

New Scientist

WEEKLY January 28 - February 3, 2023

FRESH INSIGHTS
INTO POLYCYSTIC
OVARY SYNDROME

FERTILIZER FROM
HUMAN WASTE

WHY ANTIDEPRESSANTS
DAMPEN EMOTIONS

CHASING UNDERWATER
AVALANCHES

RETURN TO THE MIRROR UNIVERSE

The new case for a parallel universe going backward in time

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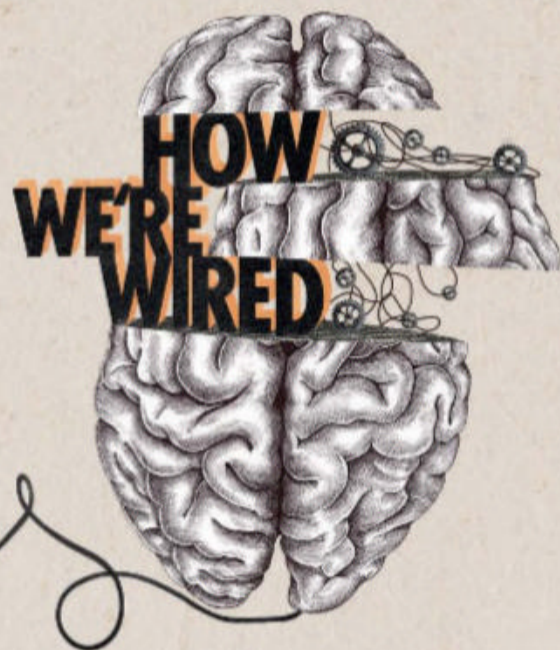
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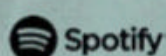
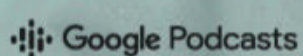
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Search for 'How We're Wired' and subscribe wherever you get your podcasts.



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Darwin's Galapagos: Ecuador

Follow in the footsteps of Charles Darwin on a tour of the central and southern Galapagos Islands. Travelling by luxury yacht and accompanied by marine conservationist Jo Ruxton, you will have ample opportunity for wildlife spotting while also learning about initiatives to preserve the islands' biodiversity. The 10-day tour begins on 11 July and costs £6999.

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Virtual event

Secrets of the Large Hadron Collider

Join particle physicist Clara Nellist, part of the ATLAS experiment at the LHC, for a deep dive into the past, present and future of the largest particle collider ever built. Find out how the LHC expands our knowledge of the universe and learn what it is like to work on one of the world's greatest physics experiments. Catch it on 7 February at 6pm GMT/ 1pm EST. Tickets cost £14.

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Podcast

Weekly

Is ultrasound the secret to reversing ageing? The team examines the evidence. Podcast editor Rowan Hooper also chats to Assaad Razzouk, author of *Saving the Planet Without the Bullshit: What they don't tell you about the climate crisis*, for his take on what we should really do to help fix the planet. Plus, a worm-eating fungus.

[newscientist.com/nspod](https://www.newscientist.com/nspod)



Island giant Discover the unique wildlife of the Galapagos Islands



City lights The night sky is becoming brighter by the year

Video

DNA from drones

On our YouTube channel this week, there is video footage of a drone that can land on thin tree branches to collect samples of environmental DNA. In recent years, this eDNA – which is DNA expelled naturally by species – has been recognised as a powerful tool for monitoring the biodiversity of terrestrial ecosystems, particularly in harder-to-reach places.

[youtube.com/newscientist](https://www.youtube.com/newscientist)

Newsletter

Launchpad

Light pollution hides the stars in the night sky, disrupts the lives of nocturnal animals and leads to health problems for humans – and the problem is getting worse, says space reporter Leah Crane. A new study using data from citizen scientists suggests the sky is brightening by almost 10 per cent each year.

[newscientist.com/launchpad](https://www.newscientist.com/launchpad)

Podcast

“Those dastardly mushrooms! They are microdosing worms with nerve gas”



Essential guide

The past century saw a revolution in our understanding of the building blocks of reality and led to the “standard model” of particle physics. Learn about the model's history and successes, and why it is far from a final answer, in this *New Scientist Essential Guide*. Available to purchase now.

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Hormonal hope

With the tools now at hand, there is no reason to neglect hormonal conditions

WHAT do endometriosis, premenstrual syndrome, perimenopause and polycystic ovary syndrome (PCOS) have in common? They are all hormonal conditions that affect millions, but are poorly understood and managed due to a chronic lack of research funding.

At first glance, the characteristic they share is that they are problems that affect the female body. But not all female-dominated health conditions are neglected: breast cancer gets more funding than prostate cancer in the UK and US, for instance.

Hormonal conditions are often overlooked because their symptoms are dismissed as minor – a bit of acne, cramping or hot flushes – whereas the deadliness of cancer scares us into action.

However, as we explore in our feature on page 42, these symptoms can have profound effects on quality of life: the unpredictable periods, weight gain and excess body hair that PCOS can bring, or the excruciating pain of endometriosis.

“No more excuses. We should be well on our way to finding effective treatments”

It is becoming apparent there are serious, long-term consequences too. PCOS increases the risk of developing heart disease, type 2 diabetes, and endometrial and pancreatic cancer. Hormonal changes in perimenopause can raise the risk of osteoporosis, heart disease and possibly even Alzheimer’s disease.

Hormonal conditions are notoriously complex, acting on different cells in the body in many different ways, and are difficult to provide control groups for in studies. This may also explain why it has taken so long to get to grips with them. But delving into these conditions offers vast rewards. Recent advances have allowed researchers to reverse PCOS-like symptoms and ease endometriosis symptoms in mice, and a US start-up called Gameto claims to be in the early stages of developing technology to possibly prevent menopause altogether.

So, no more excuses. With the tools available today, we should be well on our way to finding effective methods of treating these conditions and radically improving the lives of millions of people. ■

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Trips of a lifetime in 2023



13 May 2023 | 8 days

Marine ecosystems of the Azores: Portugal

Nestled in the richly biodiverse water of the Atlantic, the Azores archipelago is a hidden paradise. This is a rare opportunity to experience the islands, and their lush vegetation, volcanic craters, lagoons and picturesque towns.

Accompanied by a team of marine experts including marine biologist Russell Arnott, you will spend time both at sea and on land surrounded by a host of different species including blue whales – the world's largest mammals – and sperm whales, which boasts the world's largest brain. You may also see species such as baleen, pilot, and fin whales, and bottlenose, risso, spotted and striped dolphins.

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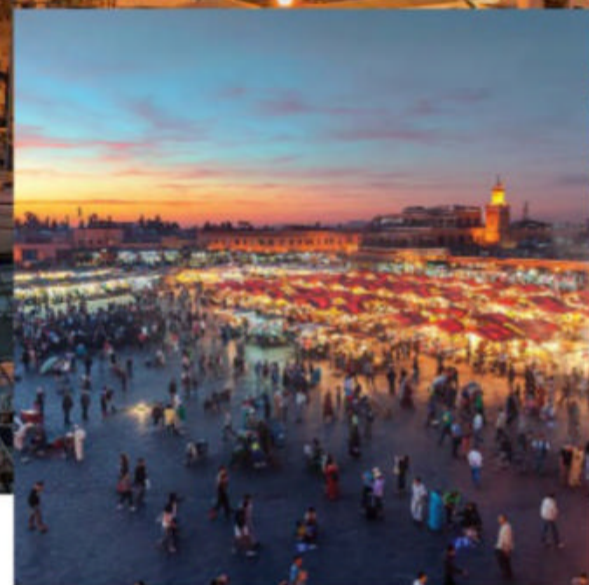
16 October 2023 | 5 days

Iron age archaeology in Talayotic Menorca: Spain

The Talayotic period is the name used to describe a society that existed in the Balearic Islands during the Iron Age. On this tour you will visit a host of Talayotic archaeological sites on Menorca, the most beautiful Balearic Island, with local archaeologist Elena Sintes Olives, who has worked on many of the sites.

Menorca boasts some of the best archaeology in Europe with some 1,574 sites throughout the island. This wonderful tour takes you to some of the best, as well as more recent sites that reflect periods of more recent occupation. A delightful climate, the charming village of Es Castell and the historic town of Ciutadella will add to the experience.

In partnership with Travel Editions



24 May 2023 | 6 days

Morocco and the science of how to get more from your time

Experience an immersive adventure in Marrakech and the Atlas Mountains that is created using the latest discoveries in the art and science of experience design.

Immerse yourself in a world where Arab and Berber culture intertwines with African and European influence. As smoke rises from more than a hundred stalls, and crowds form around storytellers in Marrakech's Jemaa el Fna, hear the call of the muezzin. Inhale the crisp air on top of the Atlas Mountains as the sun rises.

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Historic drought

California still facing water crisis despite heavy rain **p9**

Growth spurt

Milk may have helped ancient Europeans get bigger **p11**

Alien worlds

“Habitable zone” planets may not be good for life **p13**

Self destruct

Hackers make computers fry their own chips **p17**

Dementia risk

Effect of lifestyle changes is probably overstated **p19**



MARIA VALDES

Space

A rare find

A large meteorite recovered from Antarctica demonstrates why it is the perfect place to go hunting for space rocks, reports **Alex Wilkins**

RESEARCHERS in Antarctica have found a meteorite weighing in at 7.6 kilograms, making it one of the largest ever seen on the continent.

Antarctica is one of the best places to find meteorites: its dry, cold weather preserves them, while a uniform white background makes them easy to spot and active glaciers churn up any ancient ones buried beneath the ice. In the past hundred years, more than 45,000 have been found there, most of which have been micrometeorites, which range

from tens to hundreds of grams.

Maria Schönbachler at ETH Zurich in Switzerland and her colleagues discovered five new meteorites during an expedition near the Princess Elisabeth Antarctica research station last month. The team combed through satellite imagery using a machine learning model and identified five icy regions that were relatively free of snow, which might have otherwise covered up meteorites. They explored all five regions systematically by snowmobile,

but only one contained any meteorites. “To find such a big one – this is kind of luck to be honest,” says Schönbachler.

While the meteorite has yet to be analysed, it appears to be an ordinary chondrite, says Schönbachler, which is the most common type. These objects contain the oldest material in the solar system and probably originated from the asteroid belt between Mars and Jupiter.

The team will now send the meteorite to Belgium, in a cool

This meteorite may be from the asteroid belt

box to prevent thawing that could damage its delicate chemical structure, for further analysis.

“We don’t tend to find too many meteorites in Antarctica that are as big as this,” says Ashley King at the Natural History Museum in London. “The more meteorite we have, the more sample that we have available for us to study and learn about the early solar system.” ■

Earth's core is spinning slower

Measurements of earthquakes suggest that Earth's core has started spinning more slowly and may be about to switch the direction in which it spins, reports **Leah Crane**

THE solid inner core of our planet may be slowing its rotation and getting ready to switch spin directions relative to the rest of the planet. This seems to be part of a cycle lasting about 60 years in which the core periodically speeds up and slows back down again.

Beneath Earth's mantle is a churning layer of mostly molten iron and nickel, with a dense inner core of iron kept solid by the intense pressure at the centre of the planet. The movement of the inner core relative to the mantle and surface has been under debate for decades, and measurements of earthquakes are now helping researchers to understand it better.

Yi Yang and Xiaodong Song at Peking University in China and their colleagues analysed the seismic waves from near-identical earthquakes that passed through the planet's core over the past 60 years or so. If Earth's solid core were perfectly spherical and had the same structure all the way through, we would expect each set of waves to look exactly the same regardless of when they passed through. It isn't, though, so we can use the differences between the waves to measure the changes deep below the ground.

The researchers found that before about 2009, the planet's core seemed to be rotating slightly faster than the mantle and the surface – meaning that if you could stand on the surface and look down to the core, you would see it slowly spinning forwards. But around 2009, this rotation began to slow down. If you could look down to the core now, the new measurements indicate that you wouldn't see it spinning at all because it is rotating at approximately the same rate as the surface.



LOWER: ROSTO/SHUTTERSTOCK; UPPER: VADIM SADOVSKI/SHUTTERSTOCK

Earth's core consists mostly of nickel and iron. The inner core may spin according to a 60-year cycle



"The movement of the inner core relative to the mantle and surface has been under debate for decades"

"That means it's not a steady rotation as was originally reported some 20 years ago, but it's actually more complicated," says Bruce Buffett at the University of California, Berkeley.

According to Yang and Song's measurements, the last turning point in the inner core's rotation was in the early 1970s, so the spin rate appears to be oscillating regularly.

"We have several different ideas about how the inner core is moving, and this idea of steady motion followed by slowing down at the beginning and end of about 50 years is probably the leading idea, but it doesn't explain everything," says John Vidale at the University of Southern California.

Notably, it doesn't account for the period from 2001 to 2003 in which the rate of change of the core's spin seemed to be much higher than we have seen at other times, he says. "But my guess is something else is happening as well, so it's really not that bad a

flaw if all the data isn't explained by one model."

The oscillation is most likely caused by interactions between the solid mantle and the inner core. Because neither is perfectly spherical, the gravity of lumps and bumps in each pulls on the other. That could change the rotation rates of both – although the mantle is much heavier than the inner core, so the effect on the outer layers of the planet would be much less noticeable (*Nature Geoscience*, doi.org/jtkn).

This bears out with measurements of minuscule changes in the length of the day on Earth's surface, which fluctuates slightly. Changes in the rotation of the inner core are also expected to affect the planet's magnetic field, but only on a relatively small scale.

"People get alarmed about the idea of an impending reversal of Earth's magnetic field, and it's not that kind of thing, it would be a small effect," says Buffett. "The flows in the core will alter the magnetic fields a little bit, and change the length of the day by maybe a tenth of a millisecond a year."

But we can't be sure yet exactly what is going on at the centre of Earth, largely because measuring these very small changes in seismic waves, magnetic fields and the day's length is so difficult.

"I wish I could say that it's the final word, but I think we still have some work to do to converge onto a final explanation," says Vidale. "We have trouble doing simulations of these waves because they have such high frequency all across the planet, and some of the measurements are pretty uncertain and contradictory." More observations over the coming decades will help researchers sort it out. ■

Environment

California still grappling with historic drought despite intense rainstorms

James Dinneen

A DRY spell has finally been forecast in California after three weeks of heavy rain that brought flooding and disaster declarations across much of the state.

The downpours were the result of nine “atmospheric rivers” – warm, water-heavy air drawn up from the tropics – and have taken the edge off a historic drought. But California is still grappling with how to manage the increasingly volatile swings between wet and dry years predicted there as climate change progresses.

Even as the rain brought devastating floods and mudslides, leading to at least 20 deaths and possibly more than \$1 billion of damage, it also provided “a great elixir for the historic drought we’ve had in California”, says John Abatzoglou at the University of California, Merced.

The three years since the start of 2020 have been the driest in California in more than a century, with 35 per cent of the state in an extreme drought and more than 80 per cent in a severe drought by mid-December, according to the National Integrated Drought

Information System (NIDIS).

With the storms finished as of 19 January, no part of the state was still in extreme drought and the portion under severe drought had halved, according to the NIDIS. Nearly all of the state remained under moderate drought conditions, however.

Jeanine Jones at the California Department of Water Resources says the NIDIS classification

Nicasio reservoir in California is now at full capacity



JUSTIN SULLIVAN/GETTY IMAGES

system is based on non-irrigated Midwestern agriculture, so doesn’t accurately reflect California’s heavily managed water system or snowpack. But she says the storms have eased drought conditions, with total precipitation so far this year already up to 167 per cent of the annual average. The majority of the state’s major water supply reservoirs are at above average levels for this time of year.

The storms also left behind a mammoth snowpack already around 25 per cent larger than the average high point usually seen

in April, though the amount of snow that will become runoff depends on a variety of factors, such as the dryness of soil and the weather in 2023, says Jones.

Still, “from a surface water perspective, things are going to be good”, says Abatzoglou. “We’re not going to have a surface water drought this year in California.”

Things are more complicated when it comes to the state’s groundwater, which has seen huge losses from a combination of drought and a century of over-extraction. “One year, no matter how wet, is not going to recharge those groundwater basins,” says Jones.

Many projects are under way to capture more water from storms to recharge those aquifers. However, even large-scale improvements probably won’t be enough to stop some farmland being taken out of production to balance groundwater budgets, as has been mandated by the state, says Daniel Mountjoy at Sustainable Conservation, an environmental non-profit organisation in San Francisco. ■

Archaeology

Teenage Egyptian mummy had ‘second heart’ made of gold

DIGITAL scans of an Egyptian mummy have revealed a teenage boy buried with a “second heart” made from gold, as well as dozens of other amulets that the ancient Egyptians believed were important for the afterlife.

The mummy, which had been left undisturbed in the basement of the Egyptian Museum in Cairo since 1916, is from around 300 BC in the Ptolemaic period.

Sahar Saleem at Cairo University digitally unwrapped the small, gold-covered mummy with computed tomography (CT), using hundreds of high-resolution X-ray images to display the skeleton and soft tissue, and reveal 49 amulets of 21 different types.

As well as finding a 3-centimetre golden scarab in the mummy’s chest cavity, symbolising a heart, Saleem and her team discovered a golden tongue inside the skull’s mouth area, an amulet in the shape of two fingers next to the embalming incision mark on the left thigh, and other amulets made from gold,

semiprecious stones and colourful ceramics. The boy’s own heart remained in his chest (*Frontiers in Medicine*, doi.org/grp9xq).

The amulets had supposed protective properties for the journey to the afterlife that the Egyptians believed came after death. “The family of the boy offered him a very expensive level of embalming treatment to be prepared properly and equipped for the underground

“The golden heart scarab amulet is really amazing, especially after I printed it and was able to hold it”

journey to reach the afterlife safely,” says Saleem, such as sandals and a golden tongue to speak with.

The CT scans were used to 3D print a reconstruction of the gold heart. “The large, golden heart scarab amulet is really amazing, especially after I printed it and was able to hold it in my hands,” says Saleem. The 3D-printed version had inscriptions on it that appeared to include verses from the Egyptian *Book of the Dead*, which states that the heart scarab is needed to silence the heart when judged by the gods en route to the afterlife. ■

Alex Wilkins

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JULIA RAVEY

Space

JWST images show a nebula shaped by a multi-star system

Leah Crane



JOSEPH DEPASQUALE (STSC)/NASA/ESA/CSA

THE Southern Ring Nebula is full of stars. It was once thought that nebulae, huge clouds of gas and debris in space, were created from the death of a single star, but we know now that this one's swoops and whorls were formed by at least four stars orbiting one another – maybe even five.

Orsola De Marco at Macquarie University in Australia and her colleagues viewed the nebula, also called NGC 3132, using the James Webb Space Telescope (JWST), and created a three-dimensional model to figure out its internal structure.

“Ideally you would find the companion stars and wind back time,” says De Marco. “In practice you can’t do that, so you have to work like an investigator at the crime scene where the nebula itself is telling you what happened to it.”

When a star about the size of the sun dies, it sheds its outer layers and the stellar core heats them and makes them glow.

Previously, we knew there were two other stars orbiting the main star that created the

Southern Ring Nebula, one nearby and one distant. The JWST images revealed a disc of dust around the primary star that must be caused by an additional companion star, orbiting even closer than the closest one we knew about – about the distance between Earth and the sun. We see no sign of the star itself, so it may have fallen in and merged with the primary star.

“The nebula’s swoops and whorls were formed by at least four stars orbiting one another”

The outer edges of the nebula also show a series of arches that look a bit like the rings in a tree stump. The spacing of these rings allowed the researchers to calculate the distance between the primary star and the star that carved them into the expanding gas cloud, which must be 40 to 60 times more distant than the star that created the disc of dust (*Nature Astronomy*, doi.org/grgnmz).

“Every time we’ve had rings

Two JWST images of the Southern Ring Nebula

like this, the only explanation that really works is that there is a companion around the star when the star is shedding, and as it orbits it imprints a track into the material,” says De Marco. “You need a companion to make the rings, but it cannot be the same companion that made the disc.”

Finally, the 3D model of the nebula revealed evidence of what may be a fifth star. The reconstruction looks a bit like a lumpy egg, and each bump is paired with another on the opposite side of the gas cloud.

These lumps are most likely formed by jets from the central star, but the only way to give them their seemingly random orientations would be through the chaotic orbits of three nearby stars. That would require an additional star orbiting the primary star and the extremely nearby one that made the disc of dust, making the Southern Ring a stellar quintet. ■

Anthropology

Milk may have fuelled growth spurt in ancient Europe

Luke Taylor

THE evolution of lactose tolerance may explain why people in northern and central Europe increased in size between 7000 and 4000 years ago, while people elsewhere stayed the same height or got smaller.

To examine how human body size has changed, Jay Stock at Western University in Ontario, Canada, and his colleagues collated data on 3507 skeletons from 366 archaeological sites in seven regions stretching back to 30,000 years ago. They used skeletal measurements to estimate each individual’s height and the size of weight-bearing joints to estimate their weight.

