New Scientist

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QUESTIONS OVER OXFORD VACCINE TRIAL

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By Simon Baron-Cohen

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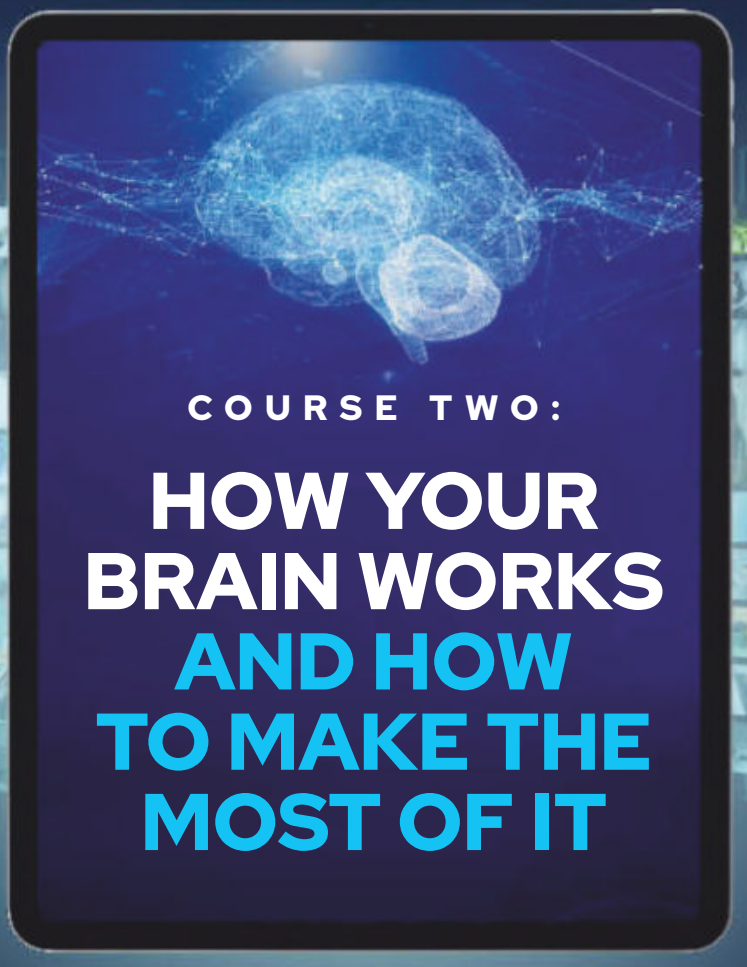

