vera Rubin telescope (below) is about to start building a new one

RUBIN OBSERVATORY/NSF/AURA

phases and eventually coalesced into the galaxies of today. This left density variations that acted as a blueprint for the pattern of clusters of material and the voids we see making up the landscape of the universe today.

When Ryan Camilleri at the University of Queensland, Australia, and his colleagues extracted the BAO data from the DES observations and tested them against the predictions of lambda-CDM and timescape, they found the standard cosmological model won convincingly. Wiltshire and his team want to check this result. "The most interesting thing that we could do at the moment is to approach that baryon acoustic oscillation question and see if this is true, that lambda-CDM inherently fits better," says Ridden-Harper. The waves that left this imprint are related to the speed of sound in the primordial plasma, which has been carefully and precisely calculated within lambda-CDM, but not for the timescape model. So Wiltshire and his team are working on that now.

It is critical to get this right because there is so much at stake. The lambda-CDM model provides a foundation for our understanding of the universe, yet despite its many undoubted successes, there are a number of challenges to it emerging from cosmology – and not just from the timescape idea.

The bottom line is that lambda-CDM itself cannot fit all our observations. In 2005, Adam Riess at Johns Hopkins University in Maryland, who shared the Nobel prize for the discovery of dark energy, began drawing attention to a puzzle called the Hubble tension. This concerns the fact that our two main methods of calculating the current expansion rate of the universe, a figure called the Hubble constant, don't match. The first method, using observations of supernovae in the relatively nearby universe, gives a value of about 73 kilometres per second per megaparsec. The other way to calculate the Hubble constant is to start with observations of the extremely distant cosmic microwave background – the faint radiation left over after the big bang – and use lambda-CDM to track the past 13 billion years or so of cosmic evolution to arrive at its present value. This says that the Hubble value today should be 67.7 km/s/Mpc. The mismatch in these figures is troubling. "In my mind it's a hint of a crack [in the standard cosmological model]," says Riess.

It is a crack that Wiltshire thinks timescape cosmology might fill. Back when the radiation that makes up the cosmic microwave background was emitted, about 380,000 years after the big bang, the primordial plasma that filled the universe was very nearly homogeneous. But as gravity pulled matter together, it created structure and eventually gave the modern universe its inhomogeneous pattern of clusters and voids. The timescape model compensates for this evolution, whereas the standard model doesn't. The upshot is that timescape cosmology predicts a higher Hubble constant today, explaining the Hubble tension, because of the additional expansion that has taken place in voids.

Crunch time for the timescape idea is just around the corner. In the next five years, more and better datasets will become available to cosmologists, and Wiltshire says these will be able to discriminate once and for all between his model and lambda-CDM. These include results from the Dark Energy Spectroscopic Instrument in Arizona, which is creating a map of the cosmos that's expected to be complete by 2026, plus data from the European Space Agency's Euclid space telescope and the giant Vera Rubin telescope in Chile.

Euclid is mapping the 3D structure of galaxies, which will give much more information about the BAO ripples. Rubin, which will begin its own vast sky survey this year, will be a supernova discovery machine. "These two are game changers – definitely a big leap in the context of cosmological galaxy surveys," says Imogen Whittam at the University of Oxford, who researches galaxy evolution.

All this means that the future of cosmology hangs in the balance for the moment. But Wiltshire, at least, doesn't mind the wait. He has already worked on his timescape hypothesis for almost two decades, so he is more than willing to wait another few years to find out if he has uncovered a secret of the universe that others have dismissed. "By the end of this decade," he says, "we are going to know the answers." ▮

Stuart Clark is a science writer based in the UK. His latest book is *Beneath the Night*

LILY BUNGAY

The truth about blue zones

We have long looked to regions with a high proportion of centenarians for tips on how to live a long and healthy life – but do these blue zones actually exist, asks **Helen Thomson**

WALK the shores of Ogliastra in Sardinia, an Italian island with crystal-clear waters and pink hillside flowers, and you'll see families eating fresh fish, people working the land and older couples strolling the hills.

You might also see an unusual number of centenarians. This area of Italy is one of three Sardinian provinces that make up a blue zone – a handful of regions in the world with a disproportionately high number of exceptionally older people. These areas are highly prized by researchers keen to uncover the genetic and lifestyle factors that influence longevity. But not everyone is convinced.

"The biggest secret of the blue zones is that they don't exist," says Saul Newman at University College London. Newman recently threw a wrench into decades of claims that centenarians can be found congregated in five blue zones. He says the data behind these claims can't be validated and appears riddled with mistakes – and sometimes outright fraud. Demographers who have spent their careers investigating blue zones, and others who have created profitable business ventures around these regions, are hitting back against the claims.

The saga recently hit new lows. Relationships among the originators of the Blue Zones Project have disintegrated, and *Science* and *The New York Times* recently reported that a leading voice in the venture – journalist Dan Buettner, who wrote a 2005 *National Geographic* article that popularised the concept of blue zones – only included a location in the US to please his editor. However, Buettner has claimed he was misquoted on this point.

So, is there evidence that the lifestyles or genetics of people in blue zones really do extend their lifespans, or should the whole idea be ignored?

Preposterous claims about centenarians have a long history. In the January 1973 issue of *National Geographic* magazine, physician Alexander Leaf described populations in the Soviet Union, Ecuador and Pakistan that had 10 times more centenarians than Western countries, despite poor sanitation and high infant mortality rates. Later checks of the data revealed that age misreporting was rife – people tended to exaggerate their age to improve their social status or promote local tourism. In 1981, Leaf acknowledged these problems and agreed the claims of extreme longevity were wrong.

Things began to change with physician Gianni Pes at the University of Sassari in Italy, who, at a demography conference in 1999, presented evidence on unusual longevity in the province of Ogliastra in Sardinia, a relatively isolated Mediterranean island. Initially doubtful of Pes's conclusions, Michel Poulain at the Catholic University of Louvain, Belgium, and his colleagues attempted to validate the data. They sought official documents, cross-checked them with census information and birth, death and marriage records, then interviewed individual centenarians and their families. Pes and Poulain used a blue pen to mark on a map whenever they confirmed someone's age. This led to a blue ring in which there were confirmed higher numbers of extreme ages. Sardinia was henceforth known as a blue zone.

> *"To be a blue zone, at least 1 in 50 people must live to 100 in that area"*

Meanwhile, Buettner's wildly popular story in *National Geographic* detailed extreme longevity in Sardinia as well as in Okinawa, Japan, and Loma Linda, California. He teamed up with Pes, Poulain and other researchers and, over time, the group identified other blue zones in the Nicoya Peninsula in Costa Rica, the Greek island of Ikaria and the Caribbean island of Martinique. "To be considered as a blue zone today, you need verifiable data to show that at least 1 in 50 people live to 100 in that area," says Poulain. Different researchers use different metrics, however, as some say the number may have to shift as the average age of a population changes with time.

There have been many studies that attempt to find reasons why these areas might encourage long life. In one study on Sardinians, Pes, Poulain and their colleagues noted that hotspots of longevity often appear in the island's more isolated mountainous regions. There may be benefits to such isolation, they say, with low immigration and potential inbreeding creating a smaller gene pool that could potentially lead to the emergence of genetic traits that protect people from conditions associated with old age. Generally, a small gene pool is thought to produce lower genetic diversity, which can lead to recessive genes causing reduced fitness or disease. The team didn't study the idea that there may be benefits of such inbreeding.

Another study, published in 2019, suggests that people in the Sardinian blue zone were more likely to possess a specific variant of a bitter taste receptor called TAS2R38 compared with people in other regions of the island. People with this variant showed a lower preference for high-fat foods. The variant is also associated with a more efficient immune system, and links have been found between possessing the variant of the gene and living a long life.

Other studies suggest that gene variants associated with better mitochondrial health might also contribute to longevity in blue zone regions. Poulain and his colleagues have ›

studied several genetic markers but haven't found clear differences in favour of blue zones. For example, research indicates that Ikarians are slightly more likely to have the *ApoE2* gene that is protective against Alzheimer's disease. However, supercentenarians – people 110 years or older – in Okinawa had a slightly increased likelihood of possessing a variant that makes them more likely to develop Alzheimer's.

Buettner and Poulain disagree on the specific combination of factors that lead to the development of blue zone populations. Buettner has a list of nine factors, which include such populations taking part in more incidental activity in their daily lives such as walking or climbing stairs, eating a plant-based diet, drinking a moderate daily amount of alcohol – "preferably Sardinian Cannonau wine", Buettner notes – and having a supportive community.