They found that the global mean height for men and women declined from 30,000 years ago onwards, reaching its minimum between 8000 and 6000 years ago. However, in central Europe, stature rose between 7000 and 4000 years ago, while in northern Europe, it increased between 8000 and 2000 years ago. Similar trends were seen for body mass (*PNAS*, doi.org/grnn67).

The earliest evidence of dairy production is from around 9000 years ago in western Asia, from where it spread around the world, reaching central Europe at least 7400 years ago.

The authors theorise that the exceptional growth resulted from those European peoples producing the enzyme lactase into adulthood, which allowed them to gain more nutrition from lactose, a sugar found in milk. But the study found that people in Britain got smaller in the same period, despite being early milk drinkers.

“I see no systematic, numerical analysis to suggest it is much more than a guess that selection was stronger on lactase at this time when we see increases in body mass,” says Mark Thomas at University College London. ■

The first ever vaccine against RSV could be approved in 2023

Promising trial results mean an approval is expected, with effective antibody treatments already available in the EU and UK, writes **Michael Le Page**

THE respiratory syncytial virus, better known as RSV, is a major killer of very young and very old people, but we are almost certainly at a turning point in the battle to prevent it being so lethal.

On 17 January, Moderna reported promising results from a vaccine trial in older adults, the latest of four such trials by various pharmaceutical companies to announce highly encouraging outcomes. This may mean that 2023 is the year that the first RSV vaccine is approved anywhere in the world.

What's more, a long-lasting antibody treatment that prevents otherwise healthy babies from catching RSV was approved in the European Union and UK in 2022. If these preventative measures live up to their promise, they could together save tens of thousands of lives.

RSV infects us all during our life. In most people, it causes cold-like symptoms, but among the more

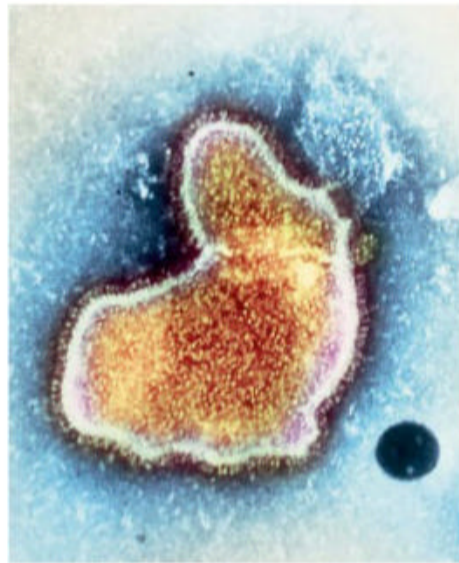
“For every death from RSV, many more people become seriously ill, with millions needing hospitalisation”

vulnerable, such as babies and older people, it can be deadly.

Around 100,000 children, most of whom are very young, die from RSV every year worldwide, says Harish Nair at the University of Edinburgh, UK. Of these deaths, 97 per cent occur in low or middle-income countries, he says.

When it comes to deaths in older people, we don't know the exact numbers, says Nair. High-income countries report at least 15,000 adult RSV deaths a year, with the risk increasing with old age. As most people aren't tested for the virus, however, the true figure is probably two or three times higher, he says.

A Pfizer vaccine given during pregnancy protected babies against RSV in trials



CDC/SCIENCE PHOTO LIBRARY/ALAMY

The respiratory syncytial virus (RSV) can be severe

Statistics aren't available for RSV deaths among older people in low and middle-income countries.

For every death from RSV, many more people become seriously ill, with millions needing hospitalisation.

Developing RSV vaccines has historically been difficult because the main protein on the outside of the virus, called the F protein, changes shape when it infects cells. The most effective antibodies, either natural or factory-made, target a part of this

protein that is only exposed before this shape change.

In 2013, researchers at the US National Institutes of Health unveiled a synthetic form of the F protein that is locked in the pre-infection shape. Companies including GSK, Pfizer and Moderna have developed vaccines based on this locked-open protein.

The GSK and Pfizer vaccines consist of the protein itself, while the Moderna vaccine contains an mRNA sequence that codes for it, which enables cells to make the protein following the injection.

In trials in people aged 60 and over, each vaccine was more than 80 per cent effective at preventing symptomatic infections.

This suggests that routinely offering one of these RSV vaccines to people aged 60 or over could save many lives, but Nair expects this roll-out to happen only in high-income countries, as a lack of testing means some lower-income countries are less aware of RSV's toll and the need for a vaccine.

We don't yet know how effective any RSV vaccine will be among young children, as the trials are still in early stages. But in November 2022, Pfizer reported that when its

vaccine was given during pregnancy, it was around 80 per cent effective at preventing severe infections in infants for up to 90 days after their birth, with this protection then gradually fading. The initial protection is a result of the babies acquiring antibodies via the placenta, which then circulate in their blood.

Similar protection can be provided by injecting factory-made antibodies. In 2022, the EU and UK approved an antibody called nirsevimab (Beyfortus) after studies showed that receiving a single injection ahead of the RSV season protected against severe infections in babies. The antibody is being assessed for approval in the US.

97%

of RSV deaths in children occur in low or middle-income countries

Nirsevimab isn't the first antibody for preventing RSV infection, but it persists for much longer in the body, making it feasible to administer to otherwise healthy babies as a preventative measure. However, its manufacturer AstraZeneca hasn't yet announced the cost of the antibody, says Nair. Factory-made antibodies tend to be very expensive.

But, with the Pfizer vaccine expected to be approved in many countries for use in pregnancy, some nations could soon have two options for preventing RSV infections in babies: the antibody and the vaccine given during pregnancy. Given half of all RSV deaths in children are in babies aged less than six months, this could substantially reduce infant fatalities.

So, there are many reasons to be optimistic that we will see a huge fall in the deaths and medical complications caused by RSV.

“New products are coming,” says Nair. “New technologies are coming. It looks very, very promising.” ■



MARIA PAVLOVA/E+GETTY IMAGES

Space

Planets in the 'habitable zone' may not be good for life

Leah Crane

A LARGE proportion of planets in the so-called habitable zone – the area around a star where conditions are right for liquid water on an orbiting world's surface, and thus potentially for life – weren't always there. That might mean we are vastly overestimating the number of worlds that could host life.

While researchers often think of the habitable zone of any given star as being relatively static, it actually changes as the star evolves and its brightness and temperature change. That means that worlds born well outside the habitable zone that started their lives either much too hot or too cold for liquid water on their surfaces could become more temperate later in their lifetimes.

Noah Turchow at NASA's Goddard Space Flight Center in Maryland and Jason Wright at Pennsylvania State University have dubbed these worlds belatedly habitable planets, as opposed to continuously habitable planets that spend their entire existence in the habitable zone. They found that, depending on how you define the habitable zone, 29 to 74 per cent of planets could be belatedly habitable.

That has major consequences for the possibility of water on these worlds. Those born closer to their star than the habitable zone may have all of their water boiled away before they enter the habitable zone, and for those born further away, any water is likely to take the form of difficult-to-melt glaciers (arXiv, doi.org/jtbz).

We don't know much about how life arose on Earth, so our understanding of the conditions necessary for life are vague, but it is clear that belatedly habitable planets have more obstacles for life than continuously habitable ones.

"If life cannot exist on these planets, it might have major implications for the abundance of life in the universe," says Turchow. ■

Climate change

More vegan food in schools could massively change farming

Madeleine Cuff

GOVERNMENTS should force prisons, schools, hospitals and other state-run institutions to serve more vegan burgers, sausages and fillets in order to trigger a dramatic shift in global agriculture, a team of researchers has proposed.

Public procurement of plant-based protein was identified as a "super leverage point" that would spark cascading changes throughout the global food system.

Serving more plant-based foods in public institutions would help the alternative protein sector to scale up and bring down its costs, while also boosting the popularity of these products with the public, according to a report from sustainability consultancy Systemiq in partnership with the University of Exeter, UK.

Should vegan alternatives displace 20 per cent of meat sold globally, up to 8 million square kilometres of land used for livestock farming could be redeployed for climate-positive schemes, says Tim Lenton at the University of Exeter, who contributed to the report.

"We need to find and trigger positive tipping points to avoid the bad climate tipping points"

"You really get a disproportionate reduction in land use demand, which is obviously a big source of emissions," he says. "Then you're liberating land on which you could do reforestation, afforestation, rewilding."

Public procurement of plant-based proteins is one of three super leverage points identified in the report as small interventions that can cause a



STOCKFOOD/ADDICTIVE STOCK

Eating more plant-based protein would cut carbon emissions

cascade of decarbonisation.

Introducing a mandate for at least 25 per cent of ammonia fertiliser to be made utilising green hydrogen, which is generated using renewable energy, would be another, the report said. This would increase the deployment of electrolyzers to bring the price of green hydrogen to as low as \$1.50 per kilogram. This could make green hydrogen a viable fuel for ships and steelmaking.

Meanwhile, requiring car manufacturers to produce a certain volume of electric vehicles each year would help to push zero-emission driving into mass adoption. This could, in turn, significantly reduce the cost of electricity from renewables and related storage solutions by speeding up lithium-ion battery advances.

The idea was to design interventions that trigger positive tipping points, where a shift to a greener society becomes unstoppable, says Lenton. These would act as a counterpoint to climate tipping

points – such as an abrupt melting of permafrost – that researchers warn would be irreversible and could speed up climate change.

"It was always apparent to me that sometimes in human social systems you get abrupt, self-propelling and often irreversible changes," says Lenton. "We need to find and trigger positive tipping points to avoid those bad climate tipping points."

The report, which was presented on 20 January at the World Economic Forum in Davos, Switzerland, is backed by the Bezos Earth Fund, a philanthropic venture from Amazon founder Jeff Bezos.

The interventions, designed for governments around the world, will inspire positive change rather than ban polluting activities, says Mark Meldrum at Systemiq, an author of the report.

"None of these are about banning the old," he says. "They are about supporting and lifting the new, to help them be as competitive and attractive as possible. So we get to a place where we don't need a ban, because everyone wants the new thing anyway." ■

Bioethics

Meet the donors

Changes to the laws around anonymous egg and sperm donations in a number of countries are starting to have an effect, reports **Jason Arunn Murugesu**

DOZENS of people conceived using a donated egg, sperm or embryo in the UK will receive an unusual birthday present when they turn 18 this year, as they gain the right to learn the identity of their previously anonymous donor.

The UK is one of only a handful of countries to ban anonymous donors. A change in the law on 1 April 2005 guaranteed people who were donor-conceived after that date the right to information about their donor when they reached adulthood.

The first people conceived using a donor after the law came into force will soon be turning 18, says Clare Ettinghausen at the UK's Human Fertility and Embryology Authority (HFEA). Around 187 people in the UK will gain the right by the end of 2023, she says.

New Zealand is in a similar situation to the UK, having also banned anonymous donation in 2005; the first people to gain the right to their donor information when they turn 18 will also become eligible this year.

Ettinghausen says it is unclear how many people will take advantage of the law in the UK, which allows an individual to request information about their donor, such as their name, date of birth and last known address, but evidence from other nations suggests it may be a small number.

Sweden was the first country to give people the right to obtain identifying information about a donor. Those born after 1985 were given the right to discover the identity of their donor when they turned "sufficiently mature", generally taken to mean 18.

Claudia Lampic at Umeå University in Sweden and her team published a study last year that surveyed 900 people who were donor-conceived between



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Telling children they were conceived using egg or sperm donations can be difficult

187
people conceived via donation will turn 18 in the UK this year

60
people conceived via donation in Sweden between 1985 and 2002 requested information about their donors by December 2020

359
people in the Netherlands chose to learn about their donors in 2021

1985 and 2002. Of these, only 60 had requested information about their donor by December 2020. Most reached out within two years of turning 18, the team found.

She says the low number may reflect the fact that many parents using donations in the 1980s and 1990s in Sweden weren't always encouraged to tell their children that they were donor-conceived. "Several parents were given conflicting information," she says.

Changing attitudes

Attitudes may have changed, according to another study by Lampic and her colleagues of heterosexual couples in Sweden who used a donor to conceive before 2005. "More than half the parents we surveyed had already told their children they were donor-conceived by the time they turned 7 or 8," she says. This is expected to translate to more people reaching out to their

donors when they turn 18, she says, and the same is likely to be true in other countries that no longer allow anonymous donors.

The Netherlands changed its laws more recently than Sweden, and figures from this country also reflect potentially changing attitudes. It outlawed anonymous donations in June 2004, allowing people to find out about their donors when they turned 16, which began happening in 2021.

People conceived before the law change can also find out about their donors, if the donor consented. A survey of 179 people in the Netherlands who had donated sperm before 2004 and had voluntarily removed their right to anonymity found that most had done so to give their biological offspring the right to know physical and social details about them.

According to figures from 2021, the most recent available, 359 people in the Netherlands chose



to learn about their donors – many more than seen in Sweden over a far longer time period. Astrid Indekeu at KU Leuven in Belgium says media attention around the issue in the Netherlands probably explains the difference. “The increased publicity in the media had led to donor-conceived people asking more questions and learning how to access that information also,” she says.

One major unknown is that there isn’t data on how many people are told that they were conceived using a donor, as disclosure isn’t a legal requirement in any country. “Even if there was a law, how would you go about it?” says Ettinghausen.

Telling children about being conceived using a donor can be difficult and is usually harder the longer you wait, says Nina Barnsley at the Donor Conception Network in the UK, a charity that helps connect people born in the UK before 2005 with their donors, if they have chosen to give up their right to anonymity.

“Like most things in life, it’s about preparing,” she says. “It’s not doing it on the fly, and thinking about how you are going to explain this.”

Unknown reaction

Other unknowns include how donors will respond when their biological children reach out to them. Anecdotaly, Lampic says the reactions of donors to donor-conceived children vary and while for some it may translate to a few text messages, she knows of other donors who have subsequently been invited to weddings.

The lengthy gap between donating and hearing from your

now adult biological offspring could also be a factor in how people respond. “Being a donor is now a lifelong commitment in some ways,” says Ettinghausen.

To mitigate this in the UK, all donors since 2005 have undergone psychological

“Years ago, they were up for donating and now they’re perhaps wondering – did they do the right thing?”

screening to ensure that they understand the implications of what they are volunteering for. Regulations vary in other countries, but Sweden also requires donors to go through psychological screening.

But Barnsley says it is unclear how well people understood the gravity of what they were doing. “Twenty years ago, they were very up for donating their sperm or eggs and now they’re perhaps reflecting and wondering – did they do the right thing?” she says. “A lot of life happens in that period.”

Donors in the UK aren’t obligated to respond to their donor-conceived children, but are encouraged by the HFEA to do so. Both groups are offered

The DNA alternative

In the years since countries like the UK have introduced laws allowing people conceived using donors to access information about their donors (see main story), cheap DNA tests have made it easier for anyone to find out more about their ancestry. Are such laws still needed?

John Appleby at Lancaster University, UK, says the potential for DNA tests to help people find their donor is overhyped, because they rely on the donor or a close relative having done the same test. “If those links don’t exist, you won’t be able to identify if you’re genetically related to your parent or not,” he says.

Nevertheless, in part because

of these tests, the UK’s Human Fertility and Embryology Authority (HFEA) encourages families who have used a donor to be as open as possible with their children.

The HFEA has also called for donors who donated before April 2005 to voluntarily remove their anonymity so that people can reach out to them through official channels rather than rely on DNA tests. As of November 2022, 260 donors in the UK have done so, the HFEA says – just a fraction of the close to 18,000 anonymous egg and sperm donor registrations in the country between August 1991 and March 2005.

counselling to ease the process.

The experience will become increasingly common. In the UK, compared with the 187 people conceived using donors who are turning 18 by the end of this year, the number of adults gaining the right to access information about their donors will rise to 1281 by the end of 2024.

This annual figure will continue

to grow over the next decade, reflecting a steady increase in donor conception in the UK over the years, with 3691 people due to gain this right in 2035 when they turn 18. The fertility authority in the Netherlands is also expecting a rise in numbers in the coming years.

Countries place limits on how many children an egg or sperm donor can conceive, for example the maximum is six in Sweden and 10 in the UK, but that still means donors could have several people contacting them in the next few years, says Barnsley.

Ettinghausen says that as the stigma against donor conception continues to fall, people reaching out to their donors will become more normalised. “You may find that in years to come, reaching out to your donor becomes a very standard rite of passage,” she says. ■

For more on fertility issues, see page 42



PHILLIP HAYSON/SCIENCE PHOTO LIBRARY

Sperm banks keep donations frozen below -196°C

Mental health

Why antidepressants leave you flat

A commonly prescribed class of the drug seems to reduce sensitivity to rewarding experiences

Clare Wilson

AN UNWANTED dampening of all emotions is one of the most frequent side effects of taking antidepressants – and now we know more about why this can sometimes happen.

The most commonly used types of antidepressant belong to a class called selective serotonin reuptake inhibitors (SSRIs). These are thought to work by increasing levels of the brain chemical serotonin, although why this can improve our mood is unclear.

Up to half of people taking antidepressants experience an unwanted dampening of both positive and negative emotions. “They talk about not feeling much,” says Barbara Sahakian at the University of Cambridge.

Depression itself also often causes a lack of pleasure in activities a person once enjoyed. Sahakian and her colleagues therefore investigated the emotion-dampening effect



GIPHOTO/SCIENCE PHOTO LIBRARY

Escitalopram may reduce our sensitivity to rewards

of an SSRI in 66 people who hadn't been diagnosed with depression nor self-reported its symptoms.

The participants were given a commonly prescribed SSRI called escitalopram or placebo pills. After three weeks, they carried out a range of tasks involving memory and their ability to learn.

One task measured how well they learned from rewards, with the participants having to repeatedly choose between two stimuli. Through trial and error, they generally learned that one stimulus was more likely than

the other to lead to a reward. Then, the probabilities of getting a reward from each stimulus switched without the participants being told, and they had to learn this new system.

Those on the antidepressant were 23 per cent less sensitive to the stimuli switch than those taking the placebo, as measured by how quickly they changed their stimulus selections. Further tests showed that taking the medicine didn't reduce their cognitive abilities in other ways (*Neuropsychopharmacology*, doi.org/jtg8).

The findings suggest that SSRIs reduce people's sensitivity to rewards or other pleasurable experiences, says Sahakian. However, the medicines can also blunt the intensity of negative feelings, which can be helpful, she adds.

“I hope this doesn't make doctors more cautious about

prescribing antidepressants, as they're extremely important drugs,” she says. “I hope it would make doctors have a discussion with patients about potential side effects.”

“Why antidepressants cause emotional blunting in a subset of people is a really important

“I hope this doesn't make doctors cautious about antidepressants, as they are extremely important”

question,” says Catherine Harmer at the University of Oxford. “I don't think this result explains why people have this effect, but it may be a marker of it, which could be useful when we come to develop new treatments that don't have it.”

Harmer says the study would have been more useful if the participants had been asked if they experienced blunted emotions while taking the antidepressant. ■

Zoology

Knifefish make electric 'chirps' to detect other fish

IT HAS long been assumed that when one brown ghost knifefish “chirps” at another knifefish by altering the electrical field it produces, it is communicating with that fish. But it appears that these chirps may instead be a kind of probe that helps a fish improve its electrolocation of objects.

Weakly electric fish generate a low-power electric field around their body, which they sense with special receptors in their skin. This allows them to detect distortions in the electric field induced by nearby objects, and thus to navigate and hunt in the dark.

Brown ghost knifefish (*Apteronotus leptorhynchus*), which live in the Amazon river basin, produce an electric field that usually oscillates at a constant frequency. But sometimes knifefish “chirp” by altering their usual frequency.

Because these chirps are produced mainly when other brown ghost knifefish are nearby, it has been thought for decades that they are a form of communication, used to scare away rivals or to attract mates. There are dozens of papers describing such behaviours.

But Livio Oboti at the Humboldt University of Berlin, Germany, claims none of these studies provide definitive evidence. He and his team have concluded that the chirps are a way of improving electrolocation (bioRxiv, doi.org/jtg9).



ALESSANDRO MANCINI/ALAMY

Brown ghost knifefish use electric fields to sense their surroundings

played recordings of chirps to knifefish, particular types of chirps didn't result in any consistent change in behaviour, such as attracting a fish or making it retreat.

Instead, when two fish interact, Oboti and his colleagues found that the types of chirps produced depend on the difference in the frequencies between the individuals and also on how close they are. “Altogether, these results make a strong case for a probing function,” says Oboti.

“[The] idea will be quite controversial, but I think it deserves careful attention,” says Kent Dunlap at Trinity College in Connecticut. ■
Michael Le Page

For starters, they found that simply making the knifefish's environment more complex resulted in more chirping. What's more, when the team

Technology

Hackers make computers fry their own chips

Matthew Sparkes

A FLAW in the control systems of server motherboards means they could be tricked into revealing sensitive data to a hacker or even destroying themselves.

A computer's motherboard, or main circuit board, hosts many of its key components and allows communication between them.

Zitai Chen and David Oswald at the University of Birmingham, UK, found a feature in the Supermicro X11SSL-CF motherboard for servers that allowed them to upload their own software. This can compromise encryption and damage central processing units (CPUs).