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This week's issue

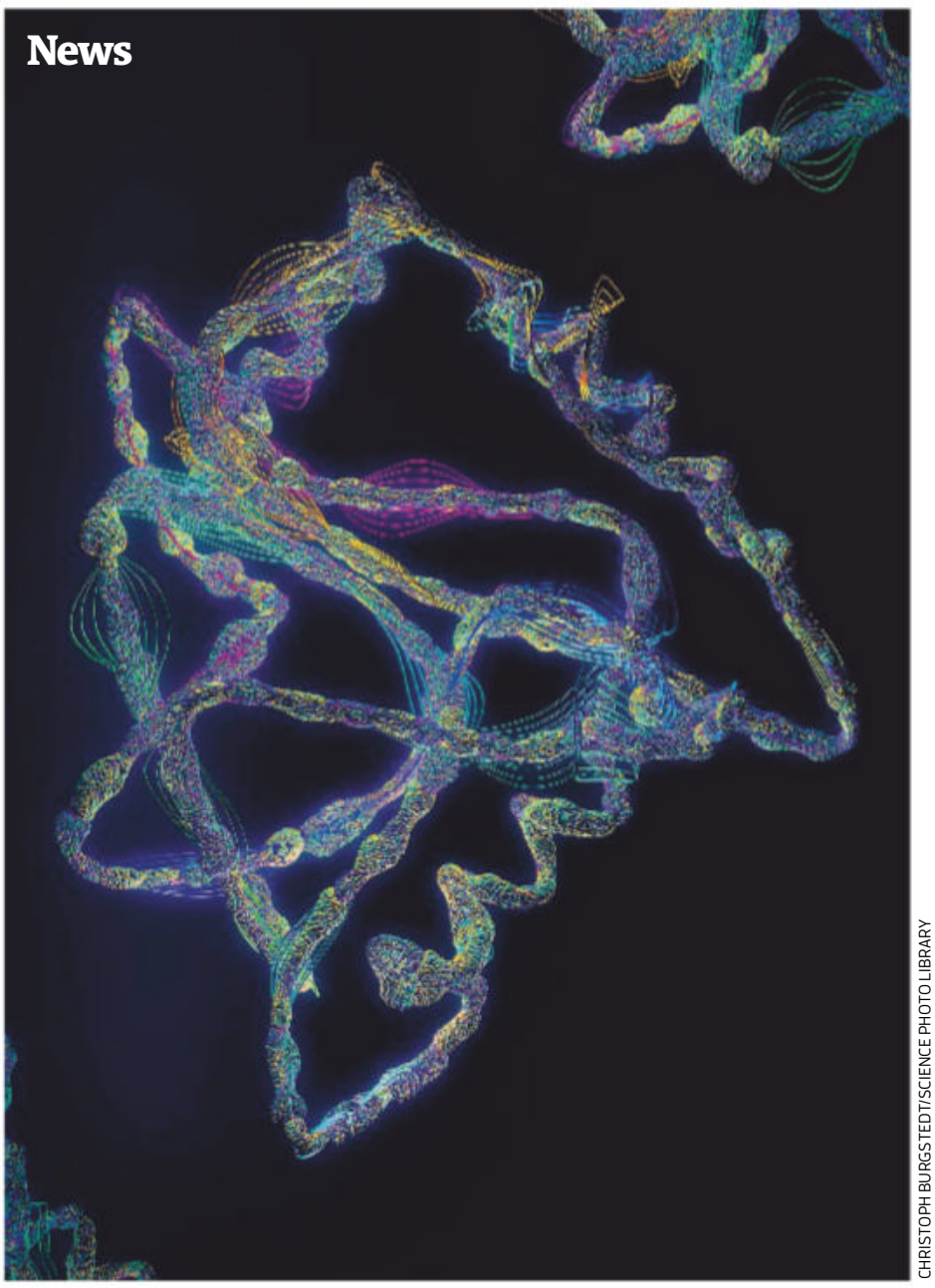
On the cover

34 Your inventing mind
A new theory of how humans came to innovate and create
By Simon Baron-Cohen

Vol 248 No 3311
Cover image: Brian Stauffer

News

Views



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The back pages

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In this week's podcast, vaccine scientist Katrina Pollock answers the biggest questions about covid-19 vaccines, and the team discusses how our universe is expanding too fast, China's moon mission and how nematodes produce "milk".

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Christmas cracker Rowan Hooper will host our special festive event

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Create Training and Educational Videos

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The shape of things to come

DeepMind's latest AI could spark a medical revolution

ALMOST a century ago, a chance discovery revolutionised medicine. Alexander Fleming left a petri dish of bacteria out while he went on a two-week holiday. On his return, he found that the dish had been contaminated by a fungus that produced an antibacterial substance. He named it penicillin, and it has since saved millions of lives.

Even in the modern world, drug discovery still essentially relies on chance. Pharmaceutical companies often screen thousands of compounds trying to find one with the desired effect.

The dream, though, is to make drug development a much faster and more rational process. Almost all the machinery of life is made of proteins, and pretty much every drug works by binding to proteins and changing what they do. In principle, it should be possible to use computers to work out the shape of proteins and then design drugs to bind to specific sites.

Thanks to the genome revolution, it is now easy to discover the DNA recipe for any protein. Figuring out their shapes, however, still requires expensive experiments that can take years. As a result, we know the recipes for 180 million proteins, but the shapes of only about 170,000.

"We know the recipes for 180 million proteins, but the shapes of only about 170,000. That is about to change"

That is about to change, thanks to artificial intelligence. DeepMind's AlphaFold system solves protein shapes like a jigsaw puzzle. It works out the easy bits first, based on what it has learned about other proteins, and then gradually puts all the parts together over a matter of days. It is the first computer-based system to achieve results that match those of experimental methods – but much faster (see page 15).

The hope is that this kind of approach can be extended to predict how proteins interact with other molecules, to find or design drugs that have specific effects. Accomplishing this would revolutionise medicine all over again.

Biologists will still have to carry out lab experiments and clinical trials. Biology is too messy and complicated for artificial intelligence to do all the work. But AlphaFold and its ilk should greatly accelerate the already astonishing pace of progress, and millions more lives could be saved. ▮

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Email media@newscientist.com.au
Australia New Scientist Ltd, ABN 22 621 413 170
418A Elizabeth St, Surry Hills, NSW 2010
UK **Tel** +44 (0)20 7611 1200
25 Bedford Street, London WC2E 9ES
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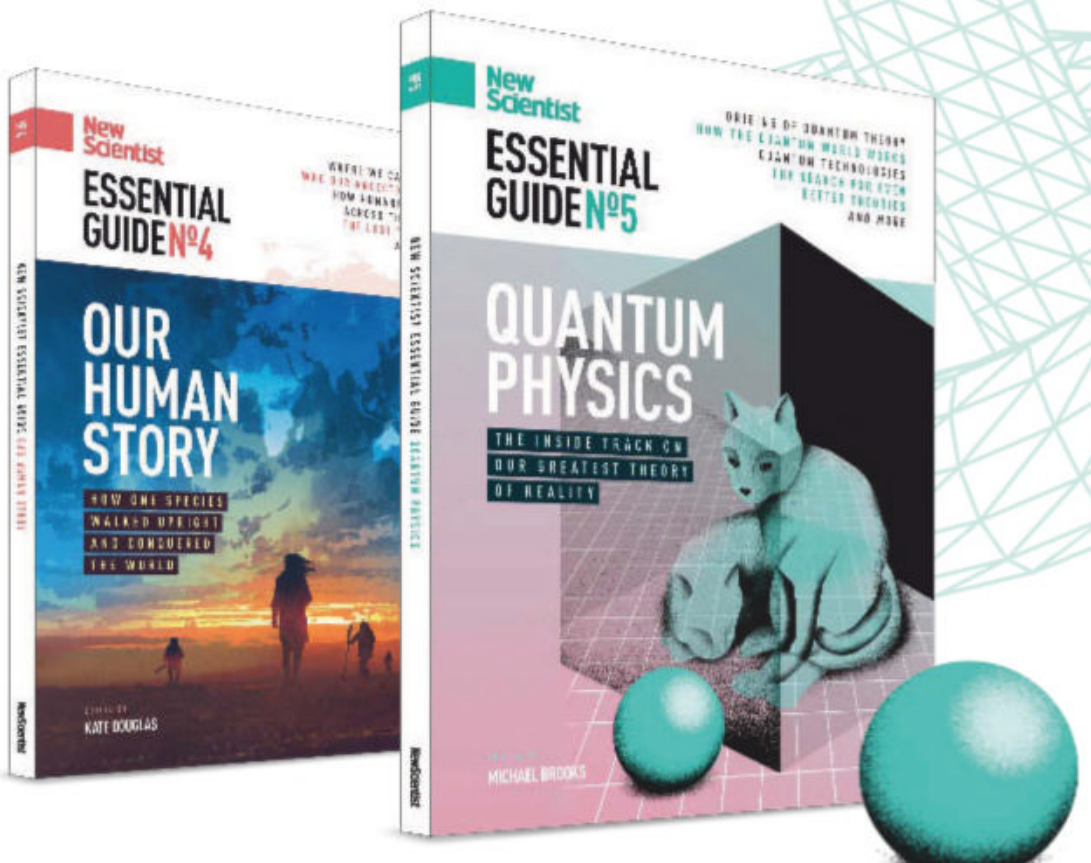