"The key insight is this: when it comes to longevity, there's no short-term fix," says Buettner. "The only things that work are things you're going to do almost every day for decades. People in blue zones live a long time because they live in environments that govern their unconscious decisions – every day for a lifetime."

Most of the behaviours Buettner suggests – with the exception of drinking alcohol, which is now generally well accepted not to be beneficial even in small quantities – have evidence behind claims that they are beneficial. Incidental activity was shown in a 2022 study to reduce risk of cardiovascular disease, for instance, while veganism is often associated with markers of good health. However, while they may be healthy lifestyle choices, no one has yet convincingly proved that these are the secret behind the extreme ageing thought to occur in blue zones.

"Some researchers will tell you they know the secret of longevity," says Poulain. "We don't. To progress, we need to work together; psychologists, environmentalists, exercise, nutrition, genetics researchers. There is no research on blue zone areas that puts all these disciplines together."

Despite this, Buettner has built a business empire on the concept, with several books, cookery courses and a documentary all based on the concept of emulating blue zone lifestyles.

All was relatively well until last year, when Newman, an interdisciplinary senior researcher, published a non-peer-reviewed paper claiming the data on which blue zones are based is flawed. "What these researchers are doing is checking the consistency of documents. But when the documents are consistently wrong, errors are undetectable," says Newman. "This happens all the time – when you have someone's age written down incorrectly at some point in their life, the error gets carried over."

Pension fraud

There are several ways in which these errors can occur, says Newman. Young boys have exaggerated their age to sign up to the army during wartime, for example. People forget their age when filling in forms, and some don't report deaths to fraudulently claim state money. In 2012, for instance, Greek authorities reportedly saved $1 billion worth of pension payments after discovering that 200,000 people who were claiming the money were either not entitled to it or dead.

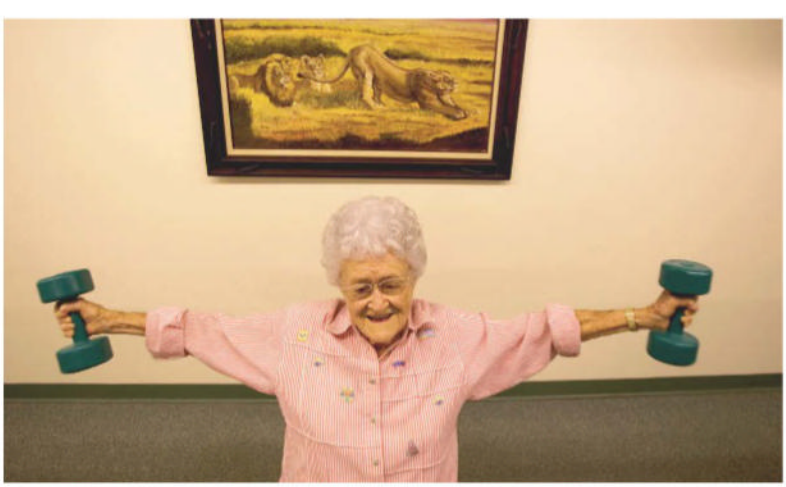
Newman says that errors in reporting age, although rare at younger ages, increase exponentially over time. Consider a million 50-year-olds, into which 100 40-year-olds (let's call them "young liars") are accidentally included, an error rate of 0.01 per cent. As the cohort ages, the young liars are less than half as likely to die as the actual 50-year-olds, says Newman, because they are 10 years younger. He calculates that by age 85, more than half of this population would be young liars and by 100, the young liar errors would make up almost the entire population.

Newman analysed data from several national databases to show that regions with the highest number of centenarians were mainly in countries that had unreliable birth certificates, high levels of poverty, had previously had no centralised government or had a communist dictatorship, or were actively engaged in war or genocide. Puerto Rico came in second place, for example. The US territory has had such a problem with stolen or forged birth certificates that the entire certification system relaunched in 2010, invalidating any certificates issued before then.

The designated blue zones of Sardinia, Okinawa and Ikaria correspond to regions with low incomes, low literacy and a high crime rate – they also have a shorter life expectancy relative to their respective national averages, says Newman. "Relative poverty and short lifespan constitute unexpected predictors of centenarian status," he says. "How plausible is that? It's astounding." In 2024, his work won him an Ig Nobel, a satirical award presented by the humour magazine *Annals of Improbable Research*.

Several blue zone researchers signed a public letter in 2024 rebutting Newman's claims. In it, the researchers describe how they validate the ages of centenarians using civil status databases, handwritten records, genealogical reconstruction, interviews and cross-checking of data with siblings. They maintain that the exceptional longevity of the people in blue zones is well-documented, and call Newman's paper ethically and academically irresponsible. "We are deeply shocked that after nearly 25 years there is someone who disputes the existence of long-lived populations," says Pes.

Buettner rebuts Newman's conclusions on



DAVID MCLAIN/AURORA PHOTOS/CAVAN IMAGES/ALAMY

A 100-year-old woman exercises in Loma Linda, California

GUTEKSK7/ALAMY

EZEQUIEL BECERRA/AFP VIA GETTY IMAGES

Far left: Ogliastra in Sardinia was the first blue zone; Near left: Clementina Espinoza, 91, and her husband Agustin, 100, in Nicoya, Costa Rica

several accounts. For instance, he points to the fact that, despite Newman's claims that birth certificates in Costa Rica are unreliable, the United Nations has, since 1961, denoted the birth and death registration system there as free of error and "complete".

"There's an amazing circle of logic to all this when you're checking the consistency of documents, even when it's UN data," says Newman. "When documents are consistently wrong, errors are undetectable."

Poulain acknowledges the difficulties in age validation, having published several papers and book chapters on the subject, but stands by his research. He says that he has personally visited 200 centenarians and validated their individual ages in multiple ways: "I have the full conviction that they are really centenarian based on documenting their life."

Marilia Nepomuceno, a demographer at the Max Planck Institute for Demographic Research, says it's crucial to validate any claims with multiple methods. In her own work, using several statistical analyses of census data, she has shown that the number of self-declared centenarians in Brazil was almost 30 times higher than it should have been in 2000. But, she says, that doesn't undercut all other claims of longevity.

"The peer-reviewed work of Michel Poulain has been done with great care," she says. "The methodological part of his papers is full of details that allow the reader to follow all the steps performed and identify potential problems in the papers."

Meanwhile, more doubt was cast on the blue zone concept when *The New York Times* reported that Buettner had initially added Loma Linda in southern California to his list of blue zones because his editor at *National Geographic* wanted him to find "America's blue zone". *Science* later quoted Buettner as saying he had "never bothered to delist it".

Buettner says this has been misreported.

> *"Some will tell you they know the secret of longevity – we don't"*

"After much research... and using data from the Adventist Health Study showing that [members of the Seventh-day Adventists Church] were living seven years longer than their California counterparts... I named Loma Linda a blue zone," he says. Buettner didn't provide clarification on the rate of centenarians in Loma Linda after several requests. *National Geographic* pointed to the publicly available letter rebutting Newman's paper in response to our requests for comment. Loma Linda still appears on the Blue Zones Project's website, which Buettner sold in 2020 to Adventist Health, a non-profit based on the principles of Seventh-day Adventist traditions. The website states that "a community of 9000 Adventists live in Loma Linda and live as much as a decade longer [than average]."

Poulain and Buettner have since parted ways; Poulain now runs his own blue zones website.

Many researchers – including Buettner and Poulain – suspect most, if not all, blue zones will disappear as their inhabitants increasingly take up Western diets and lifestyles linked to poorer health outcomes. "I am quite sure that I will not discover a new blue zone and that the existing ones will dissipate," says Poulain. Buettner and Poulain both say Okinawa is no longer a blue zone, and that it can be argued that Ikaria and Nicoya aren't far behind.

Newman says the decreasing numbers of centenarians in places like Okinawa support his claims of historically invalid data: "Okinawa was found to be a blue zone 20 years ago. What happened, did all the 80-years-olds suddenly give up a lifetime of healthy eating habits and go to McDonald's? It doesn't make sense."

Ultimately, does it matter if blue zones are real? When asked whether the World Health Organization uses them to plan health policies, Ritu Sadanu, head of ageing and health at the WHO, says that blue zones appear to provide insights into lifestyles and environments that promote healthy ageing. Nevertheless, WHO's global strategies don't explicitly promote blue zones, nor have they focused on the veracity of blue zone research.