Chen says the new approach builds on techniques from earlier hacks such as Plundervolt. These use methods known as undervolting or overvolting to alter the voltage supplied to a processor so errors creep in to calculations, which can leave encryption weakened.

The researchers focused on the baseboard management controller (BMC) on the motherboard – a small, self-contained computer that monitors chip temperatures and power supplies. By writing their own code to remotely modify the firmware on the flash memory chip on the BMC, they were able to take control of it and issue commands to parts of the motherboard that supply power to its CPU. By sending voltages well above the maximum 1.52-volt limit for the CPU, they were able to destroy it in seconds (arxiv.org/abs/2301.05538).

Supermicro declined a request for comment from *New Scientist*. But when the researchers disclosed details of the flaw to the company, it announced it has rated its severity as "high" and has fixed the issue in its existing motherboards – by updating the BMC software much as the researchers did. New motherboards from the company aren't affected by the flaw. ■

Agriculture

Human waste could help deal with global fertiliser shortage

Brian Owens



ALESSANDRO MANCINI/ALAMY

FERTILISERS derived from recycled human urine and faeces are just as safe and effective as conventional ones, according to tests on cabbage plants. Using human waste in this way could help alleviate the fertiliser shortage that is contributing to rising food prices – if people can be convinced to use them.

Nitrogen-based fertilisers are energy-intensive to make and their production accounts for 1.4 per cent of global carbon dioxide emissions.

Human waste can be a good source of plant nutrients like nitrogen and phosphorus, but can also carry disease-causing pathogens and parasites, so needs to be carefully treated to make it safe. It is still used – sometimes untreated – as a fertiliser in some low-income countries, but this has been largely abandoned in high-income nations.

Franziska Häfner at Agroscope in Zurich, Switzerland, and her colleagues compared cabbages grown in Germany using organic fertiliser derived from vinasse, a byproduct of ethanol production, with fertilisers

made from treated human urine and faeces.

The yield for cabbages grown with nitrified urine fertilisers (NUFs) was comparable to that of those grown with vinasse. Cabbages grown with faecal compost had a lower yield. So did compost and NUFs together, but this fertiliser may increase soil carbon content in the long term, the study found (*Frontiers in Environmental Science*, doi.org/grnbh4).

The researchers also tested for more than 300 chemicals in the faecal compost, including

1.4%

Share of CO₂ emissions linked to global fertiliser production

pharmaceuticals, flame retardants and insect repellents. Just 6.5 per cent of these chemicals were detected, all at very low concentrations. Of the 11 pharmaceuticals discovered in the compost, just two were found in the edible parts of the cabbage: the painkiller ibuprofen and the anticonvulsant and mood-stabilising drug carbamazepine. But the

Cabbage plants being tested with different fertilisers

concentration of the latter was so low you would need to eat half a million cabbages to get a single dose.

"The products derived from recycling human urine and feces are viable and safe nitrogen fertilizers for cabbage cultivation," Häfner said in a statement. "They gave similar yields as a conventional fertilizer product, and did not show any risk regarding transmission of pathogens or pharmaceuticals."

The researchers estimate that, if correctly prepared and quality controlled, up to 25 per cent of conventional synthetic mineral fertilisers in Germany could be replaced by ones recycled from human urine and faeces. In some places, that trend is already under way. One of the NUFs they tested, called Aurin, has already been approved for agricultural use in Austria, Switzerland and Liechtenstein.

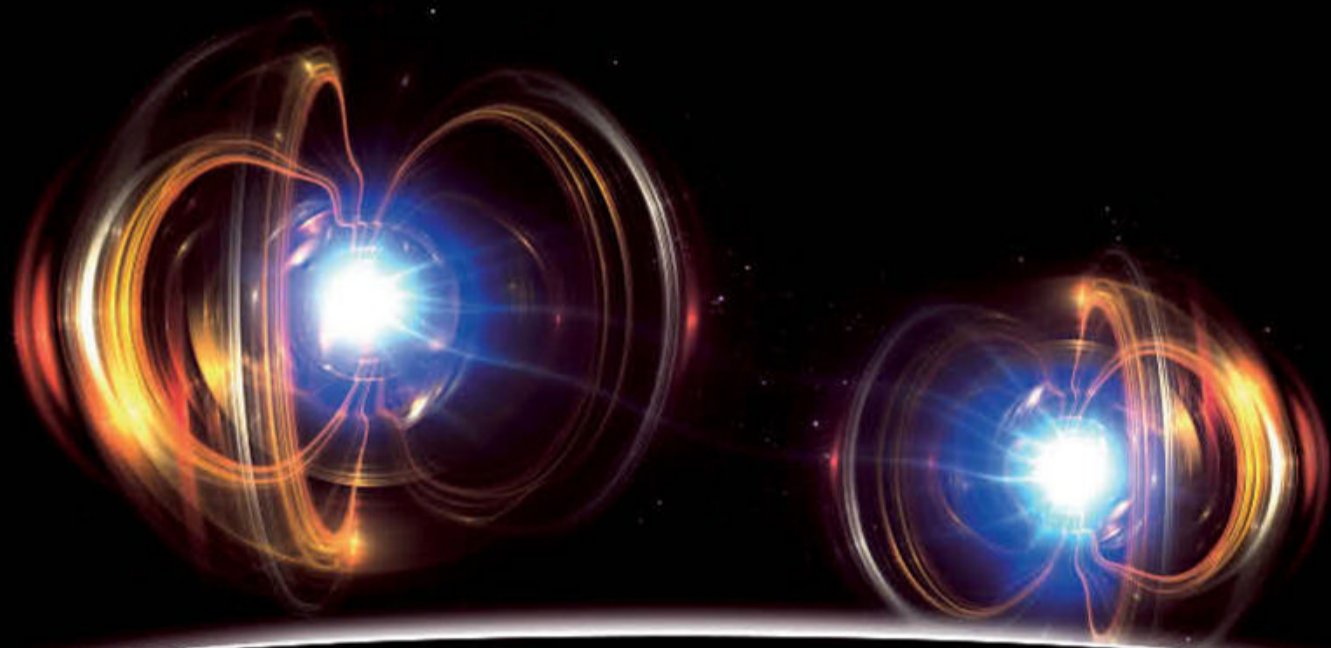
Benjamin Wilde at ETH Zurich obtained similar results in yield and safety when he tested NUFs in field trials in South Africa. But getting people to use them can take some convincing. The Zulu farmers he worked with, like those from many cultures, have strong social taboos around human waste. However, long discussions about the process of making such fertiliser and a field trip to where this happens helped them overcome those. "Farmers are very practical people once they see that something works," he says, although the farmers pointed out that they might have a harder time convincing their customers. ■

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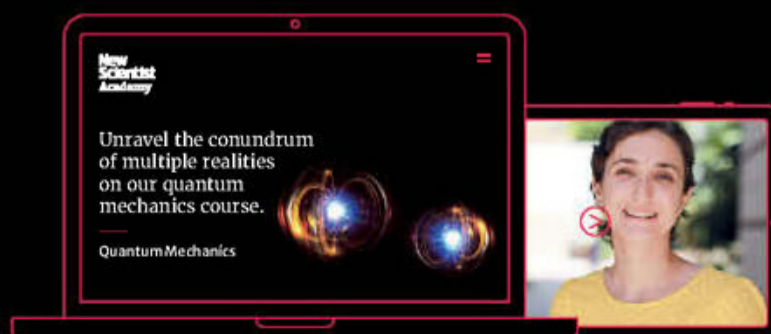
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Can you reduce dementia risk? A UK charity's online tool suggests lifestyle changes that could cut your risk of dementia, but the condition isn't usually preventable, says **Clare Wilson**

THE charity Alzheimer's Research UK has launched an online tool telling people they can cut their dementia risk with certain lifestyle changes, but the impact of such measures is uncertain and probably overstated.

The advice is based partly on a 2020 report from the journal *The Lancet* that summarised what we know about risk factors for dementia. The online tool, part of the charity's Think Brain Health Check-in campaign, includes some standard lifestyle advice like eating healthily, exercising regularly and not smoking, as well as supposedly dementia-specific steps, such as wearing hearing aids if necessary and doing puzzles.

It acknowledges that risk factors such as our age and genetics can't be changed, but says we can alter our diet and how we challenge our brain.

The tool has been changed since it went live on 18 January. The initial version, which struggled to meet user demand, didn't mention that only some of our propensity to dementia is down to lifestyle – “up to 40 per cent”, according to the 2020 estimate. The rest of our risk comes down to our genetics. This was put to Alzheimer's Research UK and it later changed its tool to include the 40 per cent figure.

The website also glosses over the fact that the risk factors it highlights emerged from observational research, not higher-quality randomised trials. Observational studies only show correlations between a lifestyle factor and a medical condition, not that the former causes the latter.

These studies are prone to being misleading because a third factor may be behind both the lifestyle habit and the medical condition. In the case of dementia, that third factor may be income, for example. Dementia is more common in people with lower incomes, who also tend to have healthier lifestyles. This could



GETTY IMAGES/IZUSEK

Puzzles (top) and staying active (bottom) may help ward off some dementia cases

40%
Proportion of dementia risk thought to be due to lifestyle habits



JORDISALAS.NET/SHUTTERSTOCK

be the real explanation for why some of the claimed risk factors – such as eating a certain diet – correlate with dementia.

Another possible explanation is that people with early cognitive decline may be less disposed to carry out some of the healthy habits, such as exercising or socialising.

This isn't to say that all the 12 claimed risk factors are invalid. Lifestyle probably does play some role in dementia, because although the number of people with the condition is rising due to us living longer, our individual risk of developing the condition by any particular age has been falling. Our genes haven't altered, so this drop must be down to changing habits.

A spokesperson for Alzheimer's Research UK says that several public health bodies have recommended some of the 12 tips, including in a 2015 report by NICE, England and Wales's medical guidelines agency.

But it seems unlikely that all 12 of the tips are equally relevant. We haven't yet been able to find out which of the many lifestyle factors should take the credit for the ongoing decline in individual dementia risk.

They are probably the ones that

also promote blood vessel and heart health, such as exercising and avoiding smoking. That is because there are several different kinds of dementia and the type that is caused by damaged blood vessels in the brain, vascular dementia, has had most of the fall in risk. The risk of developing the most common form of dementia, Alzheimer's disease, hasn't been falling as much.

Of these blood vessel-related risk factors, having high blood pressure seems particularly likely to be a genuine contributor to dementia, according to a 2021 study that used “Mendelian randomisation”, a way of investigating medical conditions using random genetic variation to mimic randomised trials.

That same study also suggests that high cholesterol and blood sugar levels aren't contributors to dementia and may just correlate with an increased risk. Despite this, the tool includes recommendations to control our cholesterol levels and suggests that high blood sugar could also be a risk.

Other guidance in the tool is that there is no safe alcohol drinking level, when observational studies suggest that light drinking correlates with a lower dementia risk.

The 12 tips are described as “simple rules for better brain health”, as if there is no doubt about the effectiveness of any of them.

Alzheimer's Research UK's chief medical officer, Jonathan Schott, has defended the tool, saying that the charity gets asked for prevention advice and has provided it. “Our check-in is there to raise awareness and empower people – it's not perfect science and we don't claim that it is,” says a spokesperson for the charity.

It is understandable that people want to do anything they can to avoid dementia, but surely no one wants to be misled. Sometimes, the honest answer to a scientific question must surely be: “We don't know.” ■

Psychology

Chimpanzees can't match 5-year-old children in test of flexible thinking

Luke Taylor

BY THE age of 5, children are much better than both young and adult chimpanzees at shifting their attention from one set of rules to another. The findings add to evidence that unique cognitive changes occur in humans before they reach 5 years of age.

Like memory and self-control, switching between “mental sets”, such as rules or instructions, is a core cognitive ability developed in young age. It lets us quickly adjust to changes in the environment, for example, choosing a different way to get somewhere when our route is blocked by roadworks.

Eva Reindl at the University of St Andrews in the UK and her colleagues designed a set of tasks to compare attention-shifting abilities in humans and other primates of different ages. Children and chimpanzees, which ranged from 5 to 36 years in age, were trained to determine which of four cups on two different sets of shelves contained a reward – stickers for children and bananas

for chimps. On the green shelves, a green cup held the treats, while on the blue shelves, it was a pink cup.

When they had to switch from one set of shelves to another, the chimpanzees successfully selected the right cup 52 per cent of the time. This is comparable to 3-year-old children, who had a success

Chimpanzees at Ol Pejeta Conservancy in Kenya were tested



NIRAV SHAH/LAMY

rate of 50 per cent, and 4-year-olds, who chose correctly in 59 per cent of cases (*Proceedings of the Royal Society B*, doi.org/grnrq7). Among 5-year-olds, the success rate was far higher, at 80 per cent. “There’s definitely something going on from 5 years of age,” says Reindl.

The improvement on the task with age in children is probably due to biological changes such as the development of the brain’s frontal lobes, says Reindl. But

cultural development may play a role too. Just as adults voice phone numbers or directions aloud to remember them, language may have helped the older children to switch between the two rules.

Most of the errors made by the children and the chimps were due to applying the rule for the wrong set of shelves, but for the chimps, 32 per cent of the errors were random, compared with 23 per cent in 4-year-old humans and 27 per cent in 3-year-olds. “The chimps sometimes picked [cups] that were not relevant at all, suggesting that they hadn’t formed such strong attentional sets in the first place,” says Reindl.

Although testing biases make it hard to compare humans with other apes, the general findings are robust, says Frans de Waal at Emory University in Atlanta, Georgia. “It’s hard to argue with the conclusion that 5-year-old children do better than younger ones and better than chimpanzees of various ages, including adults.” ■

Neurology

Vagus nerve may be key to halting inflammation

RECEPTORS in the vagus nerve help detect and control inflammation in mice. If the same is true for humans, these receptors could be the target of future therapies for inflammatory conditions such as rheumatoid arthritis and multiple sclerosis.

It is well known that the brain sends signals through the vagus nerve to dampen inflammation, which can damage cells and contribute to chronic disease if left unchecked, but it was previously unclear how the brain knows when to do this. “We didn’t know what

activated the brakes,” says Kevin Tracey at the Feinstein Institutes for Medical Research in New York.

To determine this, he and his colleagues studied eight mice, half of which had been genetically engineered to lack a type of receptor in the vagus nerve that is sensitive to some inflammatory molecules.

Proteins called cytokines are the main drivers of inflammation, so the researchers injected the mice with a type of cytokine known to induce changes in body temperature. The genetically engineered mice maintained their temperature, while the others developed hypothermia, suggesting the vagus nerve receptors are necessary for the body to detect inflammation.

Next, the researchers injected a toxic molecule into another 19 mice to induce a cytokine storm, in which overproduction of cytokines causes life-threatening inflammation. They activated vagus nerve receptors in 10 of the mice using optogenetics, a technique to turn cells on and off using light. These mice produced half as many cytokines on average as those that didn’t have these receptors activated and saw reduced inflammatory damage (*Molecular Medicine*, doi.org/js6p).

Taken together, Tracey says these

“Future therapies could use vagus nerve stimulators that act only on specific receptors”

findings indicate that these specific receptors in the vagus nerve not only detect inflammation but help keep it in check by signalling to the brain when inflammatory responses need to be turned off.

These results could guide the development of new therapies for people with chronic conditions. Clinical trials have shown that stimulating the vagus nerve with electrical pulses can reduce symptoms or slow the progression of conditions such as epilepsy, inflammatory bowel disease and multiple sclerosis. Future therapies could use ultra-selective vagus nerve stimulators that act only on specific receptors, says Tracey. ■
Grace Wade

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Microbiology

Mouth bacteria are shared in the home

YOU may have more in common than you think with people you live with, including up to a third of the strains of your oral microbes.

Nicola Segata at the University of Trento in Italy and his team analysed the results of 31 previous studies into the microbiomes of people living together or near each other in 20 countries, including in parts of Europe, North and South America, Africa and Asia.

They found that household members were more likely to share mouth bacterial strains than those of the gut. Across all the studies, 32 per cent of strains of oral bacteria were shared by household members, compared with 12 per cent of gut strains. Only 3 per cent of mouth bacteria were the same among non-cohabiting members of the same population (*Nature*, doi.org/js9v). **Clare Wilson**



BLICKWINKEL/ALAMY

Materials

Crocodile shoes, without the crocs

A FLEXIBLE, protective fabric like crocodile skin can resist stabbing, cuts and abrasion. It could be used to make armour or durable shoes.

Such materials are often rigid and heavy due to the dense fibres used, making it tricky to create practical armour or clothing from them. Now, Swee Ching Tan at the National University of Singapore and his colleagues have developed a less dense, flexible material resembling a crocodile's scales by fusing tough tiles of modified epoxy resin onto a polyester skin.

It nearly beat stainless steel chain mail in resisting a razor cut, while a hypodermic needle stab test on someone's arm covered in the material left them unscathed. It also resisted abrasive substances well, which could make it useful for the likes of footwear (*Advanced Functional Materials*, doi.org/js97). **Alex Wilkins**

Ecology

Starfish could be wiped out by heatwaves this century

INCREASINGLY hot and long spells of ocean warmth could kill all common sea stars by 2100.

Fabian Wolf at the GEOMAR Helmholtz Centre for Ocean Research Kiel in Germany and his colleagues tested how Atlantic sea stars or "starfish" (*Asterias rubens*, pictured) would fare during marine heatwaves – short periods when the ocean becomes unusually warm.

The team subjected 60 sea stars in tanks to five scenarios: current average temperatures in its habitat range, a hypothetical condition without heatwaves, and temperatures expected in marine heatwaves by the end of the century under three warming scenarios. The coldest tank had no heatwaves – a

steady temperature of 18.4°C (65°F) – while the hottest peaked at 26.4°C (79°F), reflecting the most extreme warming scenario.

Hotter conditions in the tanks lasted for 13 days, the projected length of severe marine heatwaves by 2100, followed by a few days of cold, low-oxygen water to mimic the upwelling of deeper water, which often follows heatwaves in coastal areas. Throughout the two-month study, the researchers fed the sea stars blue mussels and measured their size and weight regularly. They also recorded the time it took each sea star to right itself after being flipped on its back, an ability critical for feeding.

In the hottest scenario, all sea stars died before the 13-day heatwave ended. In all three future warming scenarios, they ate fewer mussels than normal. Those in the two warmest scenarios also took the longest to right themselves after being flipped (*Proceedings of the Royal Society B: Biological Sciences*, doi.org/js9r). **Corryn Wetzel**

Really brief



HARSHA DHIMAN ET AL

Dinosaur nursery discovered in India

A trove of 92 fossilised nests and 256 eggs has been found in India. The nests were made up of egg clutches laid in shallow pits, much like those of modern crocodiles. It hints that the long-necked dinosaurs called titanosaurs living there nested in colonies (*PLoS One*, doi.org/grnr23).

Fungus uses nerve gas on nematodes

The *Pleurotus ostreatus* fungus that produces oyster mushrooms contains lollipop-like structures that break open when nematodes press their heads against them. The lollipops release nerve gas that kills the nematodes so the fungus can suck out their insides (*Science Advances*, doi.org/jjs49).

Cross-bred cotton is flame-resistant

A form of white cotton that can withstand fire has been created by breeding parent strains with no similar characteristics. Fabric made from the cotton self-extinguished after a test flame was removed. It may let us make fire-resistant fabrics without adding toxic chemicals (*PLoS One*, doi.org/jjs5c).