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St John Ambulance volunteers in England get trained to inject vaccines

Coronavirus immunisation

Vaccine roll-out nears

As developers seek approval for their covid-19 vaccines, the race is on to get the shots into our arms, writes **Michael Le Page**

PEOPLE in Europe and the US could start to be vaccinated against the coronavirus in the coming weeks. Pharmaceutical firms Pfizer – with its partner BioNTech – and Moderna have asked for approval for their vaccines in Europe and the US. If regulators give the go-ahead, they could be in use soon after.

"It's great news," says immunologist Eleanor Riley at the University of Edinburgh, UK. While the full results of trials haven't yet been made public, regulators will have access to all the data before any approval, she says. "We can be confident that it will be safe and it will work."

Three vaccines developed in Europe and North America have been shown to be effective in phase III trials: an mRNA vaccine from Pfizer and BioNTech, another by Moderna, plus an adenovirus-based vaccine from AstraZeneca and the University of Oxford.

In the UK, vaccination could begin by 7 December, according to newspaper reports. The *Financial Times* says the UK could issue an emergency use authorisation for the Pfizer and BioNTech vaccine this week and that use could begin soon after that.

The companies filed for emergency use authorisation (EUA) in the US on 20 November and said they had initiated rolling submissions – in which regulators review data as it becomes available to allow decisions to be made faster than normal – with several authorising bodies globally. This includes those of the European Union and the UK. The US Food and Drug Administration will hold a meeting on 10 December to assess Pfizer and BioNTech's application, but the agency said a decision may take weeks.

In general, the UK has to abide by European Medicines Agency (EMA) decisions until 31 December, when it stops following EU rules. However, the Medicines and Healthcare products Regulatory Agency (MHRA) in the UK can allow emergency use without EMA approval.

On 27 November, the UK government asked the MHRA to evaluate the AstraZeneca and University of Oxford vaccine for emergency authorisation. The agency was already looking at data on this vaccine as part of a rolling review.

Moderna filed for emergency use authorisation in the US on 30 November. It said that the meeting to review its vaccine "will likely be scheduled" for 17 December, meaning it is unlikely to be authorised before 18 December.

"In the UK, vaccination could begin as early as 7 December, according to reports"

Vaccination in the US could begin within a day of approval, the CEO of Moderna told journalists.

On 1 December, the EMA said it had received applications for conditional marketing authorisation from Pfizer and BioNTech and Moderna. Similar to EUAs, this is where approval is given for medicines in exceptional cases, with less evidence than is normally needed. The body says it will meet to assess the Pfizer and BioNTech vaccine by 29 December and Moderna's by 12 January.

Elsewhere in Europe, Germany is preparing for vaccination to begin in mid-December, whereas in Australia, the government is talking about rolling out vaccination in March.

In some other parts of the world, immunisation has already begun. An adenovirus-based vaccine created by Chinese firm CanSino Biologics was approved by China for use by its military in June, after phase II trials.

At least three inactivated-virus vaccines created by Chinese developers Sinopharm and Sinovac have also been approved for emergency use in China.

Sinopharm says around a million people have been inoculated so far. In September, the United Arab Emirates approved emergency use of Sinopharm's vaccine.

Daily coronavirus news round-up
Online every weekday at 6pm GMT
newscientist.com/coronavirus-latest

Briefing: AstraZeneca/Oxford vaccine

Trial results come under fire

Doubts have been raised over some aspects of the test of AstraZeneca and the University of Oxford's covid-19 vaccine. **Graham Lawton** reports

LAST week, pharmaceutical giant AstraZeneca and the University of Oxford released positive results for their covid-19 vaccine, claiming it was on average 70 per cent effective, and could reach 90 per cent efficacy depending on dosing. Since then, questions have been raised over the findings.

How are the results not good news?
As scientists, journalists and business analysts chewed over the figures, they noticed some potential problems with the way the trial was conducted, which cast some doubt on the reported results and could be a hindrance to getting the vaccine approved.

What sort of possible problems?
In a word, methodological. "There are lots of issues," says Paul Hunter, an expert on clinical trial methodology at the University of East Anglia, UK.

Rather than results from one large phase III trial, these results were actually pooled data from two separate trials, one in the UK and the other in Brazil. And there was a glaring mistake in the way one of the trials was conducted. Due to a laboratory error, some of the participants in the UK-based trial got roughly half of the intended dose of their first shot (the vaccine requires two shots at least a month apart).

An error sounds bad. Is it?
The error violated the protocol setting out how the trial should have been conducted, but the trial continued and the data from those volunteers was included in the analysis. According to *The New York Times*, the vaccine developers noticed the error – which was the result of work by a contractor – while the trial was ongoing, but consulted regulators and were allowed to press on.

UNIVERSITY OF OXFORD / JOHN CAIRNS

A scientist works on the vaccine in a lab at the University of Oxford

But the error spawned a happy accident, didn't it?
Yes. The volunteers who received the erroneous half-dose first shot turned out to have a higher level of protection against covid-19. The "full dose" vaccine was 62 per cent effective, but the half dose was 90 per cent effective. That is the source of the 70 per cent average and the idea that the vaccine might be tweaked to hit 90 per cent.