These regions are certainly a tourist draw – Poulain, who is against promoting blue zones to tourists, says authorities in Galicia, Spain, are eager for him to designate their region a blue zone because they know it improves tourism. "They have good data, but they don't have enough centenarians to qualify," he says. "But still, they keep pushing me."

Regardless of the challenges of validating people's ages, the blue zone concept has given people a concrete visual way of thinking about how lifestyle factors can all come together to promote good health, says Walter Willett at Harvard Medical School, who has previously worked as an advisor on blue zone initiatives. "People say, 'Oh I get it now,' and I think in some sense, that's a great thing in terms of improving public health."

For readers looking to replicate the lives of supposed blue zone residents, I'm afraid it comes with no guarantee of living to 100. However, most of the advice that's come out of studying these distinctive areas is sound, practical and eminently possible to recreate in your own community: cooking more plant-based foods, eating with and supporting family and friends, and avoiding a sedentary lifestyle. If you want to have a longer, healthier life, this is what you should be focusing on, regardless of whether blue zones exist. ▮

Helen Thomson is a writer and author of *Unthinkable: An extraordinary journey through the world's strangest brains*

SHUTTERSTOCK/SKILLUP

Ancient computer code may still underpin the software used by banks and the space industry. Why does old code stick around and what happens when it glitches? **Matthew Sparkes** investigates

EARLIER this year, the technology world welcomed back a long-lost friend. ELIZA, the world's first artificial intelligence chatbot, had wowed the computer scientists of the mid-1960s with its ability to engage in seemingly meaningful conversation. But, for decades, ELIZA was considered lost because its creator – Joseph Weizenbaum at the Massachusetts Institute of Technology – never published the 420 lines of code he used to create it.

"At that time, it was actually kind of not normal to publish code," says Jeffrey Shrager at Stanford University in California. Weizenbaum might even have thought that nobody would find it particularly interesting.

How times have changed: Shrager and his colleagues are so fascinated by Weizenbaum's achievement that they founded the ELIZA Archaeology Project and began digging into the history of the ancient chatbot. A few years ago, their efforts were rewarded when they discovered the missing code in a box of

> "It's wild to think we're still using decades-old code in the era of AI"

Weizenbaum's old documents at MIT, paving the way for ELIZA's recent resurrection.

It is astonishing that we can once again talk to a chatbot that occupies such an important place in the history of AI. It got me wondering: is the ELIZA code the oldest out there, or are there even older snippets of computer code still performing impressive or important tasks? My journey in search of the oldest code took me into the heart of modern operating systems and, figuratively at least, beyond the outer reaches of the solar system. And it revealed something unexpected: this old code, far from being revered like ELIZA's, evokes strangely contradictory attitudes among those who work with it.

We appreciate the value of antiques, which means it is usually easy to identify the oldest example of a given technology. Search online for the oldest flyable aircraft, for example, and you will discover that there is a restored Blériot XI plane in the UK that is still airworthy more than 115 years after it was built. Ask for the identity of the world's oldest working light bulb, meanwhile, and you'll be directed to the Centennial Bulb, an incandescent light bulb that continues to shine 124 years after it was first switched on in Livermore, California. But look for the oldest working computer code and answers aren't quite so easy to come by.

For instance, you might be told that the notes Ada Lovelace made in the 1840s constitute the world's oldest computer program. But the mechanical computer for which Lovelace's program was intended – Charles Babbage's Analytical Engine – was never built, so Lovelace's code was never run.

Forgotten language

A stronger contender involves one of the world's earliest general-purpose computers, the Electronic Delay Storage Automatic Calculator (EDSAC), developed at the University of Cambridge. Volunteers at the National Museum of Computing in Bletchley Park, UK, have been constructing a working replica of an EDSAC machine. Once complete, it will be able to run EDSAC software that was published in scientific papers written in the 1940s and 50s. Such code might be among the world's oldest – but it won't actually run until the EDSAC replica is complete.

This made me suspect that a better place to hunt for old – but still functioning – code might be in modern software. The idea isn't as far-fetched as it might seem. Around the same time that the EDSAC computers were in use, computer scientists began streamlining the way they wrote code, leading to the first "high-level" computer languages – or those that are structured along similar lines to human languages, making programming a more intuitive process. Plenty of high-level computer languages have been developed over the years, including IBM's Fortran (appearing in 1957), COBOL (1959) and JavaScript (1995). Crucially, even a language that has fallen out of common usage isn't entirely forgotten. That is because today's software programs can contain code written in several languages, meaning snippets of old code written in a decades-old language can remain buried in the foundations of the apps we use today.

Armed with this information, I continued with my search – and I quickly found a lead. Guinness World Records claims that the slick modern websites we use to reserve and book airline tickets typically rely on software known as the Sabre Global Distribution System, developed by American Airlines in 1960. This, I realised, meant that some of the code in today's version of the software is potentially older than ELIZA's. I contacted Sabre to find out more, but I received no reply. Undaunted, I reached out to related businesses, including Delta Airlines – the world's largest airline by revenue – American Airlines Group, United Airlines Holdings, Lufthansa and British Airways. Sadly, none of them responded to my requests either.

I decided to cast my net ever wider, but the result was the same. In my efforts to track down the oldest chunks of computer code ›

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login eliza
W 945.5
Password
 M1416    10 LOGGED IN  12/21/14  945.6 FROM 700000
 LAST LOGOUT WAS  12/21/14  923.5 FROM 700000
 HOME FILE DIRECTORY IS M1416 ELIZA

THIS IS A RECONSTRUCTED CTSS SYSTEM.
IT IS A DEBUG AND NOT FULLY FUNCTIONAL VERSION.

 CTSS BEING USED IS: MIT8C0
R .016+.000

r eliza
W 945.6
EXECUTION.
WHICH SCRIPT DO YOU WISH TO PLAY
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HOW DO YOU DO . PLEASE TELL ME YOUR PROBLEM
INPUT
Men are all alike.
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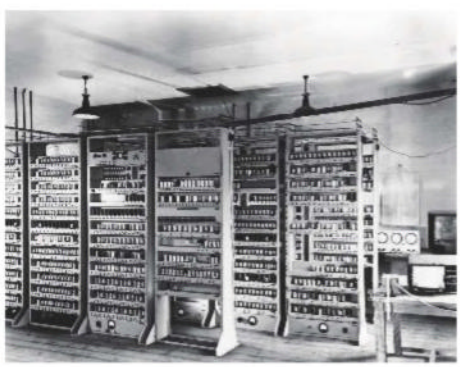
ELIZA/JOSEPH WEIZENBAUM/RUPERT LANE



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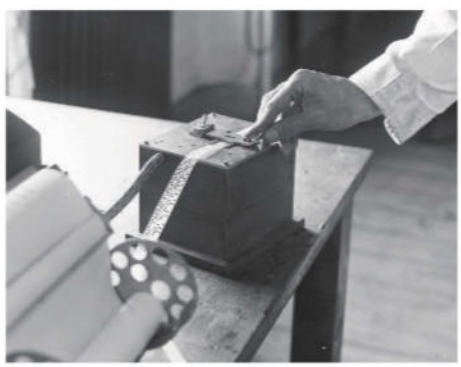


HARRY TODD/GETTY IMAGES

The 1960s ELIZA chatbot (left) was brought back to life when its code was rediscovered

A replica of an early computer called the Electronic Delay Storage Automatic Calculator (below) is under construction at Bletchley Park, UK

that remain in use within modern software, I submitted requests for interviews with technology firms including Apple, Microsoft, HP and Texas Instruments. I had no luck. The "big four" of UK banking – HSBC Holdings, Lloyds Banking Group, NatWest Group and Barclays – also failed to respond. So did Lloyd's of London and PayPal. Visa and Mastercard initially sounded interested, but ultimately said they couldn't help me. What could explain this curious unwillingness to discuss old code?

"They're probably nervous about it," says Vincent Bodsworth, a trustee of the LEO Computers Society, a charity that aims to preserve the history of a defunct brand of computer created in the UK. He speculates that businesses may be reluctant to draw attention to the existence of ancient code in their products, if any, because they might not know how it works or how to maintain it to ensure that it continues to function.