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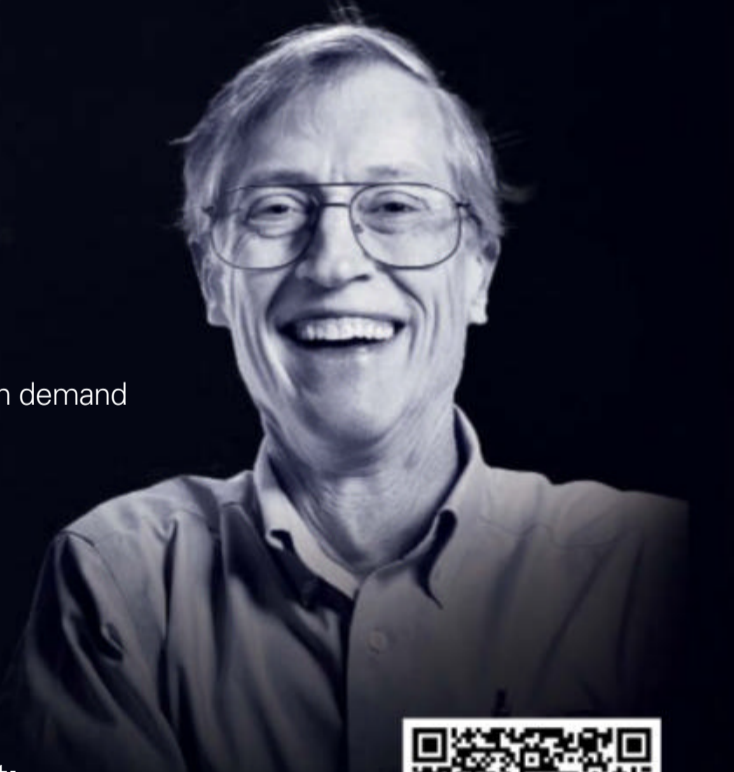
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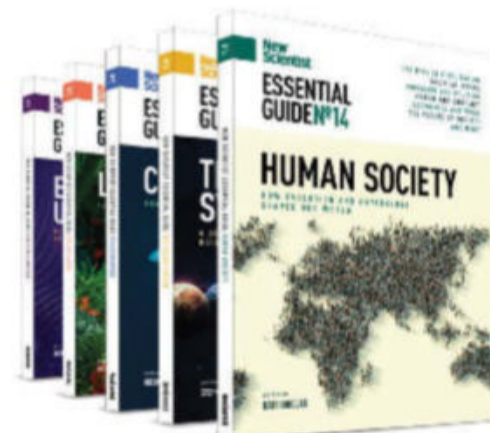
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The columnist

Alex Wilkins looks into the prospect of medical AI **p28**

Aperture

Close-up photos capture feathers' dazzle factor **p30**

Letters

Give animal feelings the benefit of the doubt **p32**

Culture

Uncovering the space industry's dirty secret **p34**

Culture columnist

Simon Ings on the disturbing android future of *M3gan* **p36**

Comment

Governing space

Access to space is growing, with more than 70 nations now operating space programmes. We urgently need to update international rules, says **Sarah Al Amiri**

A NEW space age is upon us. The two-horse race that characterised our early exploration of space has been transformed into a global, highly dynamic industry. Our existing models of space governance and collaboration are no longer effective and we urgently need new ones that address emerging geopolitical, economic and sustainability challenges.

The space industry is rightly seen as pioneering: not only does it continually expand the boundaries of exploration, but it enables growth at home. From communications to meteorology to engineering, it has an outsized impact on our economies, adding high-value services and creating skilled jobs. It isn't surprising that the market for global space systems and services is estimated to be worth \$1 trillion by 2040.

Nevertheless, the sector risks becoming a victim of its own success. As access to space grows, it is becoming more congested than ever. With more than 70 nations now operating space programmes, plus many private sector entrants, commercial uses for space have multiplied, as has the number of objects being launched into low Earth orbit.

This creates two key challenges. The first is the accumulation of human-made orbital debris, which, together with the overpopulation of satellites and assorted fragments in low Earth orbit, has raised the probability of accidents and collisions, rightly prompting



SIMONE ROTELLA

questions about environmental impact. If this is left unmanaged, our ability to navigate space safely will be compromised, which could lead to restrictions on space use and access. Spacefaring nations and private sector actors need to think about low Earth orbit as an extension of our environment and manage it accordingly.

The second challenge is the increasing militarisation of space, as the lines between commercial and military activity blur in new ways (see page 34). If satellites and spacecraft become targets for attack, the resulting debris could render entire orbits unusable. This

is troubling, and careful oversight is required. New multilateral efforts, including possible arms control agreements, need to be explored if space is to remain a safe domain used for good.

We are reaching an inflection point. The foundational United Nations treaties and international frameworks used to govern space – created largely during the cold war, when only the US and the Soviet Union had substantial access to space flight – are no longer fit for purpose.

While they provide a strong base, major upgrades and enhancements are needed to

regulate the activities of emerging players, particularly in areas like satellite use, traffic management, tourism and space exploration. Just as we have overhauled our global climate and energy policies, regulated the technology sector and reshaped privacy and data rights, it is time that we instigate a similar transformation in the space sector.

Diplomatic efforts to find a way forward have been slow to make progress. As space activity grows, existing rules of the game will come under increasing strain. To advance agreements on space governance, we need renewed international collaboration. Many government and non-government bodies are working to accelerate cooperation, including the UAE Space Agency where I work, which convened experts at the Abu Dhabi Space Debate in December.

Today, we face two divergent scenarios. Regulatory challenges and the possibility of space disasters could restrict innovation and leave the sector's promise untapped. Alternatively, global collaboration and clear governance structures could facilitate safe and sustainable uses of space. Achieving this will be no small task, but an open and thriving space community can only flourish if we do. ■



Sarah Al Amiri is chair of the UAE Space Agency and minister of state for public education and advanced technology

Artificially intelligent

The robot doctor will see you soon Trained on real electronic health records, medical AIs are making rapid progress. How long before we see these tools in the clinic, wonders **Alex Wilkins**



Alex Wilkins is a *New Scientist* reporter who covers artificial intelligence, physics and space. “Artificially intelligent” is a column that cuts through the hype, looks at what AI is really capable of and what it means for us. You can follow him @AlexWilkins22

Alex's week

What I'm reading

Barbarians At the Gate by Bryan Burrough and John Helyar, an exhilarating ride through the world of 1980s greed and excess.

What I'm watching

The Traitors on BBC, which lives up to the hype.

What I'm working on

As a very limited programmer, I'm seeing if ChatGPT can help me get my personal website into tip-top shape.

Up next week:
Chanda Prescod-Weinstein

HOW would you feel if your doctor, rather than consult their own clinical knowledge, turned instead to an AI trained on your medical history to help diagnose your next ailment or write your next prescription?

These sorts of scenarios have been hypothetical for decades – the technology has been subpar and the stakes too high to risk offloading medical advice to a machine. However, the success of large language models like ChatGPT, a popular, artificially intelligent chatbot from the OpenAI research lab, has led to a rethink of what might be possible.

In December, I was reading through a list of machine learning preprints – scientific papers that have yet to undergo peer review – when I came across Foresight, a medical machine learning model from researchers at King's College London (KCL). It uses GPT-3, the model that powers ChatGPT, and real electronic health records (EHRs) to predict “future events, estimate risk, suggest alternative diagnoses or forecast complications” for simulated or real people whose information is fed into it.

While intriguing, I would have paid less attention if it wasn't for a personal connection. King's is my alma mater and the model had been trained on real-world, anonymised data from King's College Hospital from 2010 to 2019. I had visited its emergency departments at least twice during that period while studying.

I soon found Foresight wasn't the only medical AI. At the end of 2022, Google announced Med-PaLM, a version of its enormous general purpose AI model PaLM, which is trained on text from the web and books and fine-tuned using medical documents.

Some of Google's claims were remarkable: its AI could answer common medical questions requiring a long written response, and real doctors said 92.6 per cent of Med-PaLM's replies “aligned with scientific consensus”, just 0.3 per cent less than answers given by human doctors. While the medics assessing its abilities noted that gaps in some answers and possible safety issues meant the model wasn't yet suitable for clinical use, it was clear such AIs were making rapid progress.

All this left me wondering how close we are to seeing these tools in clinics and whether my own

“It looks like medical AI models might achieve a clinical level of competency before regulatory bodies catch up”

medical data helped train an AI (and if it was truly anonymised).

I spoke with two of Foresight's creators to get some clarity. Yes, if I had visited a King's College Hospital A&E during that period, then my data would have been used to train the model, Richard Dobson at KCL told me. And it was almost certainly anonymised, he said. The EHRs had had any potentially identifying information removed, like rare diseases where there were less than 100 samples, and you couldn't ultimately get patient-level data out of the AI system.

“The risk of re-identification within the model is effectively zero,” says Foresight team member James Teo. I was reassured, but still a little spooked at the thought of a digital twin within the model.

Those behind Foresight, as with Med-PaLM, have (for now) opted not to use the AI in a clinical

setting and so it won't be assisting medics yet. But it, too, is producing encouraging results: five doctors assessed its predictions for future health issues for 34 simulated patients and found its top forecasted condition was relevant 97 per cent of the time.

Teo couldn't give me an exact date on when Foresight might be ready for real-world use and said that they needed another year or so to collect data on the model's accuracy and explainability. But it looks like the models might achieve a clinical level of competency before bodies like the UK's Medicines and Healthcare Products Regulatory Agency (MHRA) are in a position to properly assess them, he added. “To a certain degree, [Foresight] reaches technical feasibility,” says Teo. “Whether it meets regulatory feasibility still requires the regulators to develop maturity in their frameworks.”

We don't know what those frameworks might be, but they are likely to look at whether the AIs can reliably produce accurate answers and the transparency of their decision-making. AIs will also need to show they aren't biased towards certain groups of people, a risk for machine learning models because of the way they are trained. That is especially pertinent in healthcare, where demographics can affect medical outcomes, says David Leslie at The Alan Turing Institute, UK.

Another pitfall could be so-called AI hallucinations, where the system erroneously generates “fantastical, unfaithful, or nonsensical outputs”, says Leslie.

All these will be questions for the MHRA when the time comes, but, if the preliminary results from these models are improved upon, it will be a matter of when, not if, your next diagnosis is AI assisted. ■

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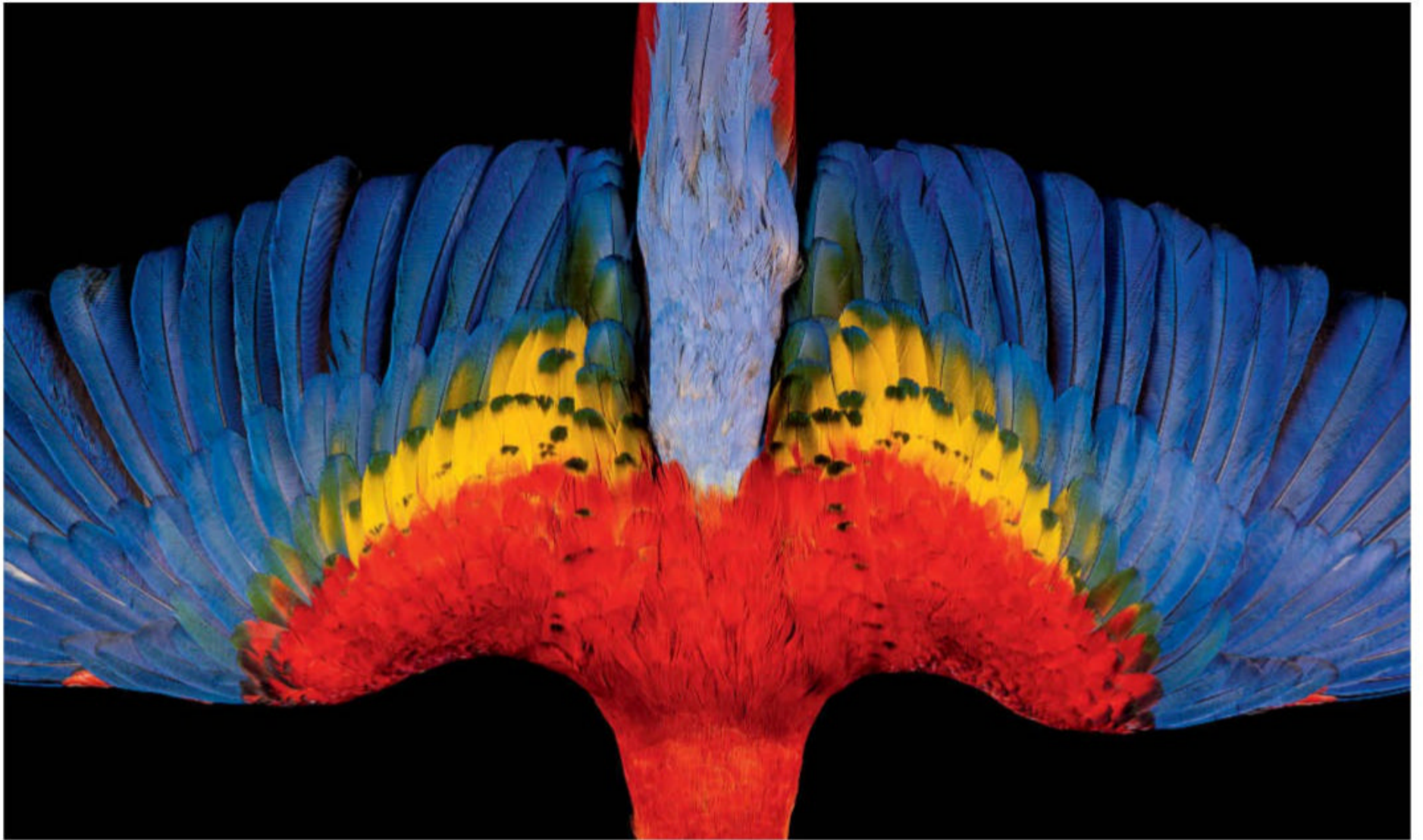
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Birds of a feather



**Photographers Heidi
and Hans-Jürgen Koch**

FEW creations of the natural world possess the dazzle factor of feathers. They are at the crux of some of the most astonishing courtship displays and migrations on Earth, and have long been a centrepiece of human culture, art and mythology. Made from keratin, feathers provide visual appeal and also help birds (and, millions of years ago, dinosaurs) to fly. They also help birds to swim and camouflage themselves, as well as keep warm, dry and protected.

Some of the remarkable vibrancy and diversity of feathers is captured in these mesmerising images taken by photographers Heidi and Hans-Jürgen Koch. “For us, bird feathers are probably the most poetic masterpiece of evolution,” they say.

Photographing various types of plumage housed at the Museum of Natural History in Berlin, Germany, they combined individual shots taken at varying levels of light to “expose the essence” of the extravagant colours, shapes and structures of feathers, which make “people succumb to their charisma”, they say. A book of their images is due out later this year.

The iconic colourings of the scarlet macaw are displayed in the image at top left, showing its mainly red plumage and blue wing feathers; to its right is a yellow shoulder-feather from the same species. Clockwise from there is the feather of a black-headed parrot, the typical eyespots of a great argus pheasant, the plumage of a blue bird-of-paradise and the tail feathers of a grey peacock-pheasant. ■

Gege Li

Editor's pick

Give animal feelings the benefit of the doubt

14 January, p 27

From Richard Brown, Huntly, Aberdeenshire, UK

When I qualified as a vet in 1981, I would have agreed with Marlene Zuk that we should question the trend of attributing human-like motivations and feelings to animals, such as bees "playing" with objects.

Now, after a 40-year career working on many continents and with many classes of animals, including insects, I have come to the opposite view. Unless science can prove that a living organism isn't sentient like us, can't feel stress and anxiety, doesn't play and doesn't feel fundamental emotions, we might do better to assume it does.

Could we have created the ancient warped trees?

14 January, p 11

From Michael Paine, Sydney, Australia

Another explanation for really ancient trees having twisted trunks and branches is that they are less attractive for harvesting for timber. In other words, artificial selection is at work.

I have speculated that this is why the Sydney red gum (*Angophora costata*) has such twisted branches. The ones with straight trunks and branches were chopped down when European colonists arrived, which changed the gene pool to favour "unattractive" specimens.

Nature has all the best answers to storing water

14 January, p 7

From William Hughes-Games, Waipara, New Zealand

You report that California is beset with longer periods of drought interspersed with ever heavier rainfall events. The heavier the rainfall, the more of this lovely water flows to the sea and is lost. Hence the various plans listed

to try to save this water and allow it to recharge aquifers, where it is safe from evaporation. This all sounds like it would cost a fortune.

Fortunately, there is a furry little alternative. Beavers build dams for free, and all they ask for is a supply of deciduous trees. Added benefits are a rise in biodiversity, a great improvement in water quality, flood mitigation and increased stream flow in drought periods.

Time for an escape capsule for satellites too

14 January, p 9

From Terrance Chapman, Thropton, Northumberland, UK
With the "anomaly" in the Virgin Orbit satellite deployment, would it not be of all-round benefit to develop a subsystem that could save the payload when missions like this run into trouble?

Astronauts often have a separate escape system for when launches go wrong. Couldn't a similar system be developed for satellites? It was sad to hear of this failure, but what if the James Webb Space Telescope had been lost?

I fear mega wind turbines may affect the weather

14 January, p 20

From Andrew Walker, High Wycombe, Buckinghamshire, UK
You recently carried an article on the development of supersized wind turbines with the potential for generating 50 megawatts of power from a single device. In the same issue – in "The limits of knowledge" (p 38) – you say that "the behaviour of some systems are sensitive to even the tiniest difference in starting conditions" of which the weather is a classic example, adding that small changes on one day can result

in unpredictable storms the next.

It seems possible that extracting 50 MW of power from the wind might be just such a small change. Could this lead to unpredictable consequences such as extreme storms? We should investigate.

A possible answer to the leftie sloth mystery

14 January, p 13

From Peter Slessenger, Reading, Berkshire, UK

The article "Sloths grip stronger than humans and other primates" states there is an unexplained left-side bias in their strength. Here is a possible explanation. If, like some animals, they favour using their right hands for fiddly tasks, then they would be hanging on a lot more with their left hands, which would get significantly more exercise and become stronger.

Undergraduate teaching can be less blinkered

7 January, p 22

From Rachel Mckeown, Cambridge, UK

Chanda Prescod-Weinstein's view on the sometimes overly narrow scope of some university science programmes made me reflect on my own experience.

As a natural sciences student, I started with a limited number of module options with lecture notes that mostly told us "how things are". As I progressed, module choices became more specialised and I focused on the subjects that really piqued my interest.

In my third and final year, I really felt like I was experiencing the reality of a life in scientific research. Lectures were designed to explore how one observation can have multiple competing hypotheses, encouraging us

to delve into the literature and fill our essays with our own critical analysis. A university programme can change in style as skills build.

Sonification is great and has been around for years

31 December 2022, p 46

From Susan Fowler, New York, US
My colleague Alice Preston and I were delighted by your article on sonification of astronomical data.

However, we were amused by the suggestion that this is new territory because we presented a range of sonification projects at a conference in 2004. In addition, the International Community for Auditory Display, which seems to have started in 1994, has 119 astronomy examples in its data sonification archive. Its next conference is in Sweden in June.

Warm connections at risk in the internet age

14 January, p 46

From Denis Watkins, St Just in Roseland, Cornwall, UK
In "How to be happy", Robert Waldinger says we evolved to be social animals and that "having warm connections with other people predicts how long you stay healthy". Yet now we live in an age of connection via smart devices, which could be viewed as less than warm. We are left with an absence of the physical contact we had as we evolved into social animals. I wonder if this is taking a toll.

Ready for the great split into two human species?

14 January, p 12

From John Woodgate, Rayleigh, Essex, UK
You report that "city-slicker" lizards are becoming genetically distinct from their rural relatives. What goes for lizards may well go for us. How far are we along the evolutionary path to Eloi and Morlocks? When will humans start to diverge, perhaps along urban and rural lines? ■



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Tainted from the get-go?

A convincing new book reveals how space technology was born out of appalling weaponry – and still has a militaristic bent, finds **Paul Marks**



Book
Original Sin
Bleddyn Bowen
Hurst

THE debt that the space age owes to Nazi Germany's killing machines may not be written in the heavens, but it is there for all to see on the streets of London. Around the city, memorial plaques record the sites where Nazi rocket designer Wernher von Braun's supersonic V2 ballistic missiles struck.

In all, some 3000 V2s were launched during the second world war, killing more than 2700 in London and 1700 in Antwerp, Belgium. After the war, however, instead of prosecuting von Braun – whose rockets had been built using slave labour from the Mittelbau concentration camp – the US spirited him away. Other Nazi V2 engineers ended up in the Soviet Union: the space race was on.

Later, von Braun became the chief technical architect of NASA's Apollo programme, and his skills in engineering liquid-fuelled orbital and suborbital rockets led to the US being the first to land humans on the moon, in 1969. Ever more astonishing feats have since been achieved in space: people can now live in orbit on the International Space Station and we recently defied the sun's gravity to divert an asteroid. We also depend on satellite constellations like Starlink for internet connectivity, and GPS or Galileo for navigation.

Does this mean space-flight technology is now an out-and-out public good? No way, says Bleddyn Bowen, a space policy analyst at the University of Leicester, UK. In *Original Sin: Power, technology and war in outer space*, he writes that all such space feats and



Above: The SpaceX Starship, which could reach Mars one day

Below: The devastation caused by a German V-weapon to a London factory in 1944



applications are mere sideshows, just “the tip of an iceberg” serving to disguise that space technology is, and always will be, a militaristic and economic tool of nation states, designed to enhance the killing power of their militaries and extend the invasive reach of their intelligence services.

Space flight has this enduring militaristic bent, Bowen argues, thanks to what he calls the sector's “original sin”: that it was based on the employment of people like von Braun, whose appalling weapons were built by Holocaust victims. Like the concept of original sin in Christianity, he says, space flight can't escape this.

People might think, writes Bowen, that the establishment of organisations like the US Space Force in 2019 means that the militarisation of space is new, when it has, in fact, always been that way. He wields convincing research to support this.

For instance, while civilians

might laud the glory of the Hubble Space Telescope, Bowen describes how Hubble is, actually, an adapted, repurposed version of a Pentagon spy satellite – one that points away from Earth instead of at it. And the space shuttle that rescued Hubble when it needed new optics? Also originally designed, he says, to suit Pentagon and US intelligence community needs. His book is overflowing with examples of quiet military advances in space that happened when everyone else was looking the other way.