Is there a "but"?
There is. Because the dosing error violated the trial's protocol, there are reasons to doubt the overall numbers. The details boil down to the fact that many fewer people received the half dose than the full dose, which risks making the sample sizes too small and "underpowering" the trial.

As Hunter explains it, the error means that the statisticians had to rely on "subgroup analysis", which may render the trial too small to draw firm conclusions. Subgroup analysis is known to increase the risk of finding false positives, he says. But he stresses that there is nothing suspicious about the methodology.

Oxford and AstraZeneca say that all the results are statistically significant, but have yet to release the numbers in full.

Is that all?
No. Another issue is that the results came from data pooled from separate trials, because these had different protocols. The UK one was a combined phase II/III trial, the Brazil one pure phase III. They also used different placebos.

> "Even if the Oxford vaccine is really only 62 per cent effective, that is still a good result"

Such variations in protocol aren't necessarily a problem, but can be. The data has to be handled carefully to take the differences into account, says Hunter.

The dosing error magnifies this potential problem, because it only happened in the UK.

Have the full results been published in a peer-reviewed journal?
No. The full, combined results have only been revealed in a press release, which didn't include detailed numbers.

This isn't unusual, says Mark Toshner, a clinical trials doctor at the University of Cambridge. He is running one of the UK parts of the trial, but doesn't work for or take funding from AstraZeneca or the University of Oxford.

The suggestion that data has been withheld is unfair, he says. In fact, the approach taken is a legal requirement intended to avoid insider trading. "The minute you have an interim analysis… you have to get that positive result out there," says Toshner – hence the speedier press release.

The University of Oxford said full results would be submitted to a journal. AstraZeneca has now set out plans for a new, global trial.

Are there any other concerns?
It seems that the people in the half-dose subgroup were younger on average than the participants as a whole, so the 90 per cent figure may prove too high. Vaccines generally work better in younger people, says Hunter.

So should we disregard this trial?
"Absolutely not," says Hunter. Even if the vaccine is really only 62 per cent effective, that is still a good result. If it had come out three weeks earlier we would have been over the moon, says Hunter. It is just that we have been spoiled by good news from elsewhere, with several other vaccine trials reporting efficacy figures of 90 per cent or more. ▮

Analysis: Lockdowns

Have Europe's latest lockdowns reversed the second wave?

Adam Vaughan

IN EARLY November, covid-19 cases in Europe were surging, accounting for almost half the world's new cases and deaths. Now many in the region are emerging from a second round of lockdowns, including England on 2 December and soon France on 15 December. So how well did they work, and which countries got them right?

The restrictions imposed by most European nations were "fairly high", says Thomas Hale at the University of Oxford, who runs a tracker on government responses to covid-19. Last week, most European nations scored more than 60 out of 100 points on the tracker's index of the stringency of responses, with most having "stay at home" orders. Exceptions included the Baltic states, countries in the Balkans and Switzerland.

Hannah Ritchie at online publisher Our World in Data, says that most national lockdowns have already caused new cases to reach their peak.

Typically, new cases in European countries peaked one to two weeks after a lockdown started, and deaths a further one to two weeks later, says Ritchie. But some say it should take two to three weeks for an effect to be seen, suggesting that the lockdown might not have been entirely responsible.

England's national lockdown, which began on 5 November, appears to have cut the virus's prevalence by about 30 per cent, according to the REACT-1 swab test study being run by Imperial College London. Around 1 in 100 people were estimated to be infected, according to results from 13 to 24 November, compared with about 1 in 80 between 16 October and 2 November.

On 27 November, the UK government's science advisers revised down the coronavirus's reproduction, or R, number for England to between 0.9 and 1 – the first time since September that it may have been below 1 – indicating that the country's epidemic is stable or shrinking.

"We know lockdowns work, but national-scale lockdowns are a blunt instrument. Countries that have fared better have largely managed to avoid them," says Ritchie, citing Finland as a success story. The World Health Organization says lockdowns should be a last resort.

"Many of us in this field are frustrated that Europe is back in this situation," says Amesh Adalja at Johns Hopkins University in Maryland. He says the sustainable alternative is effective test-and-trace systems (see page 10).

2 weeks
The amount of time before lockdown compliance falls

In their absence, second lockdowns in Europe have curbed the virus's spread. "We can say that now, at the end of autumn, the situation is quite under control. The challenge is how much have we improved our preparedness, readiness and contingency plans to face the coming months in a safer way," says Josep Jansa at the European Centre for Disease Prevention and Control.

One issue is that most countries allowed new cases to get too high before locking down, says Jansa. Austria, where a national lockdown didn't start until 17 November, is a case of waiting too long, says Hale. At the opposite end was Denmark, he says, which acted quickly with lockdowns in some areas from 6 November.

Cases in France were relatively slow to peak after lockdown, which Ritchie thinks is probably due to covid-19's high prevalence in communities before the measure.

Conversely, Wales's use of a two-week "firebreak" lockdown, 13 days ahead of England's, caused cases to peak in about eight days, says Rob Orford, the country's chief scientific adviser for health. "The models suggested we would take R below 1, and we could potentially push the epidemic back at least three weeks. And that's exactly what happened," he says.

The UK government's science advisers recommended a similar strategy on 21 September for England, which wasn't adopted. "If the government had listened to SAGE back in September, we probably could have got away with a few weeks," says Stephen Griffin at the University of Leeds, UK.

Curfew or closure?

Shorter lockdowns can help avoid public fatigue. Based on surveys and mobility data due out this week, Hale has found that compliance falls two weeks into European national lockdowns – and sharply after eight weeks.