Bodsworth tells me a story he heard earlier in his career about a nameless London bank that was confronted with a problem when the UK switched to a decimal currency in 1971. It had a computer program that carried out various financial calculations using the UK's pre-decimal currency. But someone had lost the source code, so there was no way to modify the software to run its calculations on the new decimal currency. Rather than rewriting the software from scratch at great cost, the bank simply created a bit of code that converted amounts in decimal pounds and pence into pre-decimal pounds, shillings and pence. The converted totals could then be put into the old program to run the financial calculations. Finally, another bit of code converted the results of those calculations from pre-decimal back to decimal values.

"You hear some stories," says Bodsworth, who adds that the clumsy banking patch-up is exactly the sort of code that could fall through the cracks of modernisation and remain in use today.

Call in the cowboys

Even when source code isn't lost, the expertise needed to understand and modify it may be. Take the COBOL programming language, which, in the mid-20th century, was vital for the smooth running of businesses. Bill Hinshaw – who co-founded COBOL Cowboys, a consultancy business based in Texas – has been credited with writing the very first software for a bank ATM back in 1970, which he did using COBOL.

> "Businesses may be reluctant to draw attention to the ancient code in their products"

Today, COBOL is no longer the language of choice for computer programmers. It does, however, retain a small but important role in some software. Hinshaw estimates there are 800 billion lines of COBOL running today. The problem is that few of today's programmers are familiar with the language and of those who are, many will soon be retiring. So when they need some assistance, they call in Hinshaw's crack squad of old code experts. The youngest contractor with the outfit is 40 and most are in their 60s and 70s. Hinshaw himself is 82. "We don't see a problem with [working on] COBOL right now. Ten years from now, we may," he says.

In theory, this shouldn't cause too many headaches, because code doesn't really wear out or break. But when software is updated, bits of old code can inadvertently be rendered incompatible with the rest of the program, like pieces of an intricate jigsaw puzzle that no longer fit. For instance, in July 2024, a glitch in a software update released by cybersecurity firm CrowdStrike took out millions of computers in airports, hospitals and banks around the world. In that particular case, the glitch was rapidly identified and a new update rolled out, so most computers were back online within hours. But if such a glitch involved an old code incompatibility that few programmers know how to handle, it might be much harder to fix.

With concerns like this, technology firms' possible reluctance to discuss old code would make more sense – as does the occasional effort to remove old code from modern software. The most famous example of this process occurred about 25 years ago. At that time, many computer scientists began to worry that existing software – which typically represented years using just two digits – would be unable to distinguish the year 2000 from the year 1900, potentially leading to global computing problems at the turn of the millennium. What followed, says Bodsworth, was a desperate scramble to

Recreating the EDSAC machine
Learn why volunteers are building a replica of this early computer at newscientist.com/video

forcibly remove and replace old code in an ultimately successful bid to avoid what became known as the Y2K bug.

Despite such efforts, however, some old code remains in use in surprisingly important software. For instance, Stuart Mackintosh, president of the Perl Foundation – which oversees development of the programming language for which it is named – says that the latest version of Perl, released in 2024, certainly contains some snippets of code from the first version, which was released in 1987.

Perl may be a largely unfamiliar name, but many of us rely on it every day: it powers Amazon Web Services, which, in turn, is used by sites such as Booking.com and by Apple to run its iCloud software. Important organisations use Perl too, including NASA and the CIA in the US, and MI5 and MI6 in the UK. Whenever we – or members of these organisations – use Amazon Web Services, we are employing code that is almost 40 years old.

The old code paradox

Some modern software uses even older code. Mike McGrath at Red Hat, a software company that distributes a version of the open-source operating system Linux, says that a command called "indent", which is included in many versions of Linux, uses code from 1976. "It's wild to think that we're still building and using language from nearly 50 years ago in the era of AI and cloud computing," he says.

> "NASA reportedly brings in ageing programmers to maintain code written for old missions"

There is a simple reason such old code survives, according to Mackintosh: "It just works." Weighed against the ever-present concern that such code might develop troublesome incompatibilities with newer code is the fact that, over the decades, plenty of old code hasn't done so. This creates something of a paradox: as time goes by, software engineers become increasingly concerned that old code might cause glitches, but, simultaneously, they also become more convinced that it can give reliable and accurate results.

For evidence of this, look no further than the space industry. James Eggleston works on computer systems at the European Space Agency (ESA). Space missions are costly to design, build and launch, he says, so it makes sense to run them using reliable old code, rather than risk using brand-new code that might develop problems. "These things are billion-dollar satellites, so the people who fly them are really not keen on doing anything that's not completely guaranteed to work," he says. "If you mess it up, your spacecraft is fried. End of mission."

As such, some of the oldest code still in use may no longer be on our planet – or even in our solar system. The Voyager probes, now more than 20 billion kilometres from Earth, may well be running almost exactly the same software today as they did when they were launched in 1977. In line with this, an anonymous space industry insider told me that NASA occasionally needs to bring in ageing programmers to maintain or modify esoteric code written for old missions, just as Hinshaw does with insurance and banking companies.

Yet, at the same time, the space industry seems reluctant to discuss its reliance on old code. NASA didn't respond to my request to discuss the subject – and even Eggleston admits that ESA authorities were wary about the idea of him talking to *New Scientist*, in case ESA's use of old code somehow gave the misleading impression that the agency's missions are less worthy of funding.

Putting all the pieces together, businesses and organisations show a curious mix of attitudes towards old code. Some appear to mistrust it, others seem to put their faith in it – and almost all of them appear reluctant to talk about it.

Where does this leave us in the quest to find the oldest code still running today? We can only speculate, but Bodsworth suspects it may be quietly running on an ancient computer, performing the same task year after year. One possibility, he says, is that the computer in question is located in a government office, perhaps performing an important fiscal calculation so reliably and effectively that everyone is content to let it carry on. And although such old code might eventually cause a software glitch, it is anyone's guess as to how long it can function without this happening.

"We're in the very first flash of the earliest stage of the digital revolution," says Mackintosh. "When you look at where things are going to be in 500 years' time, we're going to build on this same infrastructure." In other words, some old code might have a surprisingly bright future. ▮

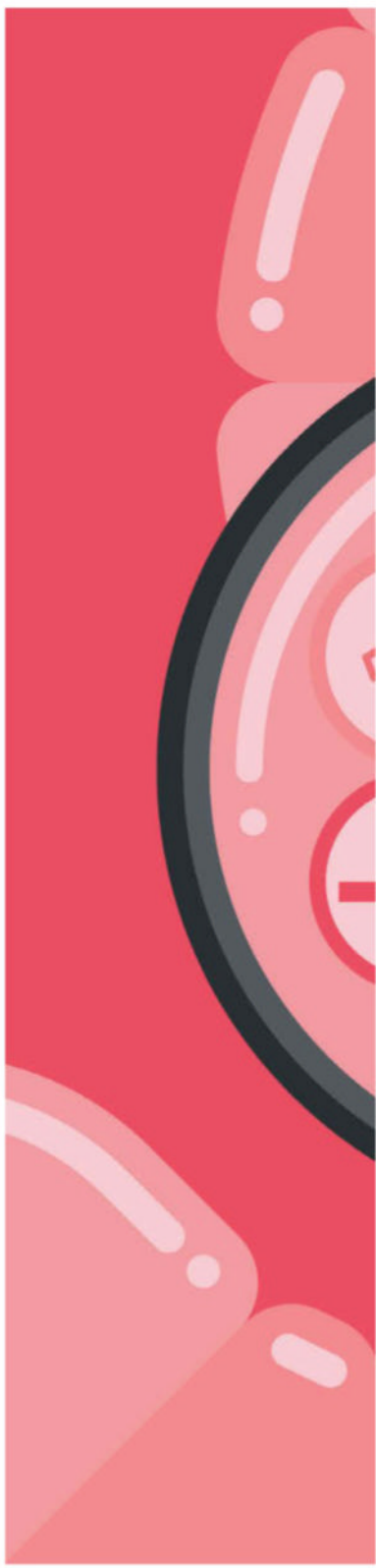
Launched in 1977, the Voyager 2 space probe may operate on old code

NASA/JPL-CALTECH

Matthew Sparkes is a technology reporter at *New Scientist*

Cancer's low blow

As rates of colorectal cancer rise in younger people, could a perfect storm of lifestyle and environmental factors be to blame? **Graham Lawton** investigates



PÂTÉ

SHORTLY after my 54th birthday, I received a package. The enclosed instructions told me that next time I emptied my bowels, I should scrape a bit of the stool into a small sample bottle, seal it in a pre-paid envelope and drop it into the post. I did the deed and, a few weeks later, was invited to hospital. My sample contained blood; a colonoscopy was ordered to rule out colorectal cancer.