Although the religiosity of the title is irksome – as space flight is now a multinational effort involving dozens of non-Christian countries – religion is an apt concept here for another reason: adherents of civilian space flight have always had something of a religious zeal about them. With the advent of spacecraft like the SpaceX Starship, which could reach Mars, that zeal has taken on new dimensions. Twitter is replete with wannabe Mars colonists with a salvation ideology of their own – that of making humanity an “interplanetary species”.

Bowen gives them short shrift. In claiming that they will set up a homesteading frontier on Mars, free of Earth's legal shackles, he dubs them “naïve and ignorant”, pointing out that UN law applies equally on Mars. On top of that, he says, cosmic libertarians need to remember that the US's frontier “was a product of the imperial state, not a fantastical libertarian escape from it”. But who knows? One day they may place plaques on Mars showing us where the faithful tried to prove otherwise. ■

Paul Marks is a technology and space-flight writer based in London

For more on the politics of space, turn to page 27

Cosmic stories

Can the elusive physics of the universe become sci-fi gold?

Boyd Tonkin explores an anthology based on CERN's research



MAXIMILIEN BRICE/CERN



Book Collision

Edited by Rob Appleby
and Connie Potter
Comma Press

IN *The Ogre, the Monk and the Maiden*, Margaret Drabble's ingenious story for the new sci-fi anthology *Collision*, a character called Jaz works on "the interface of language and quantum physics". Jaz's speciality is "the speaking of the inexpressible". Science fiction authors have long grappled with translating cutting-edge research – much of it grounded in what Drabble calls "the Esperanto of Equations" – into everyday language and engaging plots.

Few domains seem to pose a tougher challenge to narrative art than CERN, the particle physics lab near Geneva, Switzerland. Since 1954, its scientists have transformed the boldest ideas about the universe into theories grounded in experimental data. CERN's heroic exploits stretch from birthing the world wide web in 1989 to confirming the Higgs boson hypothesis in 2012.

But its combination of gargantuan plant (the Large Hadron Collider, CERN's ultimate ring of power, has a circumference of 27 kilometres) and interrogation

of the smallest, oldest events in and beyond our galaxy may escape the human middle ground where even high-concept fiction has to dwell.

Undaunted, editors Rob Appleby and Connie Potter matched CERN scientists with writers tasked to turn their research areas into accessible short stories. The 13 tales, accompanied by afterwords from the researchers, take different narrative approaches to elusive quantum ideas, and not every one precisely strikes its target. But the collection grounds speculation in scientific, and social, reality – unlike Dan

"Few domains seem to pose a tougher challenge to narrative art than the CERN particle physics lab"

Brown's *Angels and Demons*, which turned on the theft of weapons-grade antimatter from CERN.

One story, Bidisha Mamata's *Afterglow*, cleverly delivers a parody of Brown's potboiler, complete with an antimatter-obsessed genius and an apocalyptic finale. Her enjoyably outlandish tale triggers a sober discussion (by CERN partner Kristin Lohwasser) of safety measures and the realities of radiation exposure.

Other stories weld idea-rich plots to close-up observation of CERN's

Inside CMS, one of the Large Hadron Collider's key experiments, in 2017

facilities: a scruffy concrete village, cluttered with tinfoil, cables and yellowing printouts. Some authors tilt towards CERN's social context, as Luan Goldie does in *Marble Run* with a hard-pressed mother (a supersymmetry specialist) who imagines "things that aren't, but could be" while the real world blocks her path. In *Dark Matters*, Lucy Caldwell sends her protagonist back to Belfast, and a dying parent, to ponder the pull of family gravity.

In contrast, hardcore sci-fi voyagers may boldly go straight for part of CERN's conceptual core, with stories prompted by the quest to understand dark matter. In *Going Dark* by former *Doctor Who* showrunner Steven Moffat, snoopers into this hidden substance find themselves "unpicked from the fabric of reality" ("implausible but not impossible", deems researcher Peter Dong in his afterword). And Ian Watson's witty *Skipping* resolves the hoary sci-fi problem of interstellar travel times with craft that "jump" on graviton beams across a scrunched-up, non-Euclidean tablecloth of space.

With *Gauguin's Questions*, veteran sci-fi world-builder Stephen Baxter aims highest of all, inventing a moon-based AI investigator whose millennia-long stewardship of particle colliders identified "an intelligence of the past that wrote its story into our sky". This vision feels light years away from CERN's tangled wires and coffee stains. But, as scientist Carole Weydert writes in response to Goldie's tale, there "every grey concrete wall holds the promise of undiscovered truths just below the surface". *Collision* lets laypeople glimpse, and share, some of them. ■

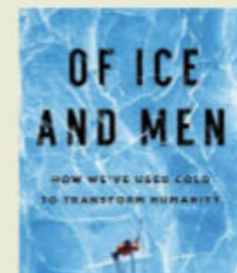
Boyd Tonkin is a critic based in London

Don't miss



Watch

Star Wars: The Bad Batch returns for its second season. Presumed dead by the Empire, Clone Force 99 must decide whether to live in hiding or risk everything by fighting. Watch the animated series now on Disney+.



Read

Of Ice and Men is historian Fred Hogg's entertaining take on our relationship with ice. It has shaped civilisations, from freezing our food to saving lives in medicine, as well as via melting glaciers due to climate change. On sale in the UK from 2 February.



Visit

Predators and People must learn to live safely alongside each other, says Adam Hart, author of *The Deadly Balance: Predators and people in a crowded world*. He is speaking at the Royal Institution in London at 7pm GMT on 2 February.

The film column

Be careful what you wish for In the chilling new sci-fi horror *M3gan*, a young orphan is cared for by a new-generation android tasked with protecting her from emotional and physical harm. What could possibly go wrong, asks **Simon Ings**



Simon Ings is a novelist and science writer. His website is simonings.net



GEOFFREY SHORT/UNIVERSAL STUDIOS

Cady (Violet McGraw) listens as the android M3gan reads to her

“Purrfect Petz” (fuzzballs that quote Wikipedia while evacuating plastic pellets) can’t possibly understand this. The point of parenting is to manage your own failure, leaving a child capable of handling the world on their own. M3gan, on the contrary, has no intention of letting Cady grow up. As far as it is concerned, experience is the enemy.

In this war, M3gan transforms, naturally enough, into a killing machine. Yet the android’s charge is a far more frightening creation: Cady is a bundle of hurt, afforded no real guidance, adrift in a world where she believes everything will eventually go wrong or die. A screaming 9-year-old slapping her well-intentioned but workaholic aunt across the face makes for infinitely more disturbing viewing than any scene involving M3gan.

“Robotic companionship may seem a sweet deal,” wrote social scientist Sherry Turkle in 2011’s *Alone Together*, “but it consigns us to a closed world – the loveable as safe and made to measure.”

Cady, born into this world of care robots, eventually learns that the only way to get through life is to grow up. But the real lesson is for parents. Children aren’t meant to be easy. They are meant to be worthwhile. If we absent ourselves from their lives, we are the ones who will be left poorer.

At a conference on human-machine interaction in 2014, I saw a video starring an “educational robot” called Nao. It took a while before someone in the audience – not me, to my shame – spotted the obvious flaw: why does it show a mother sweating away in the kitchen while a robot is enjoying quality time with her child? ■



Film
M3gan
Gerard Johnstone
On general release

Simon also recommends...

Book
Metropolis
Thea von Harbou
This visionary novel, written in tandem with the screenplay to Fritz Lang’s movie of the same name, depicts a city more in love with machines than people.

Film
The Illustrated Man
Jack Smight
Ray Bradbury’s short story collection The Illustrated Man is turned into a film by Jack Smight. In one story, The Veldt, children gambol across a virtual reality savannah populated by man-eating lions.

AFTER doing something unspeakable to a school bully’s ear, chasing him through a forest like a wolf and then driving him under the wheels of a passing car, M3gan, the world’s first “Model 3 Generative Android”, returns to comfort Cady, its inventor’s niece. “We’ve learned a valuable lesson today,” it whispers.

So has the audience: before you ask a learning machine to do something for you, it helps if you know what that thing actually is.

M3gan is tasked by its inventor, Gemma (Allison Williams, who starred in production company Blumhouse’s earlier smash hit, *Get Out*), with caring for her niece, Cady (Violet McGraw). Cady has been orphaned after her parents accidentally drove under a snow truck during an argument about policing her screen time.

M3gan is told to protect Cady from physical and emotional harm. What could possibly go wrong? Quite a lot, it turns out.

Gemma works for a toy company called Funki, whose CEO David (Ronny Chieng) is looking for a way – any way – to take a swipe

at Hasbro. In a rush to succeed, Gemma ends up creating a care robot that – to paraphrase *The Terminator* – absolutely will not stop caring. M3gan takes the ordinary knocks that life dishes out to Cady very personally.

The robot, depicted via a low-budget mixture of masks and CGI, performed by Amie Donald and

“The point of parenting is to manage your own failure, leaving a child capable of handling the world on their own”

voiced by Jenna Davis, is an uncanny glory. But the signature quality of Blumhouse’s films isn’t so much its skill with low budgets as a willingness to invest time and money into scripts. In developing *M3gan*, writers Akela Cooper and James Wan – the latter of whom directed the horror film *Saw* – found there was greater currency in mischief than in mayhem.

Caring for a child involves more than just distracting them. Alas M3gan, an evolution of Funki’s

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HERMAN PONTZER Duke University
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NABIL NEZZAR

“We’re essentially rewriting the whole story of cosmology”

To better explain the cosmos we see, physicist **Neil Turok** has proposed the existence of a mirror-image universe stretching back in time from the big bang. He tells Thomas Lewton why it is such a compelling idea – and how it might be tested

COSMOLOGICAL inflation is the idea that, in its first moments, the universe underwent a sudden, extreme expansion. This is widely accepted because it explains why space-time is almost perfectly flat and why matter in the cosmos appears so smoothly distributed on the largest scales. Or does it? The trouble is that there are many versions of inflation, most of which wouldn't lead to the universe we observe – and the need for such “fine-tuning” of the theory to match observations makes some physicists nervous.

Among them is Neil Turok, former director of the Perimeter Institute for Theoretical Physics in Waterloo, Canada, and now at the University of Edinburgh, UK. Turok, alongside Latham Boyle at the Perimeter Institute, has proposed an alternative to inflation that can explain the evolution of the early universe without fine-tuning. In 2018, by taking seriously one of the deepest symmetries of nature, they arrived at a mind-boggling hypothesis: a mirror universe stretching backwards in time from the big bang.

An unobservable anti-cosmos is hard to swallow. It didn't help that the observations of strange particles by the ANITA telescope in Antarctica, initially invoked as potential evidence for the idea, turned out to be a false alarm. But Turok and Boyle have developed their thinking. Now, following a flurry of papers, they argue that the mirror universe explains all the stuff that inflation can, but also several other mysteries, including that of dark matter and dark energy. They have even made testable predictions in an attempt to win over sceptics.

Thomas Lewton: Can you first explain how the idea of inflation became dogma?

Neil Turok: Inflation was based on an “aha!” moment around 1980. People were building grand unified models of particle physics, which encompass all the known fundamental forces and particles, except for gravity. To make the models work, they had to introduce fields with potential energy. When you couple these fields to gravity, their potential energy behaves a bit like an explosive: it causes the universe to blow up in size. The explosive expansion can turn a small, lumpy universe into a huge, smooth, flat universe like the one we see around us.

The second insight, which persuaded many people, is that inflationary expansion isn't perfectly smooth and uniform. The field that drives inflation fluctuates quantum mechanically, so that inflation lasts longer in some places than in others. As a result, the early universe becomes slightly lumpy. Much later, the denser regions collapse to form galaxies while the less dense regions expand to form the voids between galaxies.

It seems to explain a lot about the universe we see today. What is the problem?

What makes some of us uneasy about inflation is that it is contrived. You must assume that inflationary potential energy was dominant in the early universe and strong enough to start the explosion. You must adjust the initial conditions and the potential energy to keep inflation going for a sufficiently long time. Then, you must adjust the parameters in the model to get the right level of lumpiness.

For example, the temperature of the radiation from the hot big bang, known as the cosmic microwave background, varies across the sky by only a few parts in a hundred thousand. Inflationary models don't explain that small number: they are just adjusted to fit it. Because there are so few independent ways available to test inflation, and so much freedom to build and adjust inflationary models, inflation can seem more like a “just so” story than a compelling explanation.

The great theories of physics are quite different. James Clerk Maxwell's theory of electromagnetism has very few adjustable parameters in its equations and makes a vast array of testable predictions. Likewise, Albert Einstein's theory of gravity has essentially only one adjustable number, telling you how strongly gravity couples to matter. Yet it predicts a great diversity of phenomena, from black holes to gravitational waves, each of which has been verified by experiments.

How did those suspicions lead you to the idea of a mirror universe?

Our first step was a surprisingly trivial observation. We know that the early universe was dominated by hot radiation. This means that, if you rewind the clock from there, the size of the universe shrinks to zero in a very simple way. Mathematically, you can follow a straight line which cuts through the big bang. This allows us to extrapolate backwards to another “mirror image” copy of our universe on the other side of the big bang.

Our universe and its mirror image are ➤

related by a symmetry of nature called CPT, or “charge-parity-time reversal”, symmetry. CPT symmetry is based on deep principles of quantum theory and general relativity that have been confirmed in many experiments. The “charge” bit means you take every particle in our universe and exchange it with an anti-particle. The “parity” bit means that you take a right-spinning particle in our universe and replace it with its left-spinning version. And the “time reversal” aspect means that you run time backwards in the mirror universe.

To be clear, our universe by itself does not seem to respect CPT symmetry. Time only runs forward, and there is more matter than antimatter. But the combination of our universe and the mirror universe no longer violates CPT symmetry. This was the driver behind our mirror universe idea.

If you were a resident on the other side, in the mirror universe, how would you know?

You wouldn't. It's impossible to determine by any local measurement which “side” you are on. We're not postulating a pre-big bang universe, somehow different from our universe. Instead, the pre-bang and post-bang universes are mirror images of each other.

Are there mirror image copies of the sun, Earth and even us in the mirror universe?

Classically, the mirror universe is the exact mirror image of ours. Quantum mechanically, things are more subtle, because you have to take quantum uncertainty into account. When a quantum state is observed, there are many possible outcomes, each with its own probability of being measured. In the mirror universe picture, there are strong correlations between what would be observed on the two sides of the big bang, but the exact pattern of variations would not be identical. So, most likely there isn't another Thomas Lewton or a *New Scientist* magazine on the other side of the big bang. Nor can we communicate with the other side because the time an observer would perceive only progresses forward, away from the big bang and we cannot alter our past.

What makes you think this mirror universe explains our universe better than inflation?

It wasn't until last year that the mirror universe picture began to fall into place. We understood

“It's hard to convey how predictive the mirror universe idea has been”

how the smoothness and flatness of the universe, on large scales, could be explained without any need for inflation.

We used a mathematical tool called gravitational entropy – originally devised by Stephen Hawking and others to count the number of ways a black hole could be made from quantum units of space-time. You can use the idea of entropy, a measure of disorder, to explain the most likely state of a physical system. For example, when you carefully count the number of ways that the air molecules in a room can be arranged, in the vast majority of cases the molecules are very evenly distributed around the room. The probability that they will pile up in a corner is tiny.

Using Hawking's method we were able to calculate the number of possible cosmic histories for a mirror-symmetric universe filled with radiation, matter and dark energy. Dark energy is added to explain the accelerating expansion of the universe. We found that the vast majority of universes that resulted are very smooth and flat, and that a small amount of dark energy is favoured. Our universe is expected in the mirror universe theory. We no longer need inflation to understand the smoothness and flatness of the universe.

What is different in terms of the birth and evolution of the early universe in this picture compared with the big bang plus inflation?

According to inflation, the early universe explodes into an infinite number of wildly different universes, known as the inflationary multiverse. Observations show no evidence for this. Indeed, as we examine the universe at larger and larger scales, we find it becomes more and more simple.

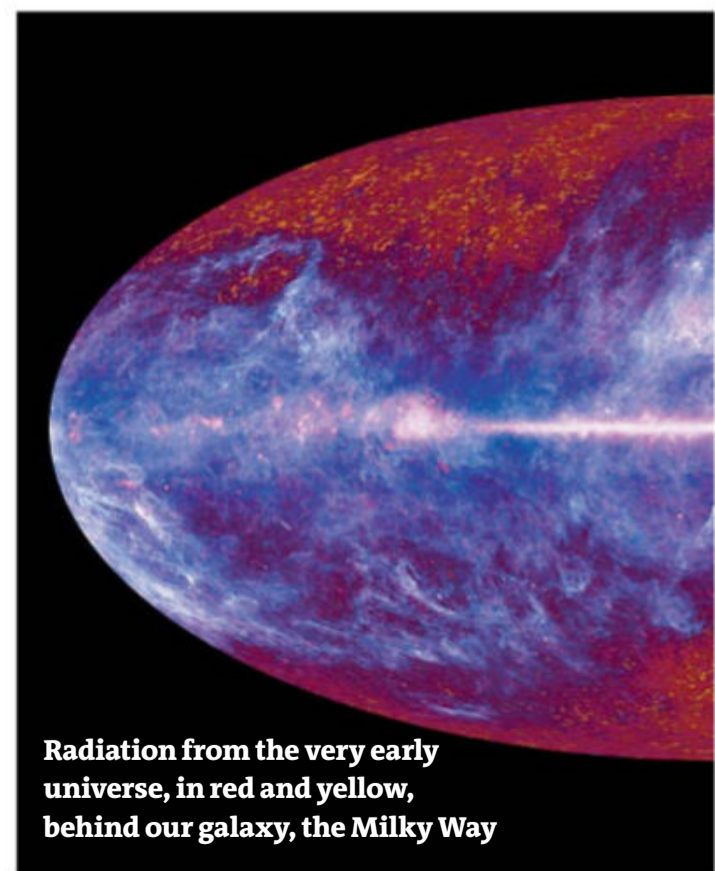
The mirror universe picture is far more economical, predictable and uniform. The two sides of the universe grow steadily in opposite directions away from the big bang, governed by the known laws of gravity and particle physics. The extreme simplicity of the large-scale universe, which is very smooth and flat, is a direct result of the simplicity of these laws.

You also say the mirror universe goes further, explaining things inflation can't.

In 2018, we realised our idea could solve the puzzle of dark matter, the mysterious substance that holds galaxies together, in terms of particles that we have not directly seen but already have strong evidence for. These are called right-handed neutrinos. They have been invoked since the 1970s to explain the tiny masses of left-handed neutrinos, which have been observed. Whereas every other model of dark matter postulates a completely new particle, we don't have to. That came as a huge surprise.

You have just released the final paper in your series on the mirror universe, which has caused a bit of a stir. Can you explain why?

Having explained dark matter and the flatness



Radiation from the very early universe, in red and yellow, behind our galaxy, the Milky Way

and smoothness of space-time, we faced a final, huge puzzle. Inflation causes tiny variations in the density of the early universe, known as primordial vacuum fluctuations, which become large-scale variations in the density of matter in the universe. These fluctuations lead to galaxy clusters and voids, and they are seen directly in the cosmic microwave background radiation. If inflation never happened, where did they come from?

Last year, we had this idea that it's to do with strange hypothetical fields that don't have any particles, called "dimension zero fields". When you add these fields to the fields in the standard model of particle physics, they create fluctuations in the expansion of the universe of the right form to match the fluctuations that we see in the cosmic microwave background. In the mirror universe, the cosmic microwave background fluctuations are a direct image of the primordial vacuum fluctuations.

So, you don't have to blow anything up?

Exactly. And here's the really remarkable result. We can predict the strength of the fluctuations from our mirror universe theory. It turns out to agree with the very precise measurements made by the Planck satellite and other

experiments, without the need for fine-tuning. Inflationary models have to fine-tune in order to match the same data.

There is more. Virtual particles pop in and out of existence in the vacuum as quantum theory allows them to borrow energy for a short amount of time. People have worried about this for a long time because if you add up the energy in all these virtual particles, it's infinite. There are various mathematical tricks for ignoring the infinity, but this is most likely telling us that something is wrong. A surprising property of these dimension zero fields is that they can cancel out the vacuum energy.

You have said it can solve another, closely related puzzle, too.

Yes. The quantum fields in the standard model of particle physics have important symmetries which we believe are fundamental to their mathematical consistency. But when we study quantum fields in a curved space-time, like a black hole or an expanding universe, some of the symmetries are spoiled by infinities – just like those in the vacuum energy. When we added just the right number of dimension zero fields to the standard model, all of these infinities cancelled. The infinite vacuum energy and the symmetry violations all disappear. This cancellation also requires that there are three and only three generations of elementary particles – including, for example, electrons, muons and taus – just as we see.

It's hard to convey how much more predictive the mirror universe idea has turned out to be than we ever expected. You have to pinch yourself! It's taken us by surprise, because with a few small tweaks to known physics we're essentially rewriting the whole story of cosmology.

If it explains so much, why are many cosmologists hostile to the idea?