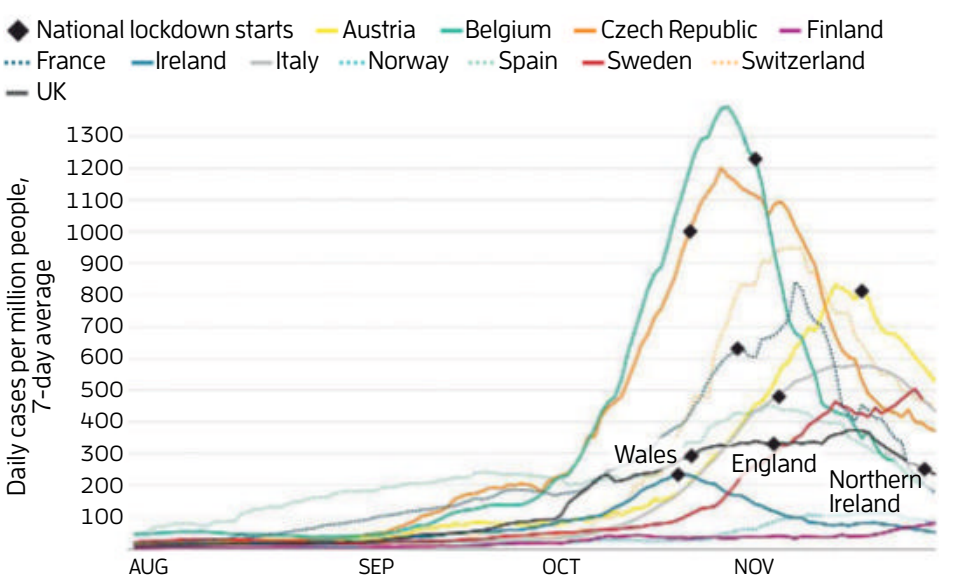
The severity of restrictions also varied between countries. One big factor in their effectiveness appears to be whether bars and restaurants were shut or made to close early. "It looks as if places that just close early, that's not particularly effective. Closing restaurants and bars does seem to slow things down," says Christina Pagel at University College London. "Netherlands and France both tried curfews, but then moved to closure of hospitality, which flattened the curve."

Sweden, which took a different response to most European countries in the first wave, has again held back from a national lockdown, but has imposed tougher restrictions than before, including a national ban on alcohol sales after 10 pm. "Sweden is much more constrained this time. The so-called Swedish exception has been less of an exception," says Hale.

Germany has been hit harder second time round, but its strict lockdown has kept cases at a much lower level than its neighbours, says Ritchie.

Most experts *New Scientist* spoke to think a third cycle of lockdowns is probable in Europe, given people mixing at Christmas. "I wouldn't say it's inevitable," says Hale. "But I think that it's more likely than not."

Europe's second lockdowns have turned the covid-19 tide



SOURCE: OUR WORLD IN DATA / HANNAH RITCHIE. CREATED WITH DATAWRAPPER

Asia

How China is beating covid-19

The country at the epicentre of the coronavirus pandemic now sees few cases and deaths. **Donna Lu** investigates the numbers and what's behind them

AS THE second wave of the covid-19 pandemic worsens across the northern hemisphere, life has largely returned to normal in the country where the virus first made its mark.

Restaurants and markets in Chinese cities are bustling, as are tourist sites and cinemas. In Wuhan, where a lockdown in late January first shocked and then became a precedent for the rest of the world, recent months have seen packed concerts, food festivals and pool parties.

China never imposed a nationwide lockdown, and seems to have avoided the new wave of cases seen in other countries.

According to official data, community transmission in China is low, aside from a few localised outbreaks – including one in Beijing in June, and one in Kashgar in October, which have been kept to a total of a few hundred cases.

Covid-19 spread quickly in China early in the year, with 80,000 confirmed cases at the start of March. But the rise in case numbers slowed. In the eight months since, China's cumulative case count has grown by 7000 cases. Is the country's success too good to be believed?

Initial under-reporting

There are reasons to be concerned over the accuracy of reported case numbers in China, says Jennifer Bouey at the RAND Corporation think tank, headquartered in Santa Monica, California.

China's top-down system of administration means that local governments are often reluctant to escalate issues to more senior officials for fear of causing unnecessary alarm, says Bouey. "It's very likely to cause a local government to cover up numbers," she says, which may have occurred in the early stages of the covid-19 outbreak.

But previous experience has shown that once China's central government becomes aware of the nature of a public health problem, it institutes severe penalties for under-reporting, says Bouey. "In 2003, they fired almost 1000 provincial officials – even someone in Beijing – because the central government suspected that they didn't give the real numbers [of SARS cases]."

Uncertainty about a new virus and a narrow clinical definition may have contributed to initial under-reporting in the early days of the outbreak, says Ben Cowling at the University of Hong Kong.

In March, Cowling and his colleagues estimated that had criteria for covid-19 diagnosis been widened to include asymptomatic or milder cases, including those with no known links to Wuhan, 232,000 people in China may have been reported as infected by 20 February, instead of just the 55,000 confirmed cases reported at the time.

Documents leaked to CNN also suggest that numbers may have initially been higher than those disclosed to the public. For instance, about 3900 cases were reported on 10 February, but according to the documents, officials knew there were 50 per cent more cases.

Since then, testing capacity in the country has drastically increased, and diagnostic criteria have broadened. In the wake of SARS, the Chinese government created a mandatory reporting system for serious infectious diseases, which is now used to track coronavirus cases.

"With this system in place, I'm confident that there are no diagnosed patients who are not recorded," says Cowling.