I don't, thankfully, have colorectal cancer, and a colonoscopy at 54 is a classic initiation into middle age. But in the coming years, this particular rite of passage might start happening much earlier. While rates of this cancer among people in my age group have been declining thanks to screening programmes like these, the story for the under-50s is far more troubling.

From being virtually unheard of in the 20th century, early-onset colorectal cancer (EOCRC), as it is called in people under 50, now accounts for around 10 per cent of all new cases worldwide. That number is predicted to more than double by 2030, and by then, EOCRC is expected to be the most common form of fatal cancer in Americans aged 20 to 49.

The reason why is uncertain, but an ambitious new project is exploring potential causes – as well as the idea that EOCRC may be a distinct and more aggressive form of the disease. Meanwhile, as routine screening is extended to younger groups – in January, England lowered its screening age to 50 – and new, less-invasive tests get approved, there is hope the worst prognoses can be avoided.

Colorectal cancer is an umbrella term for cancers of the large intestine and rectum. In 2022, the year for which the most recent figures are available, there were around 1.9 million new diagnoses worldwide, making CRC the third most common cancer after those of the lung and female breast. More than 900,000 people died from it that same year, reflecting its lethality – despite advances in treatment, it kills around half of those who get it.

The rise of EOCRC was first noted in 2003, in an analysis of cancer statistics collected between 1973 and 1999 in the US. This revealed that in people aged 60 and over, colon cancer rates were stable and rectal cancer rates falling, in part due to more active screening programmes. "Colorectal cancer screening certainly has been a success story," says Andrew Chan, a

gastrointestinal cancer specialist at Massachusetts General Hospital in Boston.

But the analysis also found that among 20 to 40-year-olds, both types of cancer were rising, with rectal cancer up by 75 per cent. Both were still much less common in younger people overall, the researchers noted, but there was a clear trend. Similar increases were soon discovered in many higher-income countries, including Australia, New Zealand, Canada and the UK, and the rise continues to this day. In the US, colorectal cancer is now the leading cause of cancer deaths among men under 50, and the second-leading among women under 50, up from being the fourth-leading cause of cancer deaths in the late 1990s.

Generation effect

But growing rates of EOCRC are no longer confined to these economies. The most recent analysis combed through data from 50 countries and territories and found that this is a growing problem in 27 of them; the list now includes some middle-income nations such as Belarus, Ecuador and Turkey.

"It's confirmation of what we already knew, that the rates are rising across many countries, more so in higher economically developed countries, but also increasingly in middle-income as well," says cancer diagnostics researcher Sarah Bailey at the University of Exeter, UK, who wasn't an author on the paper. The annual global growth rate of new diagnoses in the under-50s varies from about 1 per cent to 4 per cent, according to the International Agency for Research on Cancer, with the fastest rates of increase among people under 30. The rise is unlikely to be an artefact of better diagnosis, says Bailey. "I think it is a real effect and not just that we're picking up more cases."

The growth is an illustration of what is known as the birth cohort effect, according to Marios Giannakis at Harvard Medical School. Each successive generation has a higher risk of developing the disease than older cohorts had at the same age. In the US, for example, people born in 1990 have roughly double the risk of developing colon cancer and quadruple the risk of developing rectal cancer throughout their lifetime as those born in 1950 (see graph, page 41).

For EOCRC, the birth cohort effect began in people born around 1960, supporting the idea that the rise might be related to changes in environmental exposures, says Giannakis. ›

Additionally, though a significant portion of cases seem to involve a genetic contribution, the majority of recent ones are "sporadic". These aren't related to genetic predisposition, but rather are linked to lifestyle or environmental factors.

Potential triggers

But what factors exactly? From the 1950s, people in the parts of the world that have witnessed this rise experienced major changes in lifestyle that altered their environmental exposures, points out Manon Spaander, a gastrointestinal oncology researcher at Erasmus University Medical Center in Rotterdam, the Netherlands. People began consuming more highly processed, low-fibre foods, red meats and alcohol, while also sitting more and moving less. Alongside this came an increase in obesity and conditions such as type 2 diabetes.

At the same time, the use of antibiotics soared. Antibiotics can have a profound impact on the gut microbiome, and there is good evidence that disturbances to the microbiome are a risk factor for CRC at any age. So are inflammatory bowel diseases such as ulcerative colitis and Crohn's disease, which have also risen dramatically in young people, probably as a result of similar environmental changes.

All of these and more have been suggested as potential causes of the EOCRC surge. But despite years of research, "it's not fully understood why rates are rising so rapidly in this age group", says Bailey. The strongest evidence is that obesity, type 2 diabetes and high consumption of sugary drinks are risk factors, according to a recent review led by Natalie Cook at the University of Manchester, UK. But research on other potential triggers has produced conflicting results. For example, some findings show a link between heavy consumption of processed meat and EOCRC, but others don't; similar research on red meat, alcohol, smoking, lack of physical activity, antibiotics and low intake of fruit, vegetables and fibre has also proven inconclusive.

Last year, the Cancer Grand Challenges initiative set up a five-year research project into EOCRC called PROSPECT, with the aim of finally nailing down the risk factors, understanding the mechanisms by which they cause the disease and eventually coming up with new treatments and dietary interventions.

JEFFREY ISAAC GREENBERG 9+/ALAMY

Some places have cut the age for colorectal cancer checks

The project will initially try to drill down into the precise role of the usual suspects such as alcohol, processed foods and obesity. With alcohol, for example, it may be that certain patterns of drinking are riskier than others. "There may be differential associations between drinking with a meal versus binge drinking," says Chan, who is co-leader of the project. "We'd like to really focus on the nuance of these exposures because, ultimately, it may be more complex than just simply, 'I've been exposed'. It's 'how was I exposed and in what context?'"

The project will also go in search of previously unknown causal agents.

Possible signs of colorectal cancer

CONSULT YOUR DOCTOR ABOUT:

- **Diarrhoea or constipation that doesn't go away**
- **Changes in stool appearance, such as size or shape**
- **Rectal bleeding or blood in stool**
- **Abdominal pain or frequent cramping in the lower stomach**
- **Discomfort when sitting or during a bowel movement**
- **Sudden unexplained weight loss**
- **Anaemia**
- **Excessive fatigue**

"We're motivated to identify new risk factors, particularly new risk factors that may have a specific effect on younger individuals. We don't want to overlook factors because they haven't been previously considered," says Chan. Some of those include microplastics and certain ingredients of ultra-processed foods, such as emulsifiers and preservatives.

Another critical research question concerns the possibility that EOCRC may not be the same as late-onset colorectal cancer (LOCRC), but a distinct disease that would require a different treatment strategy. This idea was first floated in 2017, when a team led by Manish Shah at Weill Cornell Medicine in New York compared the characteristics of hundreds of thousands of CRC cases from the under and over-50s. Shah's team used genetic analysis to determine that the two cancers are "clinically, pathologically, and molecularly" distinct.

Since then, more work has uncovered other differences. The vast majority of LOCRCs are a type of cancer called an adenocarcinoma, which starts in mucus-producing cells, with just a handful being another type, neuroendocrine tumours, which start in cells in the endocrine and nervous systems and can impact hormone production. But when a team led by Kaveh Hajifathalian at Rutgers New Jersey Medical School looked at all the EOCRC cases recorded in the US from 2011 to 2020, it found that the rate of increase of neuroendocrine tumours

"There's still a perception that young people are too young to get colorectal cancer"

was greater than that of adenocarcinoma among the EOCRC cases. At the moment, this remains an empirical observation, but it adds to the evidence that EOCRC is often distinct from LOCRC.

EOCRC also tends to be diagnosed at a more advanced stage, often after having already spread to other organs. This could be owing to several factors: a lack of screening might delay diagnosis until the cancer is more advanced, when symptoms typically appear, while symptomatic people under the age of 50 typically experience a longer time to diagnosis than those over 50, often because of mistaken initial diagnoses. But studies have also suggested that EOCRC is simply more aggressive.

Another difference is that while LOCRC tends to be found on the right side of the bowel, EOCRC clusters on the left side. Left and right-sided colorectal tumours are derived from different types of tissue; around 70 per cent of early-onset cases are left-sided and these patients have a worse prognosis. The current thinking, says Bailey, is that left-sided tumours are caused by environmental carcinogens that act relatively quickly, hence their preponderance in younger adults. But, says Chan, "that work is still very much under way, and it needs to be an area of focus".