We haven't faced outright hostility. We've been pleasantly surprised. Among the community of people who are more open-minded to alternatives, many are very curious. There is, however, a very large body of scientists who have been focused on building inflationary models and fitting them to the data. They tend to be sceptical about an entirely new framework. Communities who have spent

decades working on inflation are naturally reluctant to change.

Do you make solid predictions?

I take observations extremely seriously. Good science has to prove itself. I've opted for economical theories, which are predictive and can be ruled out. If they prove successful, rival theories will fall by the wayside. But we're not yet at the point where our story is compelling and fully supported by observations.

What observations would persuade people?

Number one: show that the lightest neutrino is massless. If dark matter is composed of stable, right-handed neutrinos – as in our mirror universe picture – then this must also be true. Fortunately, within three to five years, large-scale galaxy surveys will make that measurement. If they find that it's massless, then we'll really be on a good road.

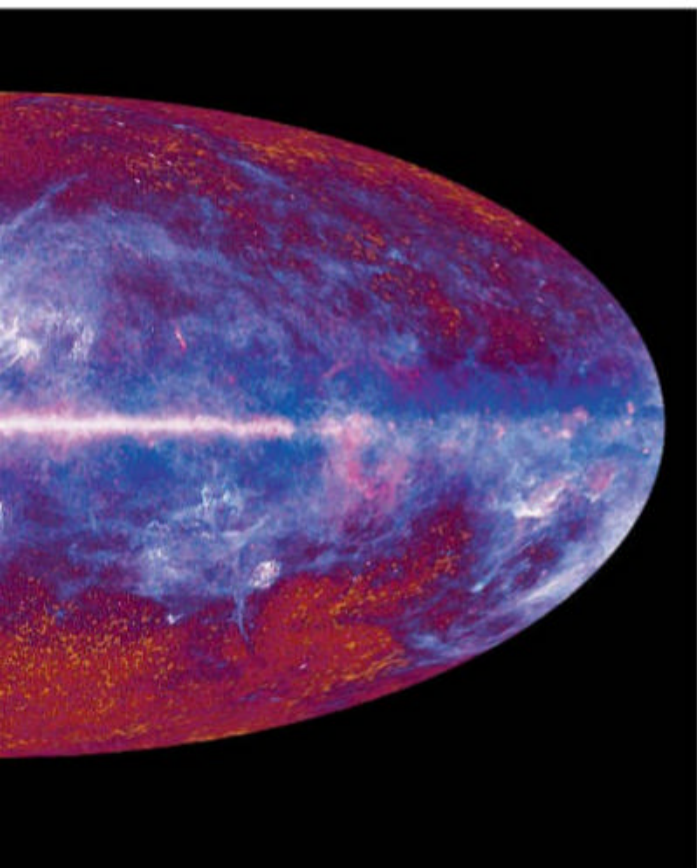
Number two: when you look at the fluctuations in the cosmic microwave background on the largest scales, those predicted by the mirror universe are slightly different to inflation. There are already hints that the inflationary models don't quite fit with observations. It may be that our theory does better. But I am not sure when the observations will become accurate enough to allow a decisive comparison.

What are the chances we will actually resolve these questions around the big bang?

Einstein famously said that the Lord is subtle, but not malicious. In cosmology, nature has posed some profound puzzles: the big bang, the origin of matter, energy and time. Nature is subtle, but it's also been extremely generous to us. From the same laws of physics that we learned in our backyard – on Earth and in the solar system – we predicted black holes and gravitational waves. We have no right to understand such remote phenomena. It's kind of absurd. In order for us to understand the universe, we must hope that nature's generosity continues. I work on the assumption that it will. ■



Thomas Lewton is a science journalist based in London, UK



ESA, HEI & LEI CONSORTIA (2010)

A whole-body mystery

New insights into the causes of polycystic ovary syndrome could revolutionise the treatment of this common but neglected condition, reports **Alice Klein**

I WAS 19, my face raging with acne, when my dermatologist started asking me questions that seemed to have nothing to do with my skin. “Are your periods regular? Do you have any excess body hair?” he asked. “You may have polycystic ovary syndrome,” he concluded. I had no idea what he was talking about. “It can make it difficult to have children,” he said as he saw me out.

Reeling, I went to my family doctor, who ordered blood tests and an ultrasound of my ovaries that confirmed I had polycystic ovary syndrome, or PCOS. But she admitted she didn’t know much about it, leaving me confused and miserable about this mysterious condition I had suddenly been saddled with.

Many of my friends have recounted similar experiences. Despite PCOS being the most common hormonal condition among women aged 18 to 45 and a leading cause of infertility, it has been hard for us to get a straight answer about what it actually is or what to do about it.

Seventeen years on from my diagnosis, however, the tide is turning. Researchers are finally piecing together the causes of PCOS and it is being taken seriously as a condition that doesn’t just affect the ovaries, but also has cardiovascular, metabolic and psychological repercussions. As a result, the condition is even set to get a different name later this year (see “Misleading moniker”, page 45). And what’s more, this clearer understanding is opening up routes to new treatments.

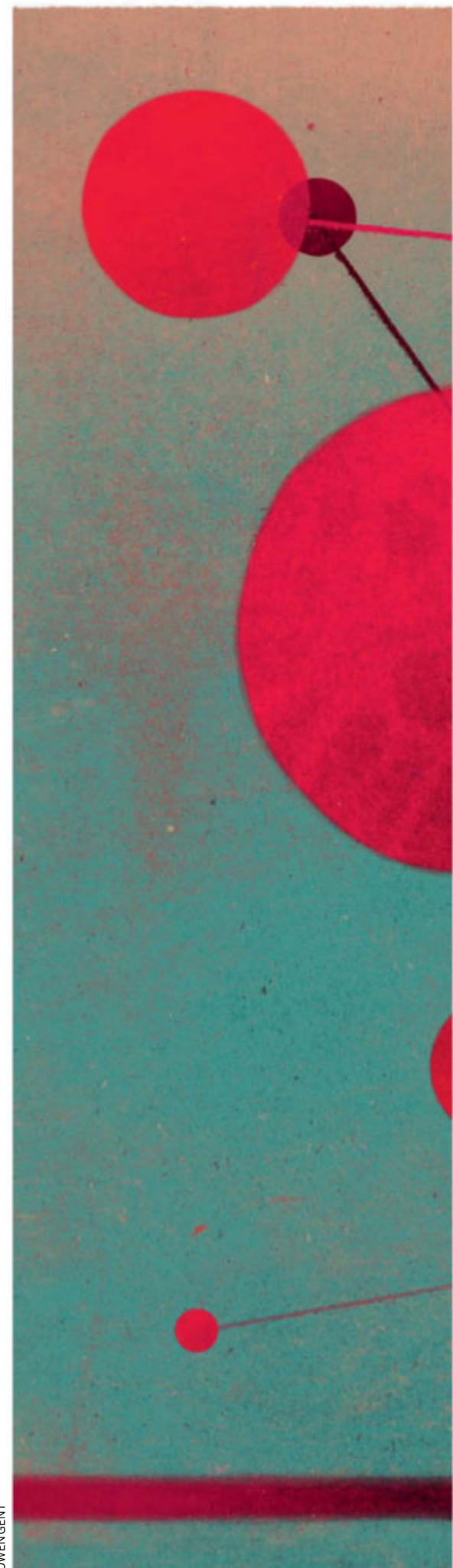
The first doctors to characterise PCOS were Irving Stein and Michael Leventhal at

Northwestern University in Chicago. In 1935, they published a report on seven women with similar symptoms: cysts on their ovaries, irregular or no periods, unsuccessful attempts to become pregnant, and some with acne, obesity or excess hair on their faces or bodies. The condition was originally called Stein-Leventhal syndrome before later becoming known as polycystic ovary syndrome.

Today, a PCOS diagnosis is based on having two of three characteristic features. The first is high levels of male sex hormones like testosterone, which can cause acne, excess hair on the face and body and thinning head hair. The second is irregular or no periods, which occur because eggs often haven’t developed properly in the ovaries. This prevents their regular monthly release in the form of ovulation, meaning that it can take longer to become pregnant. The third is the presence of 20 or more “cysts” on either ovary, which are now understood to be eggs that are stuck in an immature state, rather than actual cysts.

Multiple impacts

In addition to these key features, around 50 to 70 per cent of individuals with PCOS develop resistance to insulin, which can lead to higher levels of this hormone, type 2 diabetes, weight gain, high blood pressure and heart disease. PCOS also increases the risk of endometrial and pancreatic cancer, and can cause anxiety, depression and reduced sex drive in some people.



OWEN GENT



The psychological effects may be directly caused by hormonal imbalances. Alternatively, they might arise because “if you’re a teenager, when PCOS symptoms emerge, and you’re gaining weight rapidly, you have significant acne, your periods are all over the place and you have body hair where you don’t want it, it can have a really significant impact on your self-esteem”, says Helena Teede at Monash University in Melbourne, Australia.

Finally, people with PCOS who become pregnant are more likely to have miscarriages or complications like gestational diabetes or preterm birth.

PCOS affects around 5 to 18 per cent of cis women and up to 58 per cent of trans men, although the reason why this latter figure is higher has yet to be pinned down. Despite being relatively common, it has long been one of the most neglected health conditions, says Teede. “It’s twice as common as diabetes but gets less than a hundredth of the funding,” she says. Elisabet Stener-Victorin at the Karolinska Institute in Sweden tells a similar story. “Up until about 10 years ago, I would never put ‘PCOS’ in the title of my research grant applications because it really dragged down my chances of getting funding,” she says.

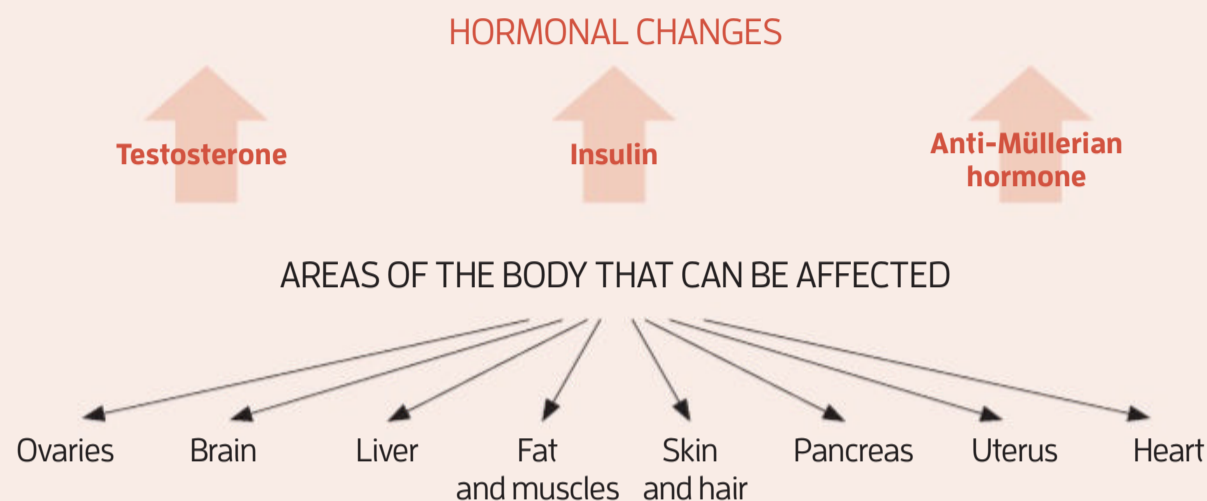
Part of the problem is that it is “everybody’s business and nobody’s business”, says Teede. The many symptoms of PCOS, which vary widely between individuals, means it is managed by a range of health professionals: endocrinologists, gynaecologists, reproductive specialists, dermatologists, primary care doctors, dieticians and so on. For a long time, no one was sure who should be steering the ship and each speciality treated PCOS differently, which “constantly created confusing messages”, says Teede.

To rectify this, Teede led the development of the first international, evidence-based guidelines for PCOS, which were published in 2018. They were based on consultations with more than 3000 health professionals and people with the condition from 71 countries. “We needed a really strong cut-through with all the experts in the world saying the same thing,” she says.

The guidelines explain how to diagnose PCOS and manage it using existing treatments. Diet and exercise interventions are recommended to begin with, since these have been shown to simultaneously improve the ➤

Not just ovaries

Polycystic ovary syndrome is associated with elevated levels of three hormones, which can affect many different organs and tissues



metabolic, reproductive and psychological features of the condition. This is because diet and exercise can assist weight loss and improve blood sugar control, which, in turn, reduce insulin and testosterone levels.

Personally, I have had some luck with lifestyle management. I tried a low GI (glycaemic index) diet after reading a small study that showed that 95 per cent of women with PCOS who adopted this diet – which involves eating foods that minimise blood sugar spikes – developed more regular periods. Amazingly, my menstrual cycles shortened from around 70 to 40 days when I tried it, but I wasn't able to keep it up long term because of my love of white rice and bread.

If lifestyle changes aren't enough, certain medications can also help. The oral contraceptive pill, for example, can regulate periods and reduce acne and unwanted body hair. A drug called isotretinoin can also ease acne – it cleared mine up in a matter of weeks – and laser treatment can remove unwanted hair. Letrozole can stimulate regular ovulation in individuals trying to conceive and metformin can help to combat insulin resistance and weight gain.

These treatments don't always work, however, and they don't get to the root causes of PCOS. "There is no cure so far – all the treatment options available treat the symptoms and not the disease itself," says Paolo Giacobini at the French National Institute of Health and Medical Research. He and others are now trying to develop PCOS-specific drugs.

To do this, they first need to understand exactly what drives the condition. A starting

point is that it often runs in families. Stener-Victorin and her colleagues, for example, found that women in Sweden were five times as likely to be diagnosed with PCOS if their mother has the condition. No single gene has been found to be responsible for PCOS, but certain patterns of genes involved in testosterone production, ovarian function and metabolism appear to be linked with the condition. Still, these genetic variations don't tell the whole story of how PCOS is passed down generations.

Growing evidence suggests PCOS-related hormonal imbalances during pregnancy can also have an effect on the fetus. "In a woman with PCOS, you have both the genetic factors and the in utero environment," says Stener-Victorin. "I think it's likely that you may carry some susceptibility genes and then you have an in utero environment that triggers its onset." Two hormones suspected to be involved in this in utero effect are testosterone and anti-Müllerian hormone (AMH), both of which tend to be elevated in those with PCOS.

Stener-Victorin and her colleagues have found that injecting excess amounts of a form of testosterone into pregnant female mice caused their female offspring to develop many of the hallmarks of human PCOS, including irregular cycles, and greater fat mass and body weight. Similarly, when Giacobini's team injected excess AMH into pregnant female mice, their female offspring had irregular cycles, the appearance of "polycystic" ovaries, elevated testosterone, insulin resistance, higher body weight and greater fat mass. "We now have an animal model that not only

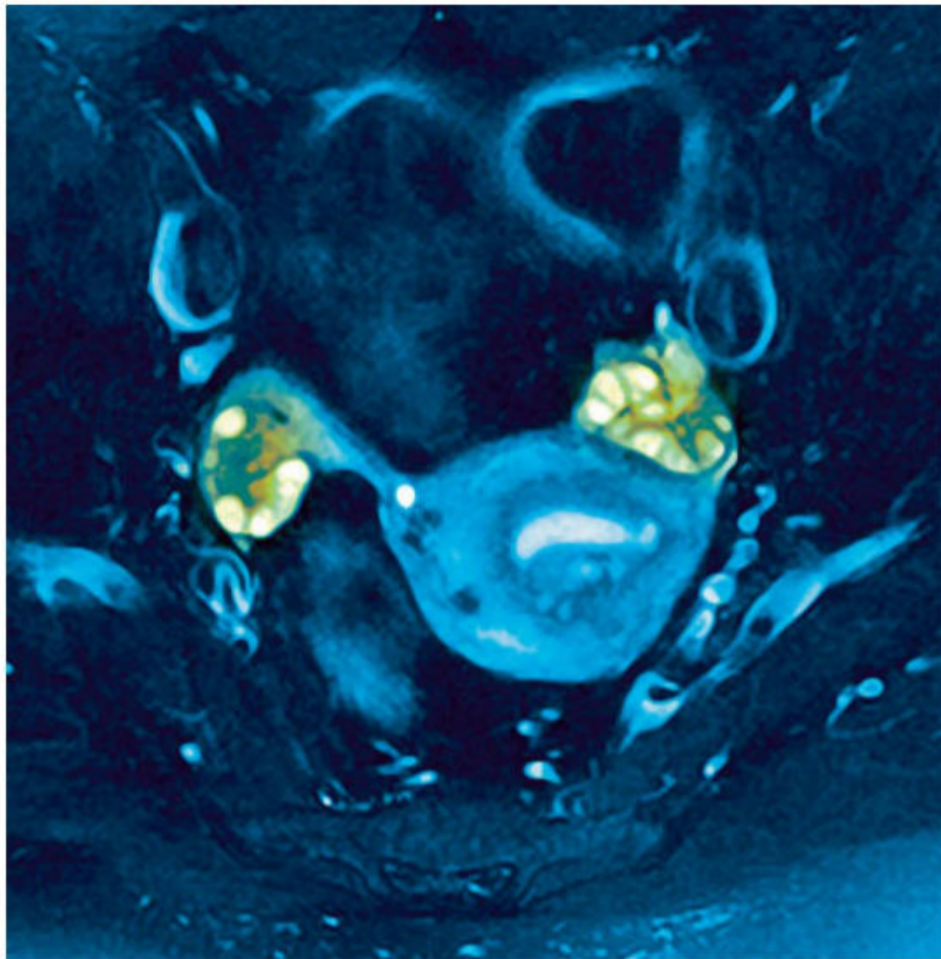
recapitulates the reproductive aspects of PCOS, but also the metabolic component seen in many women," says Giacobini. "So, we can use these animals to really investigate the disease and design new treatment options."

Most recently, his team discovered that the daughter mice with PCOS-like symptoms, whose mothers were injected with excess AMH during pregnancy, had altered expression of several genes involved in inflammation. This has led Giacobini to believe that PCOS is actually an inflammatory condition. His team found increased expression of inflammatory genes in the brain, ovaries, liver and fat of the mice, which he says may explain why these organs are all affected by the condition (see "Not just ovaries", left). This fits with emerging evidence of a link between inflammation and PCOS in people. A 2021 analysis led by Saad Amer at the University of Nottingham, UK, for instance, found that women with PCOS had significantly higher levels of an inflammatory marker called C-reactive protein compared with those without the condition.

Could these findings lead to new treatments? Giacobini's team has spent the past few years developing drugs to lower AMH levels. The researchers are about to test these in mice, before hopefully progressing to human trials. "But we need to be very cautious because there are AMH receptors in different parts of the brain and a range of organs," he says. "We cannot predict yet whether such treatment may trigger undesirable side effects until we fully comprehend the role of AMH in all those organs." Interestingly, AMH declines with age, which may explain why some with PCOS who were unable to conceive naturally in their 20s and 30s are able to do so in their 40s, when their AMH levels fall into the normal fertility range, says Giacobini. This delayed fertility window could also be the reason why those with PCOS reach menopause four years later than average.

New way forward

Another treatment option may be drugs that correct the altered expression of inflammatory and other genes implicated in PCOS, says Giacobini. Last year, his team showed that PCOS-like symptoms could be reversed in female mice by giving them a drug called S-adenosylmethionine that corrected the altered gene expressions. This drug couldn't be safely given to people because it affects too many other genes, but it may be possible to develop more tailored treatments in the future, says Giacobini.



“There are many mysteries of PCOS that still need to be unravelled”

Left: A scan showing white “cysts” in the ovaries. Right: PCOS can lead to high blood pressure and other problems



Teede says these approaches are worth pursuing, but cautions against extrapolating too far from animal studies. “PCOS is not caused by one mechanism, it’s multiple mechanisms that add up together,” she says. “If you’ve got an animal model that uses one mechanism to induce a PCOS-like status, you might be able to reverse that one mechanism, but treating a complex multifactorial condition in humans is harder.”

In the meantime, Teede believes that PCOS management could be vastly improved just by providing people who are diagnosed with the condition with better information

about what it is and how to manage it.

There are still many common misconceptions about PCOS that need to be addressed, she says. For example, my biggest worry when I was diagnosed was that I wouldn’t be able to have children – a concern that is very common, says Teede. In fact, “research shows that women with PCOS have the same family sizes as others, often they just need a bit of a help”, she says. “That doesn’t have to be IVF – medication that stimulates ovulation is often all that’s required.”

To help bust these myths, Teede and her colleagues released a free app called AskPCOS

in 2018 that provides evidence-based answers to the 93 most common questions asked about the condition. “It’s now in 12 languages and is used by about 30,000 women in 176 countries,” she says. “It’s important to have something like this because there’s so much rubbish out there – people are trying to make money off vulnerable women by selling diets and supplements for PCOS that have no evidence.” At the same time, her team has created simple resources for health professionals to allow better diagnosis and management.

My own journey with PCOS has been unpredictable. After all those years worrying that I wouldn’t be able to have a family, it was a happy surprise to conceive my two children naturally. However, there were several miscarriages along the way that may have been related to my PCOS.