MARK SCHIEFELBEIN/AP/SHUTTERSTOCK

Commuters wearing face masks in Beijing, China, in October

5 days

How long it took to test more than 10 million people in Qingdao

He believes the national statistics being reported now are accurate, though of course some cases are always missed. "I am sure there would be infections that go unnoticed and unreported, just like the rest of the world," he says.

Christoffer Koch at the Federal Reserve Bank of Dallas and Ken Okamura at the University of Oxford analysed China's covid-19 data in May using a statistical fraud-detection technique. They found "no evidence of manipulation", concluding that China's distribution of cases was similar to that of the US and Italy.

"I'm sceptical of the numbers initially reported by China, but it's clear they've succeeded in containing the virus," says Zoe Hyde at the University of Western Australia. "If there were major epidemics in Chinese cities today, we'd see evidence of it."

Various signs point to a country

largely in control of the virus. Many other countries have plunged into recession but China's economy grew in the third quarter of this year. China's National Bureau of Statistics announced on 19 October that the country's economy grew 4.9 per cent between July and September compared with 2019.

Domestic travel, too, has largely rebounded. Throughout China's Golden Week national holiday, which began on 1 October, 637 million local trips were taken, according to the Ministry of Culture and Tourism, about 80 per cent of last year's figure.

Aggressive interventions

China's swift action in containing outbreaks has been key to the country's success to date.

Analysis by Xi Chen at Yale University and his colleagues suggests that more than 1.4 million infections and 56,000 deaths may have been avoided as a result of measures such as city lockdowns, domestic travel restrictions and mandatory quarantine imposed in China in late January.

In Beijing, which saw an outbreak linked to the Xinfadi food market in June, the government shut several districts surrounding the market, and conducted mass testing and contact tracing during that period.

"It's extremely expensive to do that kind of aggressive intervention – much more expensive than public health measures that are used elsewhere in the world," says Cowling.

The approach is resource-intensive, but minimises longer term disruption, says Cowling. "After those two or three weeks, everyone can get back to normal."

China has also avoided a second wave from imported infections. This is largely because of its ban on foreign nationals entering the country, says Hyde. "South Korea took a different approach, quarantining overseas arrivals instead. Although [South Korea] had many imported cases, they've not posed a substantial problem because the community has been protected," she says.

China's approach has been more stringent than those of South Korea and Japan, says Xi. This may make sense because China has fewer intensive care unit beds per capita than Japan and South Korea, he says. "From a health infrastructure perspective, China is less prepared [for large outbreaks]."

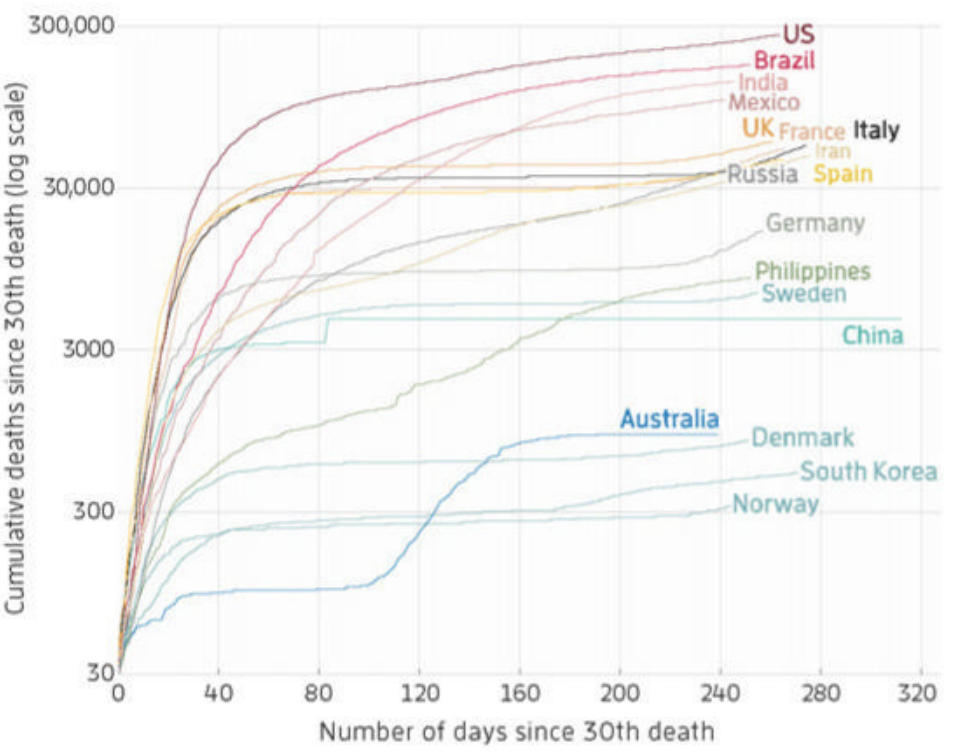
In addition, China doesn't have a strong social welfare system, and the proportion of people in jobs that can be done remotely is smaller than in countries such as the US. Both were probably factors in how decisively the Chinese government acted, in order to avoid social unrest as a result of mass unemployment, says Xi.

High compliance among the Chinese population – one that remembers the devastation of SARS – has also been a factor. In early October, when two workers handling imported seafood tested positive for covid-19 in the north-eastern city of Qingdao, the municipal government tested the entire city of more than 10 million people within five days.

"People were concerned and wanted to get tested as quickly as possible," says Fan, a Qingdao resident who lined up for 4 hours to get her test. "The masses were very cooperative. If the testing facility opened at 7am, people started queueing at about 5am."

Because the cases were discovered just after the Golden Week holiday, when domestic travel was high, those who had visited Qingdao or had contact with its residents were also required to undergo a "2+1+7": two sets of nasal and throat swabs, a blood test and seven days of self-isolation.