While we wait for definitive answers, what can be done to stem the rising tide? Earlier screening would help, says Bailey. But simply offering screening to younger cohorts is no cure-all. In 2018, the American Cancer Society recommended that the age to start routine screening should be dropped from 50 to 45 in order to reach the people most at risk of EOCRC; the US Preventative Services Task Force followed suit in 2021. However, uptake has been low. In 2021, the most recent year for which figures are available, fewer than 20 per cent of eligible adults aged 45 to 49 were up to date on their screening.

Got the ick

That is somewhat unsurprising. Standard screening methods carry a considerable ick factor, not to mention discomfort, that can put people off getting tested. Screening also carries risks, says Bailey. Most positive faecal tests, which measure the amount of haemoglobin, a protein in red blood cells, in the stool, are false alarms – but that can only be confirmed via a colonoscopy. This can be either a full colonoscopy or a partial version, known as a sigmoidoscopy, that examines only the lowest part of the bowel, or a computed tomography colonography, in which the colon is inflated so a scanner can look for signs of cancer.

Colonoscopies – believe me – aren't enjoyable, but they can also cause bleeding and come with a risk, though low, of a perforated bowel. There is also the psychological stress of being told you may have cancer. Because of these factors and others – including hospitals' finite capacity for performing colonoscopies – deciding on an ideal age to start screening is difficult, says Bailey.

New blood tests may solve some of these problems. The first, ColoHealth, which looks for DNA markers of CRC in the blood, was approved by the US Food and Drug Administration in 2016, and another, Shield, followed last year. More are in development. A small clinical trial found that offering the blood test to adults who were overdue for a CRC check increased the overall uptake of screening.

Neither of the approved tests, however, are as accurate as traditional methods in detecting EOCRC; moreover, people who test positive will still need a colonoscopy. Colonoscopy screening also has the added advantage of being a preventative measure, according to Uri Ladabaum at Stanford University in California. While examining the colon, doctors can remove suspicious-looking growths before they can progress to cancer. Indeed, the new blood tests may paradoxically increase deaths from CRC, according to a recent analysis by Ladabaum, if they drive people away from the traditional methods of detection.

In the meantime, other forms of prevention must also play a role. "With the main theory being that it's linked to lifestyle choices and diet, that's something that we can do something about," says Bailey. Beyond the standard but useful prescription of eating less processed food, ditching sugary drinks and getting more exercise, other things have been found to be protective against CRC, including high consumption of vitamin D, long-term use of aspirin and consuming both soluble and insoluble fibre.

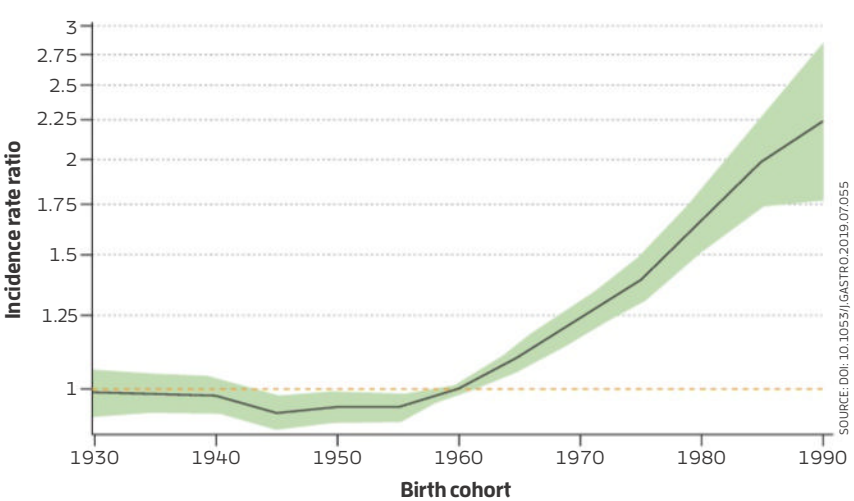
But perhaps most importantly, individuals, as well as doctors and medical professionals, must be made more aware of the risk of EOCRC, says Bailey. "There's still a perception that young people are too young for colorectal cancer," she says. As the millions of people under 50 facing a recent diagnosis will tell you, they are not. ▮

Consult a doctor before making any changes to your medication

Graham Lawton is a staff writer at *New Scientist*

Colorectal cancer risk on the rise

Research shows that, from the 1960s onwards, each successive generation has seen a higher chance of developing this form of cancer than the one before it.



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Twisteddoodles for *New Scientist*
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Stargazing at home

Guiding light

How do you tell a planet from a star – or one planet from another? **Leah Crane** shares great field tips to get you most of the way

Leah Crane is a features editor at *New Scientist* based in Chicago

RIGHT now, a lot of planets are visible in the night sky. A great alignment, which occurs when all the solar system's planets are visible at once, has just ended, but you can still spot most of them except for Mercury and Venus, which have already dipped below the horizon.

So naturally, for the past month, my phone has been dinging with friends' pictures of the sky, accompanied by, "Hey, what planet is this?" or, "This is Mars, right?" As the designated Space Friend, I am expected to know these things, but I'll be honest – I just pull up a sky map for the night and check my answers that way.

But since a sky map (or a Space Friend) isn't always available, here are some ways to figure out if you are, in fact, looking at a planet – and which one it might be. The first rule of thumb you may know is that stars twinkle and planets don't. This is because stars are so much more distant that their light comes to us as a tiny, thin beam, which gets tossed about by our atmosphere, causing it to appear to twinkle. The beam from planets, however, is much broader because they are relatively nearby. This means that when the atmosphere makes light wiggle within this wide beam, we can't really see it, so planets appear to shine steadily.

It's not always easy to tell if a point of light is twinkling or not, so another clue is the object's location. While you won't be able to see the planets moving, just as you can't tell that the sun is moving every day (imagine how terrifying it would be if you could), they do follow a predictable path.

DREW BUCKLEY/ALAMY

That path, called the ecliptic, is the same one the sun follows. It runs roughly east to west through the sky, and the planets are always near it even if they aren't perfectly aligned. So if you see a bright star away from the ecliptic, that's all it is – a bright star.

The last clue is colour. If you look closely, Mars really does appear red in the sky. This is why so many ancient cultures called it red despite its surface looking more orange, and why we call it the Red Planet. Mercury and Saturn (upper-right dot of light, above) both have a yellow tinge, for the eagle-eyed.

Once you are pretty sure it's a planet, you can try to figure out which one. Mercury is always fairly close to the sun, so you will only be able to see it right after sunset or just before sunrise. Venus is a little farther away, but always in the sun's vicinity, so if you see a very bright point of light near the horizon at those times, that is likely to be Venus. If you see one point of light that is far brighter than the surrounding stars, it is probably Jupiter. Saturn and Mars are a bit harder to tell apart from the others, but their colours can help. Uranus and Neptune are too far to be viewed with the naked eye.

If all else fails, there are many good sky map options in apps and online. Or you can send a message to your Space Friend – and if you haven't got one, I will volunteer. ▮

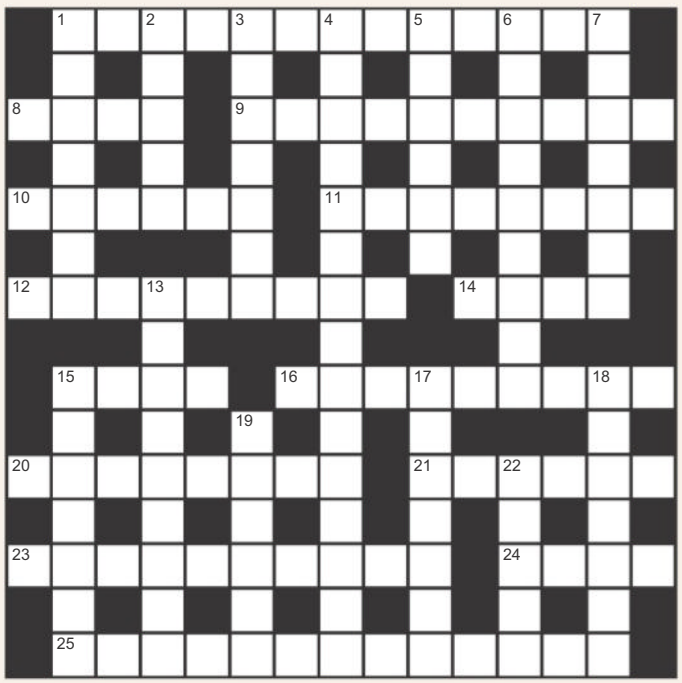
Share your stargazing successes with us on X and Instagram @newscientist using the hashtag #NewScientistStargazing