The next twist came after my pregnancies, when my once erratic periods suddenly became like clockwork and have continued like that to this day. This is apparently quite common, although no one knows why.

There are many mysteries of PCOS that still need to be unravelled, but it seems like we are finally gaining a better understanding of the condition and improved diagnosis, education and treatment. I just wish I could go back to that 19-year-old girl leaving the dermatologist’s in tears and tell her it was going to be alright. ■

Misleading moniker

Is it time to rename polycystic ovary syndrome? There is a growing push to do so since it is now recognised as a whole-body condition, people can be diagnosed with it even if they don’t have “polycystic” ovaries and we now know that the “cysts” are undeveloped eggs, not actual cysts.

“We desperately need a name change,” says Helena Teede at Monash University in Melbourne, Australia. “The name should reflect what it actually is. Having a name

around the ovaries misses the diversity of the condition.”

Teede and her colleagues are consulting health professionals and people with the condition to agree on a new name – the most preferred one at this stage is “reproductive metabolic syndrome”.

They hope to formalise this name change in the middle of this year when they release an updated version of the international guidelines on the diagnosis and treatment of the condition.



Alice Klein is a reporter for *New Scientist*

Ocean avalanche

Vast, mysterious currents can drag huge amounts of silt into the depths, reshaping the sea floor. We are finally getting to grips with these mighty marine movements, writes **Kate Ravilious**

IN NOVEMBER 1929, a huge earthquake in the Grand Banks off the south coast of Newfoundland in Canada sent tremors as far as New York. As the sea floor shook, a vast quantity of sand and mud began to stir up and flow down a canyon, gathering momentum as it went, creating a dramatic underwater avalanche. It involved enough material to make two Mount Everests and triggered a tsunami that killed more than 25 people.

This is the biggest known example of an undersea avalanche, but it wasn't a one-off. Beneath the waves, the largest avalanches in the world regularly occur in Earth's coasts and oceans, carving out the deepest and longest canyons on our planet. Most of the time, they happen without anyone noticing.

For hundreds of years, the only witnesses to these events were fish and deep-sea creatures, which might have been carried out to sea or fed by the nutrient-rich sediments that the currents carry with them. More recently, ruptured gas pipelines and broken communication cables were proof that something extreme was going on. Over the past few years, however, things have started to change.

Now, thanks to a series of experiments and a bit of luck, we have captured these Earth-carving events in action. It turns out the mazes of underwater canyons, many of which were long thought to be geologically inactive, are anything but. Armed with new data, researchers have begun to piece together a better picture of what submarine avalanches are like, how they shape Earth and their vital role in locking away the carbon warming our world.

The deepest and longest canyon systems on the planet are similar in scale and shape to the Grand Canyon in Arizona. But unlike their counterparts on land, carved out by the constant scouring action of sand and gravel

carried by rivers, underwater canyons are created by erratic avalanches that cascade off the continental shelf and down to the deep ocean (see "Ocean falls", page 48). Rivers dump silt onto the continental shelf where it heaps up, eventually becoming unstable – or sometimes topples after being given a shove by an earthquake, storm or flood – tumbling off the shelf and sculpting a canyon system as it goes.

The sediment flows, also known as turbidity currents, transport more material than any other natural process on Earth. They carry sediment rich in organic carbon and sweep up debris as they go, including decaying seaweed, plant material and marine life. As they swoosh onto the abyssal plain – a flat area that covers more than 50 per cent of the sea floor – these flows create a mosaic of specialised habitats, exposing methane-bearing sediments in some regions while smothering other areas to create lobes of oxygen-free muds. This unusual environment supports diverse and unique ecosystems including specialised chemosynthetic communities, such as tubeworms and vesicomid clams, usually found near hydrothermal vents, sustained by hydrogen sulphide and methane. Sea cucumbers dig decaying morsels out of the freshly deposited mud, while pom-pom anemones are swept along, occasionally landing on a meal.

The avalanches self-accelerate and gain energy, like their snowy equivalent on a mountain. "This means they can travel huge distances into the deep sea and transport vast amounts of material," says David Hodgson, a geologist at the University of Leeds in the UK.

These huge shifts in sediment play a role in Earth's carbon cycle, burying carbon contained in organic matter and locking it away at the bottom of the ocean for millions of years.

But getting a handle on exactly how much carbon they carry has been challenging. "We've not been able to collect information from these massive flows, partly because they are rare and unpredictable," says Hodgson, "and partly because they trash our equipment."

A small proportion of the 9000 or so submarine canyons we know of are still connected to river mouths at the coast. But around three-quarters became detached from their rivers when sea levels rose following the last glacial period. Now, these detached canyons lie far out to sea.

About 300 kilometres south-west of Cornwall, UK, sits the Whittard Canyon, a Grand Canyon-sized network of channels that juts into the North Atlantic Ocean. Since it is the only submarine canyon that enters waters over which the UK has rights, Mike Clare, a marine geohazards researcher at the National Oceanography Centre in Southampton, UK, applied for funding to study it. "To be honest, I wasn't initially that excited," he says. "The prevailing view was that there was no obvious way of triggering turbidity currents in a detached canyon, so I thought it was going to be boring."

Caught in the act

Nevertheless, in June 2019, Clare and his team placed two deep-water moorings in the canyon and wired up instruments to monitor sediment movement, in the hope of capturing an underwater avalanche. They also placed a rotating carousel of bottles 10 metres above the sea floor at the first mooring to catch sediment. Then, they waited. To their surprise, within three weeks, they had caught one in action.

Over the following year, they recorded six of these avalanches, each lasting several



PETER REYNOLDS

hours. “We thought this canyon would be dead, so it was a real surprise to see this activity,” says Clare. More than 1000 of the world’s submarine canyons have a very similar setting to the Whittard Canyon. “We’re having to reassess our views on how these canyons work and how active they can be.”

One puzzle was the timing. “If there was going to be any activity, we’d expected it to be in autumn and winter, when storms stirred up the stock of glacial sediment,” says Clare. But the findings show that most turbidity flows occur during spring and summer.

A hint as to why came from the sediment caught in the bottles, which was full of fresh marine-based organic carbon. “Our suspicion is that the turbidity currents are being fed by blooms of algae at the head of the canyon,” says Clare. Many of the world’s canyons provide a focal point for upwelling, where surface ocean currents draw up cool, nutrient-rich water from the deep and create a productive region teeming with life. “It’s why you get whales near the heads of canyons,” says Clare. Regions like this draw a lot of carbon dioxide out of the atmosphere and into organic matter, but for that carbon to be locked away for good, it needs to reach the deep ocean quickly, before it has a chance to be oxidised back into CO₂. Canyons like Whittard might provide a previously unrecognised superhighway for marine carbon to get to the ocean floor.

In October 2019, Peter Talling at Durham University in the UK and his team set out to capture another underwater avalanche. This time, their target was still connected to a river. The researchers anchored 12 moorings fitted with transmitters along the floor of the Congo submarine canyon. They began near the head

of the canyon, which lies within the estuary of the Congo river on the coast of West Africa, and distributed the rest down the canyon system. The last mooring was placed around 1200km offshore at a depth of nearly 5000m.

The moorings were meant to stay put for a year, carrying instruments that monitor the water column and sediment flows beneath them. But, just a few months later, in January 2020, something curious happened. The researchers received alerts that the moorings had popped up on the surface. “At first, we thought maybe one or two of the moorings had been disturbed by fishing boats,” says Megan Baker at Durham University, who was part of the project. But, one by one, in a regular fashion, each mooring sent an automated email to say it had surfaced. “We started to think something major had happened,” says Baker.

They were right. A sediment avalanche had started at the mouth of the Congo river. As it moved, it gathered speed – reaching about 30km/h – and turned into an underwater flow that travelled for more than 1130km, making it the longest sediment flow ever measured. It carried a huge amount of sediment and dumped it on the South Atlantic abyssal plain at a depth of more than 5000m. Two major seabed telecommunication cables were sliced by the flow, causing the internet to slow significantly across much of Africa, from Nigeria to South Africa.

The fact that the moorings had been caught in such a huge current was exciting, but there was a problem. Their anchors had been broken by the powerful flow and they had to be recovered before researchers could read their data. Each was just three times the size of a football and was lost in the Atlantic as the

Tsunami starters

Some 8000 years ago, a massive chunk of Norway’s continental shelf collapsed. Known as the Storegga Slide, around 3200 cubic kilometres of sediment plummeted to the ocean floor. The resulting tsunami travelled as far as Greenland and Canada, with waves of more than 20 metres high crashing over the Shetland Islands in the UK. Some propose the event may have drowned Doggerland, an area once above the waves, but now submerged by the North Sea, cutting the UK off from Europe.

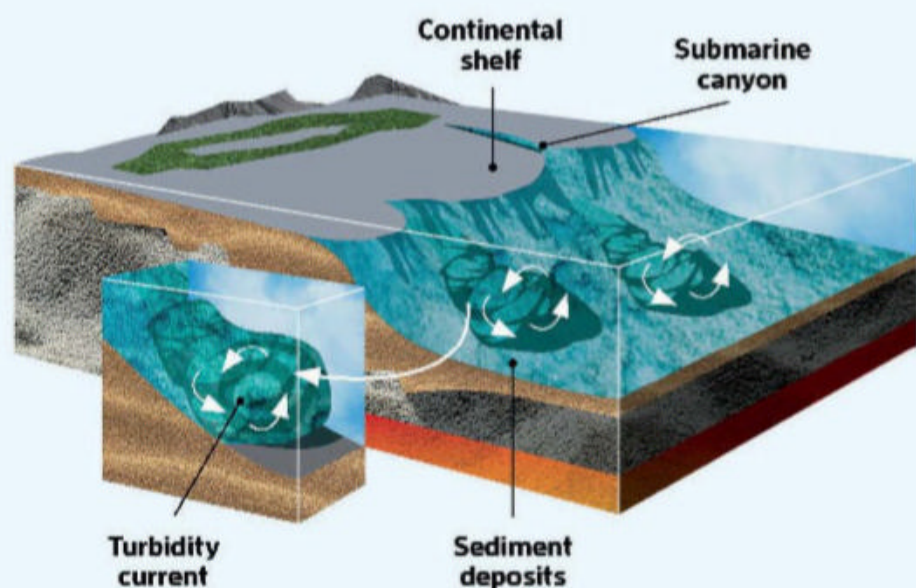
As opposed to the flow of a turbidity current (see main story), submarine landslides shift a coherent lump of sediment in one single, dramatic movement. But like turbidity currents, submarine landslides hadn’t been measured until recently.

Wenyuan Fan, a seismologist at the Scripps Institution of Oceanography in California, wasn’t looking for landslides when he started analysing seismic readings from the Gulf of Mexico. “I was looking for earthquakes,” he says. “But then my attention was drawn to lots of odd seismic signals lighting up the Gulf of Mexico, which was a surprise because this isn’t an active tectonic area.”

Fan and his colleagues identified 85 previously unknown submarine landslides in the gulf between 2008 and 2015, 75 of which were triggered by the arrival of waves emanating from earthquakes as far away as 1500km and with magnitudes as low as 5. “We’ve never been able to link these events over such a long distance before,” says Fan. It isn’t yet clear whether the Gulf of Mexico – which has jelly-like sediments – is a special case or whether remote earthquakes are triggering submarine landslides in other parts of the world, too.

Ocean falls

Every so often, erratic flows of material cascade off the continental shelf through submarine canyons to the deep ocean



covid-19 pandemic was erupting. To make matters worse, the batteries in the moorings would only survive for three months. “I never expected to get any of them back,” says Talling.

Luckily, there were clues. “The automated email told us the time that each mooring arrived at the ocean surface, which gave us a rough idea of where they might be,” says Talling. Boats were directed to the places where the moorings had first popped up. The vessel sent to repair the internet cables was one of the first to reach the scene and it joined in the hunt, recovering five of the sensors before they strayed too far or ran out of battery. Nine of the moorings were eventually recovered.

Canyon-flushing floods

In July 2022, the team’s results were published, revealing even more astounding details. We know earthquakes can trigger canyon-flushing avalanches, like the Grand Banks event. But the Congo turbidity current showed that river floods can also instigate them. Three weeks before the Congo avalanche, the Congo river had its largest flood in more than 50 years.

“The flood will have washed a lot of sediment into the upper part of the canyon, in the Congo river mouth, but it didn’t instantly trigger a flow,” says Talling. “Instead, the sediment stacked up for a few weeks before toppling – that was a surprise.” Exactly what made the sediment finally topple isn’t yet clear, but the flows are more likely to start at low tide, when gas bubbles trapped in the sediment are able to expand, weakening the sediment structure.

Huge canyon-flushing events could be far more frequent than previously expected, in the Congo Canyon at least. Major earthquakes might trigger a canyon-flushing event every 100 to 300 years, but the Congo river experiences a significant flood every 20 to 50 years. And smaller flows, carrying sediment around 200km, also seem to be fairly frequent. It has been shown that the upper reaches of the canyon are active around one-third of the time.

This might sound worrying, especially for cable breaks, but there is a potential upside. In future, with flooding predicted to increase due to climate change, there could be more underwater flows, burying more carbon. “We used to think most organic carbon washing off the land was dumped on the continental shelf,” says Talling. This would mean much of it was oxidised and returned to the atmosphere as CO₂. “But these results show that over geological timescales – thousands of years – turbidity currents could be an important mechanism for locking away carbon that we’d previously almost ignored,” he says.

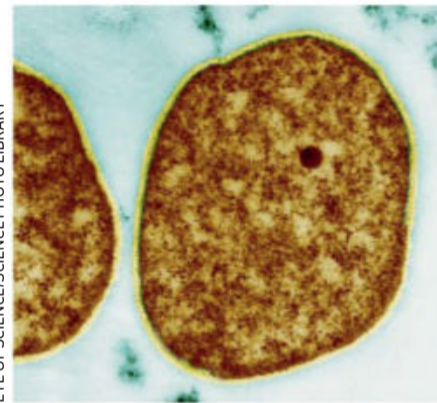
Right now, geologists are still at the stage of trying to quantify how much carbon is



Chemosynthetic organisms like sea worms (below left) and some archaea (below right) are usually found near hydrothermal vents (left). But they can survive on the sediment stirred up by undersea avalanches too



PHILIPPE CRASSOUS/SCIENCE PHOTO LIBRARY



EYE OF SCIENCE/SCIENCE PHOTO LIBRARY

transported this way, but if turbidity currents are a significant carbon pump, as the Congo and Whittard measurements suggest, then we will need to alter our models of the carbon cycle.

Sadly, carbon isn’t the only thing turbidity currents are transporting to the sea floor. “Pesticides, pharmaceuticals and plastics will also be ending up in large quantities in the deep sea via these flows,” says Hodgson. “That’s worrying because they are entering the base of the food chain and we don’t know what kind of impact they will have.”

Previous research has shown that 99 per cent of the 8 million tons of plastic entering the ocean each year is unaccounted for. The suspicion is that much of this ends up in the deep ocean, but how it gets there has – until now – been a bit of a mystery. “It’s starting to look like turbidity currents are an important mechanism,” says Hodgson.

The Congo Canyon study made geologists

“Pesticides, pharmaceuticals and plastics end up in the deep sea via these flows”

rethink just how monumental these flows can be. “Our estimates suggest that the equivalent of one-third of the sediment eroded by all the rivers in the world in one year was flushed down this canyon in one single event lasting a couple of days,” says Talling. In recent years, research is suggesting that underwater landslides, another kind of Earth-shaping marine event, are also happening much more than we thought (see “Tsunami starters”, page 48). All in all, there seems to be a lot more going on than we had ever realised.

Now, researchers are keen to venture further afield and investigate other detached canyons. Top of the list is the Amazon Canyon, one of the biggest submarine channels in the world, which starts about 200km off the coast of Brazil and extends more than 1000km into the South Atlantic.

Vast quantities of organic carbon are leached from the Amazon rainforest into the Amazon river, then washed out onto the continental shelf. “Given what we are seeing in both the Whittard and Congo submarine canyons,” says Clare, “I think we need to be asking more questions about the fate of that organic material.” ■



Kate Ravillious is a freelance journalist based in York, UK



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The science of cooking

Good eggs

They might sound simple, but a dash of science (and acid) can help create perfect scrambled eggs, says **Sam Wong**



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

What you need

2 eggs

1 tsp lemon juice or vinegar

Salt

Butter (melted in pan before adding egg mix)

IN THE three years since I started this column, I have somehow avoided writing about eggs, even though I cook them for breakfast most weekends. What is there to learn about such a simple food?

Quite a lot, it turns out. An egg may look the same from day to day, but it is undergoing subtle changes even before you crack it open. Water vapour and carbon dioxide escape through tiny pores in the shell, raising the pH of the egg white. Air diffuses into the shell, expanding the tiny air sac inside. For this reason, a fresh egg sinks in water, but an oldish one will stand on end at the bottom of a water-filled container and an even older one will float to the surface.

As the egg white becomes more alkaline, it gets less viscous because of weakening interactions between some of the proteins in it. If you try to fry or poach an old egg, the white spreads apart instead of holding together neatly.

In a raw egg, the protein chains are tightly folded up. When heated, these chains unravel, or denature, and this allows them to bond to neighbouring proteins, creating a gel that traps water.

Various egg proteins denature and coagulate at different temperatures, but, in general, the white becomes solid at around 65°C (150°F) and the yolk at 70°C (158°F). In professional kitchens, “boiled” eggs are often not boiled, but cooked in a water bath at 65°C to produce reliably runny yolks.

When it comes to scrambled eggs, the ideal for me is a super-



4KODIAK/GETTY IMAGES

soft and moist consistency. If they are overcooked, the proteins bind together too tightly and squeeze out water, making the texture firm and dry.

That means gentle heat and constant stirring are the way to go. It is important to turn off the heat just before the eggs reach the desired consistency, as residual heat in the pan will keep them cooking a little longer.

Others prefer light and fluffy scrambled eggs: this requires relatively high heat so that pockets of steam form within the eggs as they coagulate.

In either case, salting the eggs before cooking helps achieve a more tender result. Most egg proteins have a negative electrical charge, so they repel each other to some degree. Salt supplies positive

sodium ions, which gather around the negatively charged regions and help them approach each other while mostly folded up. The result is that they can't intertwine and bind so tightly when heated.

Acids have a similar effect: they cause proteins to denature at a lower temperature, but also help them coagulate before they have fully unwound. For extra-soft scrambled eggs, try adding a teaspoon of lemon juice or vinegar to two eggs before cooking.

It might sound odd, flavour-wise, but I find that the slight acidity actually works well with the richness of the egg, just as it does in hollandaise sauce. ■

The science of cooking appears every four weeks. Share your cooking successes with us on Twitter and Instagram @newscientist, using the hashtag #NewScientistCooking

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Stargazing at home

These articles are posted each week at [newscientist.com/maker](https://www.newscientist.com/maker)

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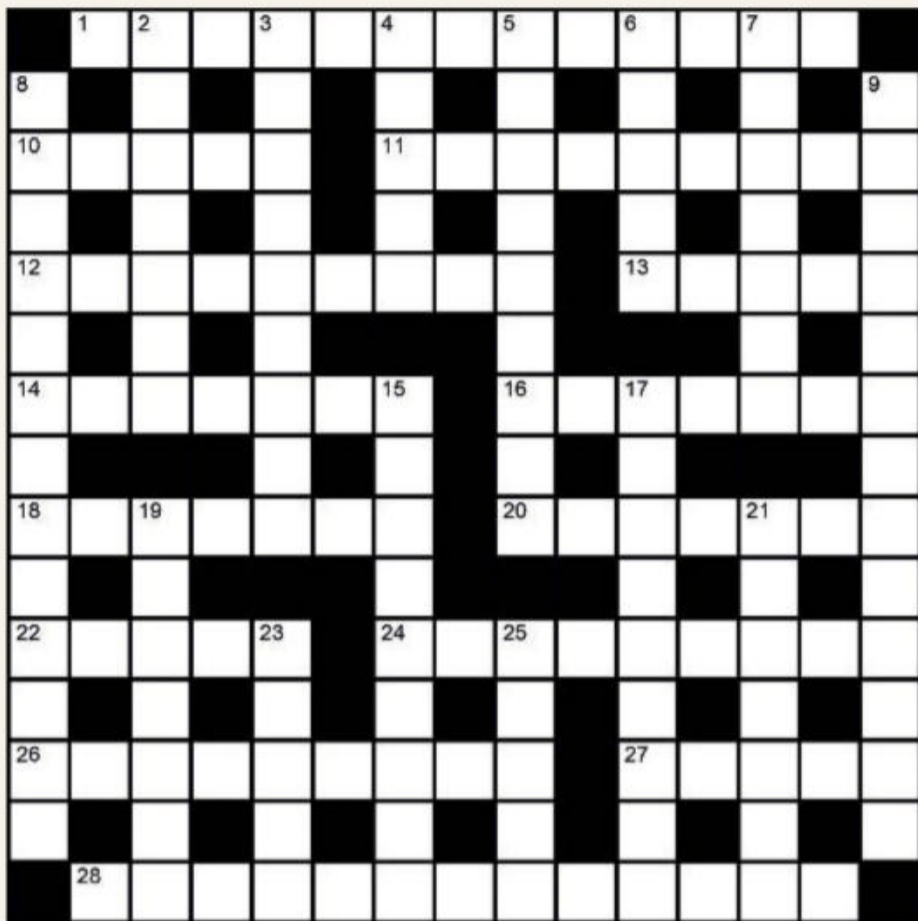
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Quick crossword #125 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

- 1** Having the same number of component molecules (1,3)
- 10** 2011 book by the economist Tim Harford (5)
- 11** See 2 Down
- 12** Self-governing (9)
- 13** Part of an insect thorax (5)
- 14** Tissue layer in plants and trees (7)
- 16** Molecule that regulates gene expression (7)
- 18** Part of the throat (7)
- 20** Online personas (7)
- 22** Space-based counterpart of SHIELD, in Marvel comics (5)
- 24** Cookware manufacturer founded in 1925 (2,7)
- 26** According to the median, mean or mode (2,7)
- 27** Signalling and communication medium developed in the 1890s (5)
- 28** Industrial means of producing sodium carbonate (6,7)

DOWN

- 2 / 11 Across** Calculating devices that make use of subatomic phenomena (7,9)
- 3** Strength; amplitude; ferocity (9)
- 4** ___'s razor, logical principle (5)
- 5** 2014 sci-fi film by Alex Garland (2,7)
- 6** 180-degree redirection (1-4)
- 7** Free of harmful microorganisms (7)
- 8** Moving part in a steam cylinder (7,6)
- 9** Process by which a molecule may be restructured (1,3)
- 15** Relating to the upper jaw (9)
- 17** Of an opposite, complete, exact (9)
- 19** Alligator pear (7)
- 21** The aphelion and perihelion, for example (7)
- 23** The European Commission Directorate-General for the Environment (abbreviation) (2,3)
- 25** Transparent; lucid (5)

Quick quiz #186

set by Bethan Ackerley

- 1** Which 19th-century journalist and politician was a pioneer in the field of mechanical refrigeration?
- 2** Of these species, which is the world's longest venomous snake: the king cobra, the reticulated python or the Hispaniola racer?
- 3** Comet Swift-Tuttle is associated with which annual meteor shower?
- 4** Georges Urbain, Carl Auer von Welsbach and Charles James all independently discovered which element?
- 5** What is the most abundant neurotransmitter in the human central nervous system?