Coronavirus deaths as of 30 November 5pm GMT



Note: Only selected countries are shown
SOURCE: NEW SCIENTIST ANALYSIS OF JOHNS HOPKINS UNIVERSITY CSSE DATA

Bouey says willingness of the Chinese public to comply with lockdown orders may have been helped by a high rate of family savings. On average, Chinese people save more than a third of their household income – far more than people in most high-income countries. "A high savings rate really helped families and even small businesses to be able to stay still for a while," says Bouey.

But as Australia and New Zealand, which have largely eliminated the virus, can attest, months of hard work can quickly be undone.

"I think infections will break through into China sooner or later, the same as in other countries," says Cowling.

On 25 October, a covid-19 outbreak was discovered in Kashgar, in the western province of Xinjiang, after a 17-year-old girl tested positive the previous day. How she contracted the virus is uncertain. More than 180 cases have subsequently been identified, linked to a factory where the girl lives and works.

Xinjiang province is home to most of China's Uighur population. Outbreaks there have led to concern that the virus could spread through the camps in which hundreds of thousands of Uighurs have been detained.

Kashgar was placed in lockdown, and 4.7 million people were tested in four days, according to Chinese state media.

New cases in Shanghai and Tianjin in early November, linked to frozen imported food, also led to mass testing and lockdowns.

Whether China's success at quashing the spread of the virus will last remains to be seen, especially as the winter months drive people inside. "If China follows the same strategy to take early action, I think it should have things under control," says Xi. ▮

Archaeology

North Sea island survived prehistoric tsunami

Michael Marshall

THE Atlantis of northern Europe sank under the seas slowly, rather than being obliterated by a tsunami.

A little over 8000 years ago, a devastating tsunami swept across the North Sea, striking a small island that existed there at the time. But new evidence suggests the wave didn't permanently swamp the island and its surrounding archipelago. People may have lived on the remaining land for centuries afterwards.

Between 110,000 and 12,000 years ago, Earth was in the grip of a glacial period. Because so much water was locked up in ice, sea levels were many metres lower and land that is now underwater was exposed.

This includes much of what is now the southern North Sea, between Britain and mainland Europe. As a result, Britain was connected to Europe by a fertile plain called Doggerland.

Most of the ice then melted, causing sea level rise. By about 8200 years ago, Doggerland had shrunk in size to leave Dogger Island surrounded by a small archipelago.

RICHARD SPLASH/ALAMY

"The tsunami slammed up a river valley, ripping up trees – but the water soon retreated"

There is some evidence that this final piece of Doggerland had a dramatic end. About 8150 years ago, a submarine landslide occurred off the coast of Norway, dubbed the Storegga Slide. This created a tsunami in the North Sea that hit the surrounding coastlines. Many researchers have argued that the Storegga tsunami helped cut Britain off from Europe.

The problem is that, so far, we have had no archaeological records of the tsunami's impact on Doggerland. "We know essentially nothing about the actual impact on the areas which were patently most susceptible to being hit," says Vince Gaffney at the University of Bradford in the UK.

As part of a long-term project to map Doggerland, Gaffney's team took sediment cores from the seabed off the coast of East Anglia, in the east of England. The cores contain traces of the Storegga tsunami, such as broken shells. It seems the tsunami slammed up a river valley, ripping trees from the sides – and leaving their DNA in the sediments. But the water soon retreated and later sediments suggest the area was above water again.

Gaffney's team compiled existing data from around the North Sea. The researchers argue this evidence suggests the Dogger archipelago survived for several more centuries. By 7000 years ago, it was underwater and had become what is now a submarine feature called Dogger Bank (*Antiquity*, doi.org/fkw5).

Doggerland linked England's east coast to mainland Europe

"It kind of confirms things we'd been thinking anyway," says Sue Dawson at the University of Dundee in the UK. Simulations of the tsunami had also suggested it couldn't have swamped Doggerland.

Karen Wicks at the University of Reading, UK, has previously found evidence that the hunter-gatherer population in north-east Britain fell around the time of the tsunami. She argues that the tsunami was part of a "perfect storm" of environmental crises, as it combined with a period of climate cooling 8200 years ago.

However, almost nothing is known about the people living on Doggerland. Last year, Gaffney's team recovered the first known artefacts: two small pieces of flint. As a result, it is unclear how long people continued living there as the area slipped beneath the sea. ▮

Zoology

Larger animals seen as more charismatic than smaller ones

Donna Lu

WE APPEAR to find bigger beasts more charismatic than tinier ones – although some exceptionally small species punch above their weight when it comes to charisma.

There are already a number of data sets that have measured animal charisma. Some involved surveying volunteers about their attitude towards particular species of birds and mammals, while others involved assessing data on the number of Wikipedia page views for a particular species and the number of images of the species posted to Twitter and the photo-sharing site Flickr.

Emilio Berti, formerly at Aarhus University in Denmark, and his colleagues pooled together the information from nine of these existing data sets. This allowed them to generate a standardised measure of the charisma of 13,680 animal species, including birds, mammals, amphibians and reptiles.

The sizes of the animals were measured as the average adult body size for birds and mammals, which typically stop growing when they reach sexual maturity, and the maximum adult body mass for amphibians and reptiles, which generally continue to grow larger throughout life.

From this, the researchers found there was a correlation between charisma ratings and animal size (*Biological Conservation*, doi.org/ghjjcd). "The bigger you get, the more sublime reaction humans have," says Berti.