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

Next week

Mathematics of life

Quick crossword #178 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

1 Drought (5, 8)
8 *The* ___, sci-fi horror film of 1958 (4)
9 Expert in infectious diseases (10)
10 Colour in the visual spectrum (6)
11 Failure of embryonic development (8)
12 Items or organisms alike in form (9)
14 Amphibian (4)
15 Phineas ___, famous brain injury case study (4)
16 Australian woodland bird (9)
20 Vitamin B1 deficiency (8)
21 Moon of Saturn (6)
23 Inability to swallow (10)
24 Scarce (4)
25 1×10^{-6}? (3, 2, 1, 7)

DOWN

1 Maurice ___, Nobel prizewinning biophysicist (7)
2 Concerning the oviduct (5)
3 Rosie the ___, industrial icon of the second world war (7)
4 Capacity to produce both male and female gametes (15)
5 Brightly coloured insect-eating bird (6)
6 Length of metal bent to 90 degrees (5, 4)
7 Vertical line on a map (7)
13 Size; vastness (9)
15 Hypothetical nanotechnology outcome (4, 3)
17 Form of vitamin A (7)
18 Hard beetle forewing (7)
19 Middlemost (6)
22 Foot bones (5)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #292
set by Corryn Wetzel

1 Which branch of physics deals with the behaviour of materials at very low temperatures?

2 What tissue in plants is responsible for transporting water?

3 What substance is physician Alexander Fleming most famous for discovering?

4 Which blood type do domesticated cats most commonly have: A, B or AB?

5 What does the word "laser" stand for?

Answers on page 47

BrainTwister
set by Katie Steckles
#63 A 2025 puzzle

The number 2025 can be split into two two-digit numbers: 20 and 25. If we add these together (20 + 25 = 45) and square the result, we get $45^2 = 2025$.

By changing one digit of the number 2025, can you find another number that shares this property?

There is only one other four-digit number that returns itself when split in half, summed and squared. It ends in a 1. What might the last digit of its square root be?

All four of this number's digits are different. What is it?

Solution next week

Flat out

When a bubble, or spirit, level is level, what does that mean relative to Earth?

Pat French
Longdon-upon-Tern, Shropshire, UK
There is a well-known story of a gentleman who held that Earth was flat. He took a spirit level on a long-haul flight and afterwards announced that, other than during take-off and landing, the aircraft had flown level over the flat Earth.

When the bubble in a spirit level lies centrally in the fluid, it means that the gravitational pull on that fluid is uniform across the container and either side of the bubble. At this point, the position of least resistance for the bubble in the fluid lies at the centre of the tube. This effect is often facilitated and stabilised by a barely visible bend in the cylinder.

Gravity works towards Earth's centre. A line that extends from any point on the planet's surface to its centre of gravity (at the core) is what we refer to as "vertical".

When level, provided that the tube containing the fluid plus bubble is mounted accurately in the spirit level, then the instrument base will be at 90 degrees to a vertical line of gravitational pull regardless of latitude – be it the polar circles, tropics or equator. The local topography – the humps and bumps on Earth's surface – make no practical difference. We call this orientation "horizontal".

"An accurately calibrated spirit level essentially tells you the direction in which gravity is acting at that point"

Mel Earp
Macclesfield, Cheshire, UK
An accurately calibrated spirit level essentially tells you the direction of gravity at that point. To test a surface, you need to take two measurements at right angles. For example, one in a north-south direction and one east-west. Because Earth isn't an exact sphere – it bulges out slightly at the equator because of its rotation – the flat surface that you have just measured isn't exactly tangential to Earth's curvature at that point, unless you are at the equator or one of the poles.

The World Geodetic System of 1984 (WGS84) defines a standard Earth coordinate system and Earth shape in the form of an ellipsoid. It also defines a gravitational model. Your spirit level will experience a gravitational field very similar to this, but not identical. There will be deviations due to local topography, such as hills and valleys, and also variations in the density of Earth deep beneath your feet. These will cause local deviations in the gravitational direction with respect to the WGS84 model. But they are tiny – of the order of one-hundredth of a degree – even in extreme circumstances such as in the Himalayas. This is far less than any error there might be in the manufacture of the spirit level, and indeed one's ability to read it, and can pretty much be ignored. So you can be sure that the objects you place on your newly fitted shelf will be grateful for gravity not acting sideways.

Hillary Shaw
Newport, Shropshire, UK
Earth's centre of gravity is also its geometric centre, and so both ends of the spirit level are the same distance from that centre when the device is level. It follows that the bubble in the middle is very slightly nearer. Assuming a 50-centimetre-long level that is totally rigid (and very precise), the bubble will be around 0.004 micrometres nearer Earth's centre. That is about the same as a stack of 10 plutonium atoms.

DIMITRIOTIS/GETTY IMAGES

Why is tea more likely than coffee to mark your cup?

This week's new questions

Mug mystery **Why is tea more likely than coffee to leave a stain in the cup?** ***Wolf Kirchmeir****, Blind River, Ontario, Canada*

Two can entangle **Quantum physicists talk a lot about entanglement. How exactly does one entangle two photons? And can I try it at home?** ***John Healey****, Adelaide, South Australia*

Dramatic flare

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

Mike Follows
Sutton Coldfield, West Midlands, UK
The sun emits solar wind and occasional solar flares, followed by coronal mass ejections (CMEs), which release clouds of up to a billion tonnes of charged particles into space. While most CMEs miss Earth, those coming our way typically take one to five days to reach us. Our magnetosphere deflects most of the particles, and the atmosphere protects us from ionising radiation, but CMEs can cause geomagnetic storms.

Because the CME is a moving cloud of charged particles, it has an associated magnetic field that interacts with Earth's field, causing it to vibrate. The changing field induces voltages, which drive geomagnetically induced currents along paths of least resistance on Earth's surface, including power grids. A notable example is the 9 March 1989 Hydro-Québec power grid failure, which left over 6 million people without power for 9 hours.

The Carrington event of 1859, a significant geomagnetic storm, was caused by a CME that took 17.6 hours to reach Earth. Today, given a similar warning time ahead of an approaching CME, passenger jets could avoid the poles, where charged particles are most intense, or fly at lower

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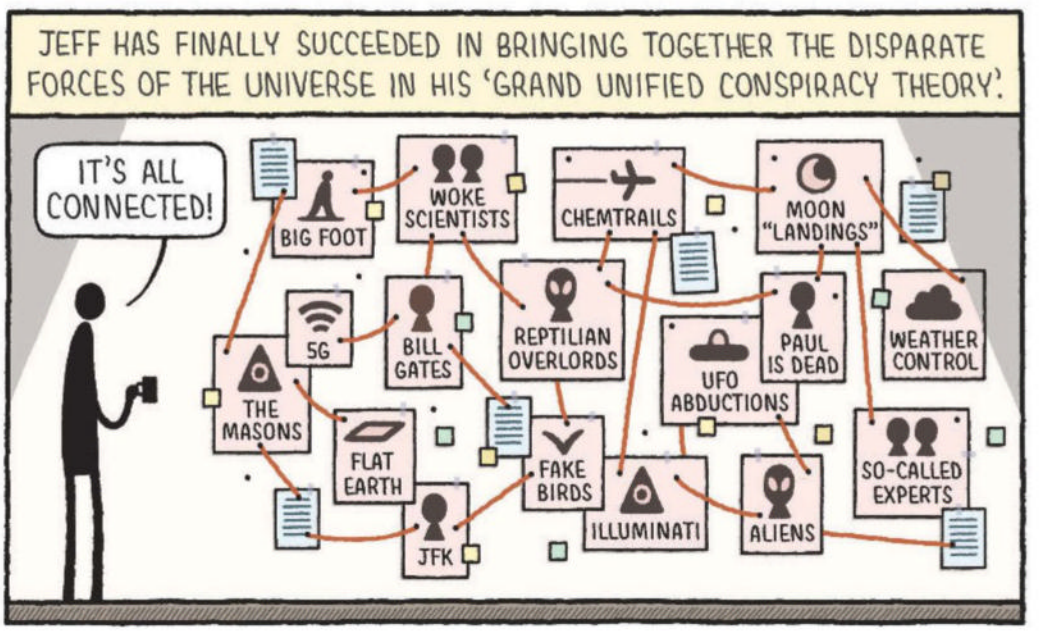
Tom Gauld
for New Scientist



altitudes to reduce radiation exposure. Aircraft could also be grounded if necessary. These measures would be to protect the passengers and crew.