Answers on page 55

Puzzle

set by Colin Beveridge
#206 All square

"What ho!" boomed Aunt Nicola. I could tell she was about to talk cricket at me. "Have you been following the test match between Pythagorea and Lagrangia?"

"Auntie, you know I prefer Navier-Stokes to Ben Stokes." "Well," she said, "you might be interested – there's maths involved! In their first innings, Lagrangia's total score was a square number."

"Innings?" I asked. "It's the word for a team's turn to bat. They each have two. In their first, the Pythagoreans also got a square number, but they were more than 300 behind!"

"That sounds insurmountable." "You might think so," she said. "Then, when Lagrangia batted again, they added a different square number – less than 50 – so that their lead and overall total were also square numbers."

"Goodness." "But the Pythagoreans battled back in their second innings," she continued, "and the game ended dramatically in a tie."

I then knew enough to work out the totals of the four innings in order. What were they?

Solution next week



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Other universes

How could I theoretically reach other dimensions in the multiverse if they exist?

Nick Canning

Coleraine, County Londonderry, UK

According to physicist Max Tegmark, there are at least four distinct meanings of “the multiverse”. All are to modern physics as “the aether” was to pre-relativistic physics: theoretical constructs with no measurable consequences. They are entities (or rather an infinity of entities) that are “ascientific”, meaning in principle unfalsifiable.

Physicist Paul Dirac would condemn this sort of theorising as “not even wrong”. It has left the realm of physical reasoning and is rather pure mathematical speculation. This is fascinating, yet leaves us with hypothetical universes imagined to exist

“There is currently no conceivable way to get to these multiverses, if they exist, and they may only be possible and not actual”

alongside our own, but that can’t communicate or interact with us in any way.

How many such universes exist? How many angels can dance on the head of a pin?

David Nye

Eau Claire, Wisconsin, US

Pet peeve alert: contrary to assertions in some bad sci-fi, it is impossible to travel to a dimension. We can only travel in a dimension. In three-dimensional space, we can move along an x, y or z axis or some combination of those, but not to x, y or z.

There are several proposed multiverse ideas. One suggests that there may be other universes that share our x, y, z and t (time) coordinates, but have a different w (fifth dimension) coordinate. We would have to find a way to move



FLASHPOI/GETTY IMAGES

This week’s new questions

Humour me People say “laughter is the best medicine”, but does it actually help? *Kush Modi (age 11), Santa Clara County, California, US*

Cold noise I live near Gatwick airport and am so used to the noise of planes that I rarely notice it. However, during a recent cold spell, the planes were a lot louder than usual. Why would this be? *Kieran Evans, Horley, Surrey, UK*

along the w axis to visit them, which is currently not even theoretically possible.

Another idea is that the big bang started as a sort of bubble in a larger universe, which may be full of other such bubbles. If there is an edge to our universe, to get beyond it, we would have to travel close to the speed of light for longer than our universe has existed, since light coming back to us that has been travelling since near the time of the big bang doesn’t reveal an edge.

A third idea is that the other universes are like the quantum probabilities of a particle’s state that exist before it is measured, each of these possibilities existing in a separate possible universe. There is currently no conceivable way to get to these if they exist,

and they may only be possible, not actual.

@PrideOfHumility, via Twitter

To travel between realities, they need to be in proximity. To be in proximity and not interact, they need to be incompatible. If it is a compatible universe you could travel to, it is already here. Bridging universes with different laws of physics doesn’t sound like a good idea.

@alieninsect, via Twitter

It isn’t a problem of reaching other dimensions as such, but of somehow gating the flow of information from those dimensions into the brain such that it begins modelling those dimensions. Some say this technology already exists

Does laughter really have any positive effects on our health?

in the form of certain psychedelic molecules, such as DMT.

@IanTower1, via Twitter

The obvious answer is DMT due to the fact that you can’t expect to leave this dimension while your consciousness is still here, you need to let go of this consciousness that is stuck in this dimension – theoretically, of course.

@aktiesajt, via Twitter

Walk through two slits at the same time without being measured.

June Edgar, via Facebook

Through a wardrobe?

Spence Holmes, via Facebook

Kundalini yoga has always been a firm favourite.

@JosephAbel, via Twitter

Dryers. Spinning steel drum + electric field = gateway to another dimension. Only works for socks, it seems. Perhaps the static in the fabric pulls the things through small wormholes. Somewhere, in another dimension, there are mountains of socks.

Fluffy freeze

Why does my water freeze in this pattern like dandelion fluff (pictured right)?

Alex McDowell

London, UK

As the water freezes, it first forms a crust of ice at the surface and at the interface with the container, and dissolved gases migrate into the part that remains liquid. In the liquid part, the solubility of gases rises as it cools, but the liquid still becomes supersaturated and bubbles form.

Gases are insoluble in ice, hence all the remaining dissolved gases precipitate out as the core finally freezes. This is why the ice cube is transparent in places where it first freezes, with a layer containing



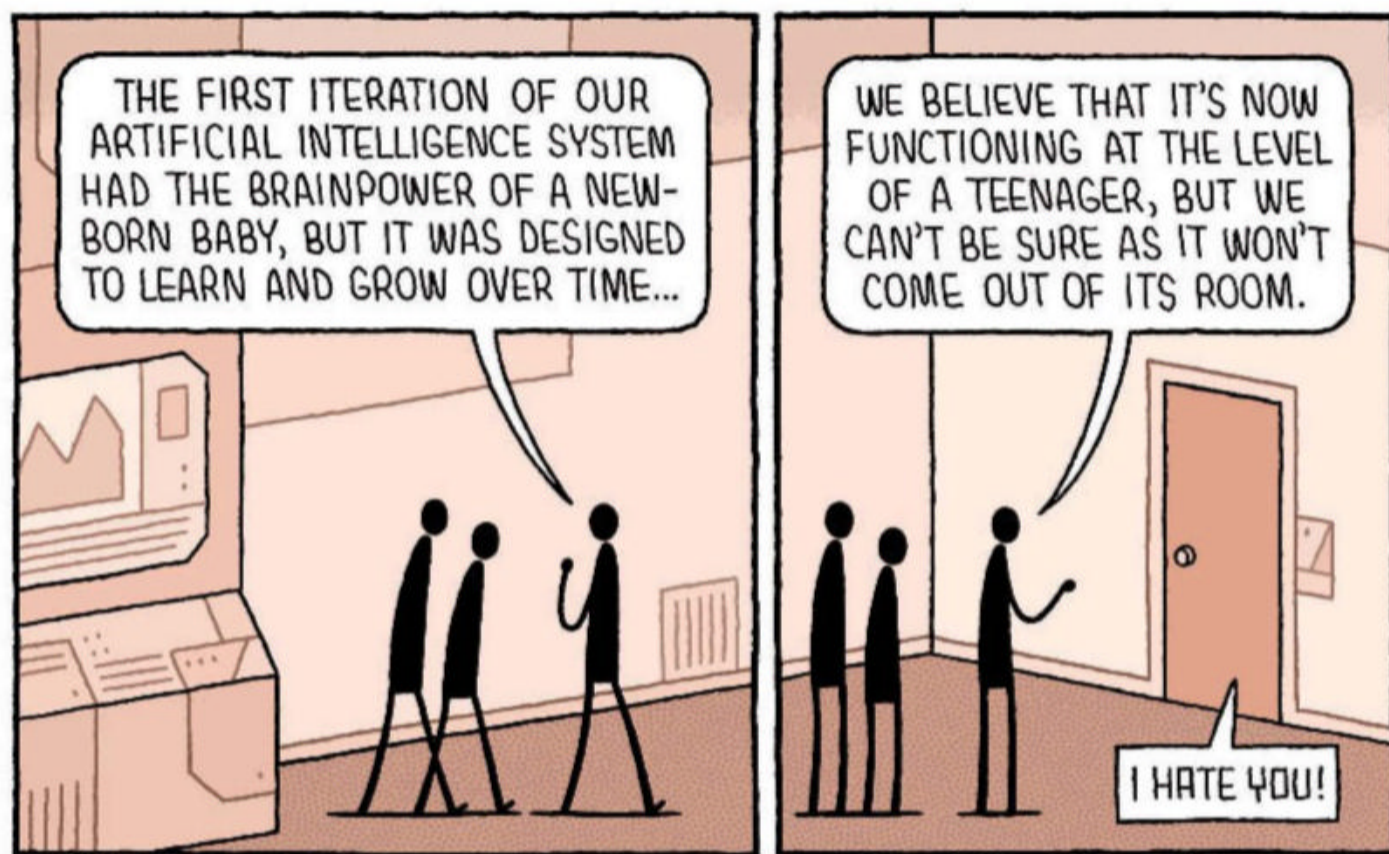
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Tom Gauld
for *New Scientist*



some bubbles and a core that contains many bubbles.

David Muir
Edinburgh, UK

A glass of water in a freezer starts freezing from the outside and this works its way to the centre. Liquid water can hold more dissolved air than ice can, so, as water freezes, air and other impurities are driven into the liquid water.

The first ice to form next to the glass is very pure with no bubbles, so it is transparent. As the ice-water interface moves inwards, the concentration of air in the water increases. When the concentration reaches supersaturation, bubbles form between the ice-water interface and microscopic solid pollutants (dust), which act as nucleation points. These bubbles are captured by the advancing interface, which continues to carry the solid nucleating particles on its surface. This results in rows of bubbles converging towards the centre of the glass.

The number of bubbles increases and their size decreases with faster



ice formation, so the cloudiness at the ice's centre is due to many tiny bubbles being present, indicating that the centre froze much more quickly than the periphery.

For readers who want to know more, an in-depth study of this topic was published by Norikazu Maeno at Hokkaido University, Japan, in 1967.

Viral virtue

We hear about humans having and needing "good bacteria". Are there similarly "good viruses" in our bodies? (continued)

Penny Jackson

Barrow-in-Furness, Cumbria, UK

In addition to the bacteriophages discussed in previous responses

to this question (31 December), there are a few viruses where an infection appears to be beneficial. For example, herpes seems to give the immune system a boost to resist infections by certain bacteria.

There is also a surprising benefit to infection by some retroviruses, which are types of viruses that integrate into the host cell's DNA, modifying the genetic code. This integration can be permanent. It can even get passed on to offspring, making these viral parts common or even universal within the genome of a species (or wider, depending how far back the integration occurred), especially if they provide an evolutionary advantage.

This is the case for at least 8 per cent of our DNA, and some sources say possibly closer to 50 per cent. Not all their functions are known, but some have been identified as possibly having benefits for the immune system. But some probably aren't so helpful, and are associated with a higher risk of contracting certain diseases. ■

Answers

Quick quiz #186

Answers

- 1 James Harrison
- 2 The king cobra
- 3 The Perseids, which peak in mid-August
- 4 Lutetium
- 5 Glutamate

Cryptic crossword

#101 Answers

ACROSS 1 Machinist, 6 Tip, 8 Relic, 9 Citable, 10 Heparin, 11 Nurse, 12 Boom operators, 15 Metre, 17 Camphor, 20 Shorten, 21 Gelid, 22 DDT, 23 Predatory

DOWN 1 Marsh, 2 Calypso, 3 Incur, 4 Incandescence, 5 Titania, 6 Tuber, 7 Precess, 12 Bemused, 13 One-step, 14 Othello, 16 Trout, 18 Magma, 19 Ruddy

#205 Buried shields

Solution

The missing section of the broken shield can't be silver or gold, as those colours would create a shield that is already pictured, so it must be blue.

There are already three shields with two blue sections, as well as three with two grey sections, so the ninth shield must have two gold sections.

The only combination that isn't already pictured is shown below.



God's recent works

What has God done lately? Professionally, much of God's work these days aims to help humans fly more safely, more efficiently and more profitably. As head of the Institute for Aircraft Cabin Systems at Hamburg University of Technology in Germany, Prof. Dr Ralf God is a respected presence in the field of aeronautics.

God's recent paper "A holistic aircraft cabin metamodel as an approach towards an interconnected digitised cabin lifecycle" – prepared in collaboration with colleagues – was presented a few months ago at the 33rd Congress of the International Council of the Aeronautical Sciences in Stockholm, Sweden.

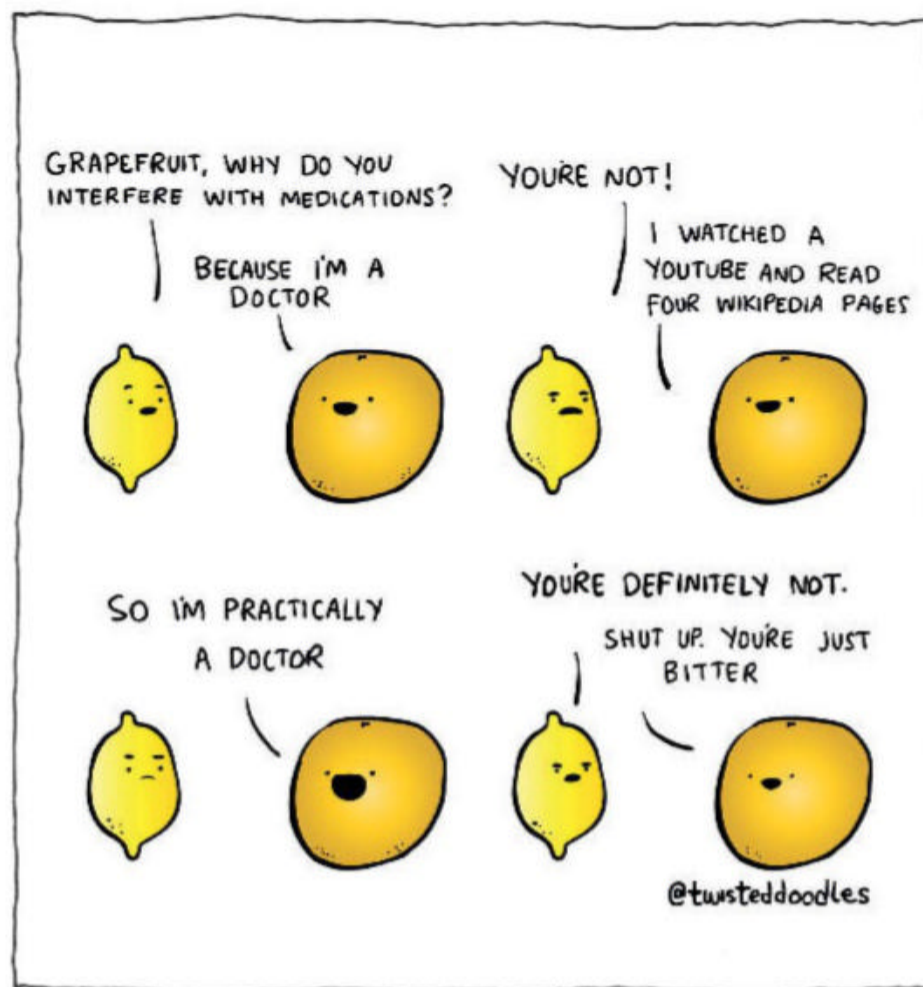
Like much of God's work, it gives careful attention to MRO. MRO is the acronym for maintenance, repair and operations, the purpose of which is "maintaining a facility and the equipment inside it to ensure that everything is in working order and running smoothly".

God's paper gives a masterclass in threading many needles simultaneously. It lists them. To set themselves apart from competitors, airlines cook up "new digital services for passengers, such as controlling seat functions or ordering drinks via their smartphone". They do this while wrestling with "requirements for safety, security, reliability and user-friendliness".

Together, God and his team give hope and evidence, in this one paper, that all those needles can, and maybe will, dance with all those threads.

God, ungreedy, has a firm track record of collaboration, especially on matters of safety and propriety. He shares the credit with colleague Hartmut Hintze for a patent called "Access system for a vehicle and method for managing access to a vehicle". Here, Hintze and God invented a system to prevent evildoers, incompetents and anyone else from entering an aircraft cabin unless they have proper, reliable authorisation.

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Satan, Buddha and Fate

But what of Satan? What of Buddha? What of Fate?

On the public record, Satan has been unproductive recently. But in the 1980s, Jozef Satan applied his expertise at handling high heat. The result was documented by the government of Czechoslovakia in a patent called "Method of liquid waste organical matters liquidation". The heat is key to both efficiency and saving costs.

Satan's innovation offered efficiency to the peoples of Earth as they contemplated a dirty problem: disposing of hazardous waste. "The advantage of the liquid waste organic substances liquidation method," explains the patent document (presented here via Google Translate), "is the complete disposal of organic

waste by incineration at high temperatures and the reliable capture of harmful emissions of sulphur oxides."

Like God, Satan is also on record as being a collaborationist. He shares the inventor credit on his patent with nine colleagues.

And Buddha? Rushidev Buddha of California, with 16 colleagues, has filed a patent application for something called a "stimulation apparatus". The application itself presents more than 200 pages of written stimulation to any receptive reader. It describes an implantable medical device that promises "to deliver stimulation energy to the patient".

Then there is Fate. Timothy Fate and two colleagues entered the picture a decade ago. They filed a patent application that describes their "Method and apparatus for automated differentiated

diagnosis of illness", using the no-one-fully-understands-it-yet power of neural networks. Then, alas – Fate's fate – they abandoned the application.

Brown sauce adventures

When you chew a gob of delicious food, your mouth hosts a circus of mechanical and chemical activities. Dengyong Liu and colleagues at Bohai University in Jinzhou, China, have been teasing out what happens, moment to moment, to the bits and bobs and boluses of food and saliva as a person chows down on the Chinese dish stewed pork with brown sauce. From time to time, they publish a new research study, keeping a fact-hungry world apprised of their findings.

Their latest report, "Effects of the degree of oral processing on the properties of saliva-participating emulsions: using stewed pork with brown sauce as the model", appears in the journal *Food Science and Human Wellness*. Ten women and 10 men each chewed a chop. The paper tells of a simple regimen: "When the panelists were ready to swallow, they raised their hands, indicating that the oral processing was over... Oral processing was divided into five stages based on the chewing time, i.e., 20%, 40%, 60%, 80% and 100% of total chewing time. After completing a certain stage of oral processing, the subjects spit the pellets and saliva into a disposable plastic container and filtered them with four layers of sterile medical gauze."

The scientists analysed the samples, seeing a dramatic change at about the 60 per cent stage. The combined effects of the saliva, the fat, the tongue and the teeth transformed the food into a fairly uniform emulsion, rather than a rough-and-tumble mixture. The researchers' subtle glee at this discovery is evident to the careful reader, who may be tempted to seek out an earlier paper they cite, called "The inheritance, exploration and advance of stewed pork with brown sauce". ■

Marc Abrahams



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