That said, while electrical grids are vulnerable to geomagnetic storms, aircraft are less affected. Their smaller size means that smaller voltages are induced. Modern avionics are tested and protected against electromagnetic interference. Redundancy is built into these systems and, if necessary, a mechanical fail-safe could be deployed.

However, solar activity can affect aircraft navigation, so flights relying on GPS may be compromised by unreliable vertical guidance. High-frequency radio communication can also be disrupted by upper-atmospheric disturbances from solar storms.

Researchers warn of rarer, more powerful "superflares", or Miyake events, which could release energy up to 1000 times greater than the Carrington event. These could disrupt GPS by damaging or displacing satellites,

"While electrical grids are vulnerable to geomagnetic storms, aircraft are less affected, as they are smaller"

and they would probably cause widespread power grid failures, bring down the internet and potentially pose an existential threat to humanity.

Steel banned

Would it be possible to have an advanced technological society without abundant iron? (continued)

Alex McDowell
London, UK
In many cases, non-ferrous metals can replace steel. We already use alloys of aluminium and titanium to save weight. Aluminium was discovered in the 19th century and was expensive because it requires electrolysis of the molten oxide to smelt.

It would be feasible to build steam engines out of bronze or brass – Thomas Savery's first steam engine was built of brass, bronze and copper. Early cannons were also made from brass.

If iron were rare, then so too would be lodestones (magnetic rocks made from the iron mineral magnetite). This could have delayed the discovery of magnetism, which is key for many technologies, such as electricity generators.

Magnetic compasses are another example, as these were originally made using lodestone. However, objects made of cobalt or nickel can also be permanently magnetised, and perhaps this could be caused by nearby lightning strikes, in the same way as is thought to happen for lodestones. Even if it weren't possible to make permanent magnets in this way, dynamos and electric motors can be made with electromagnets instead.

Perhaps a shortage of iron would have driven other technologies, such as the use of ceramics and ceramic coatings in internal combustion engines.

Answers

Quick quiz #292 *Answers*

1 Cryogenics

2 Xylem

3 Penicillin

4 Type A blood

5 Light amplification by stimulated emission of radiation

Cryptic crossword #156 *Answers*

ACROSS 1 Pontiac, **5** Orion, **8** Hawthorne, **9** CPU, **10** Whirl, **12** Otalgia, **13** Contradiction, **15** Piccolo, **17** Aloof, **19** Eco, **20** Flip chart, **22** Yodel, **23** Emerald

DOWN 1 Pshaw, **2** New, **3** Inhaler, **4** Carbon dioxide, **5** Omega, **6** Incognito, **7** Neumann, **11** Ionic bond, **13** Coppery, **14** Chancre, **16** Offal, **18** Fetid, **21** Aga

#62 Particular patterns in piles *Solution*

There are three ways to arrange five balls, five ways to arrange six balls and 22 ways to arrange nine balls. (This might start off looking like the Fibonacci sequence, but it fails after eight balls!)

A sensitive topic

Feedback reads a lot of academic articles, and we are often distressed by their titles, which can be not so much meandering and unclear as digressive and circumlocutory. The only things worse are the ones that preface the academese with an allegedly humorous pop culture reference.

However, sometimes we run across research whose title is brisk and to the point. We are fond of the 2000 structural biology paper "The ribosome is a ribozyme", which is an absolute model of efficiency (assuming you know what the two nouns mean). And then there is a February paper on bioRxiv brought to our attention by *New Scientist* contributor Chris Simms, titled "The coarse mental map of the breast is anchored on the nipple".

That may, perhaps, need a bit of context. Some parts of the human body are more sensitive to touch than others. The face – especially the lips – and the tips of our fingers are highly sensitive, while our backs are much less so.

This is one of those classic experiments you can do at home. Get a chopstick or some other blunt tool and gently poke a willing partner. You will find that they can tell if you move the location of successive pokes, even by mere millimetres, if you poke them on the lips or fingertips. But if you poke them on the back, they will be terrible at determining whether you moved it. This is because your back has fewer touch-sensitive nerves there.

The authors of this new preprint spotted a gap in the literature. "While tactile acuity has been extensively studied on the limbs and face, acuity on the torso has received far less experimental attention... with the breast being largely ignored," they write.

Let's not drag out the suspense. It turns out breasts have very low tactile acuity, even worse than backs. Apparently, "touches needed to be between 3 and 4 times as far apart on the breast than on the hand to yield equivalent location discrimination performance".

Feedback isn't sure if this is quite what Caroline Criado Perez had in mind when she wrote *Invisible Women*, documenting the myriad ways women have been excluded from scientific research. But, as a piece of basic information, it seems like it might have its uses.

Feedback's main takeaway is that we would like to have been a fly on the wall for the recruitment process. "You want to do what to my what with what?"

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

An even longer word

Back in early November 2024, Feedback was running a bit short of material due to a brief hiatus (long since over) in global idiocy, so we padded the column with a torrent of increasingly long words – or, as we said at the time, we engaged in sesquipedalianism.

Except it turns out we did it wrong. Francis Wenban-Smith wrote in to point out our mistake: "you were 2 letters short in your attempt to pad out your column with 'floccinaucinihipilification'. The correct word is: 'floccinaucinihilipilification'."

If you can't see the difference between those two blizzards of letters – and we wouldn't blame you, because we evidently couldn't – the second has an extra "li" just before the "pili". Feedback would like to assure readers we have been given a stern talking-to.

In the process of confirming that we had indeed misspelled floccinaucinihilipilification, Feedback entered the two versions into a popular search engine. The correct version brought up a dictionary entry as the highlighted response. The incorrect version brought up our article (how embarrassing), above which was an AI summary of the fake word. Here are the opening lines:

"Floccinaucinihipilification is a long word that means to regard something as worthless or trivial. It was the longest word in the Oxford English Dictionary until 1982. Floccinaucinihipilification is a 29-letter word with 12 syllables. It contains nine i's but no e's."

Readers who can count to 29, unlike the AI, will notice that all those claims about the number of letters and syllables are wrong, bar the one about the letter e. Feedback is proud to have contributed, in our own small way, to the ongoing pollution of the information ecosystem.

Unsafe dating

Like so much else in life, dating is becoming micro-targeted. You can still use huge apps like Tinder, but there is also a growing proliferation of ever-more-niche dating sites.

Perhaps the nichest of all is Unjected, aimed at those not vaccinated against covid-19. Or, to be more precise: "While we do not support vaccination of any kind, Unjected is specifically tailored for Covid-19 unvaccinated or any mRNA based injection."

As technology analyst Benedict Evans put it on Threads: "Someone built a whole company around the Darwin Awards".

Feedback has a lot of questions about Unjected, the most pressing of which is: how does the company decide who can join? Perhaps this is so basic it doesn't need saying, but you can't prove a negative.

Scouring the site's FAQs, we found the answer: "Since the beginning, Unjected has believed the healthiest realtionships [sic] have a foundation of trust, and we have operated on an honor system. However, for our members who want the most safety and security in choosing their future partner, we recommend our 'Unjected Verified' upgrade. Unjected verified members attest to their unvaccination by affidavit." Love, like SARS-CoV-2, is in the air.

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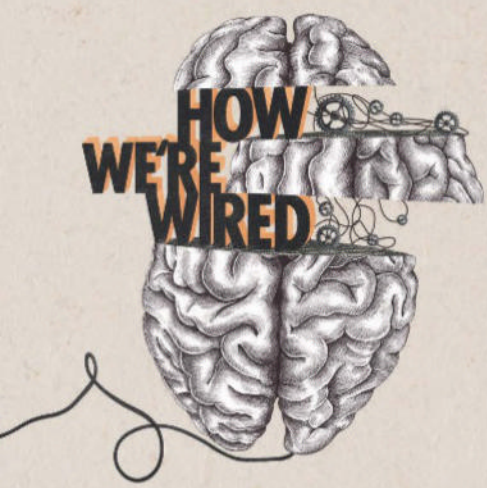

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