However, he and his colleagues found that a few of the smallest species also had a very high charisma rating. These included the Virgin Islands dwarf gecko (*Sphaerodactylus parthenopion*). This is one of the smallest terrestrial vertebrates at 18 millimetres long – and it may be perceived as cute and therefore charismatic, says Berti. ▮

Gene editing

CRISPR might prevent Alzheimer's

Editing brain cells with a rare gene variant may help protect against dementia

Michael Le Page

IT MIGHT one day be possible to gene-edit brain cells to prevent Alzheimer's disease. This is because altering a key gene in human nerve cells turns out to reduce the formation of a protein associated with the disease, although so far this has only been shown in a dish.

Alzheimer's is the main cause of dementia and the risk rises sharply as we grow old. Around 1 in 4 people aged over 90 have it.

The cause of Alzheimer's still isn't fully understood, but the leading hypothesis is that a build-up of clumps of a protein called beta-amyloid outside cells is to blame. Beta-amyloid forms when another protein, the amyloid precursor, is cut by an enzyme called beta-secretase.

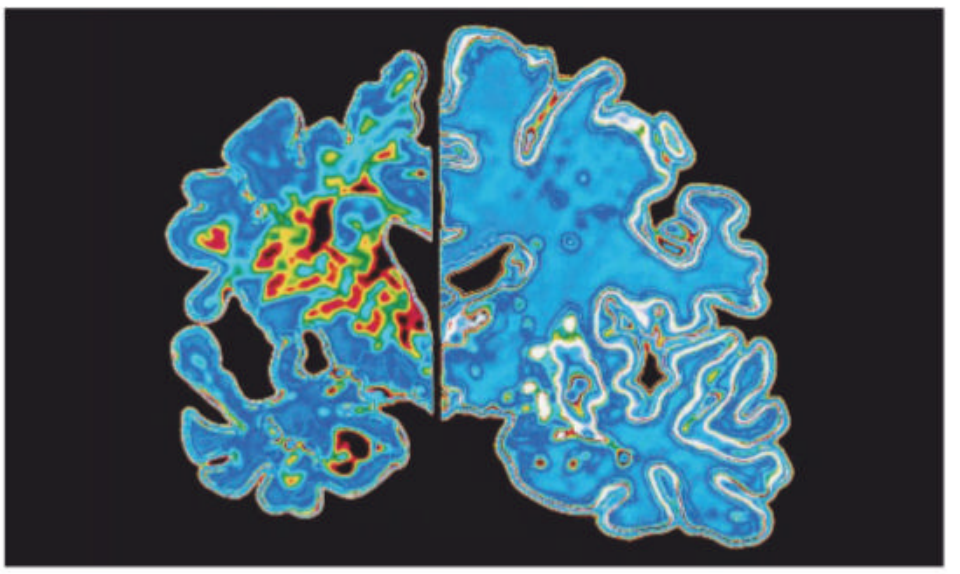
In 2012, it was discovered that a few people of Scandinavian ancestry have a gene variant called *A673T* that makes them four times less likely to develop Alzheimer's. "You are not only protected from Alzheimer's, you have a tendency to live longer," says Jacques Tremblay at Laval University in Canada. "There is no downside."

Many variants of the gene for the amyloid precursor protein increase the risk of Alzheimer's. But the *A673T* variant, which involves a change in a single DNA letter, instead reduces beta-amyloid production by altering the site to which the beta-secretase enzyme binds. It also makes the resulting beta-amyloid less likely to clump together.

The *A673T* variant is found in roughly 1 in 150 people in Scandinavia, but is rarer elsewhere. Because its benefits kick in very late in life, it isn't selected for by evolution, says Tremblay, meaning the variant doesn't spread.

Engineering the variant into people's brain cells could have many of the same benefits as inheriting it, he believes. His team has taken the first step to demonstrating this by showing that beta-amyloid production is reduced when this change is made in human cells growing in a culture dish (bioRxiv, doi.org/fkgz).

Brain with Alzheimer's (left) and without (right)



ALFRED PASIEKA/SCIENCE PHOTO LIBRARY

Tremblay's team didn't manage to alter all the cells – just 40 per cent in the best effort. A higher proportion might be needed, says Selina Wray at University College London, and achieving this in the human brain will be much harder.

Another major problem is that by the time people start to show the symptoms of Alzheimer's, it might be too late for gene editing to make a difference, says Wray. But this is true for any Alzheimer's treatment and the gene-editing approach is still worth pursuing, she says. "We should be considering as many potential therapies as possible."

For initial clinical trials, Tremblay plans to get around this problem by trying the approach in people with mutations known to cause early-onset Alzheimer's.

If so-called germ-line genome editing does start to be widely used in humans, this change could also be made in sperm, eggs or embryos, so people are born with the *A673T* variant.

"In the long term, I think that this will probably happen," says Tremblay. ▮

Ecology

Ivy is multiplying in Europe's forests as climate warms

EUROPE'S forests contain substantially more ivy today than they did in the 1930s, probably because of environmental changes across the continent.

Michael Perring at Ghent University in Belgium and his colleagues spotted the trend while working on a study of more than 1800 research plots in 40 forest regions across temperate Europe, from Ireland in the west to Hungary in the east. The study looked at data gathered between 1933 and 2015.

The research reveals that common ivy (*Hedera helix*) has become even more common. By the end of the study period, it was found on average in 14 per cent more of the research plots in each forest region than at the outset. Most other plant species haven't spread to more of the plots, and some species are now found at fewer of them.

It is "quite dramatic", says Perring. "It's a coherent signal across multiple forests in Europe."

Local temperature rise was the biggest predictor of where common ivy would flourish, followed by shade and nitrogen levels, although these didn't fully explain its spread (*Frontiers in Ecology and the Environment*, doi.org/fknb).

Forests are becoming darker as management practices change. This helps common ivy to outcompete other plants because its evergreen leaves allow it to photosynthesise through the winter, when more light gets through.

"An increase in ivy is not necessarily a bad thing. It's great habitat for birds, bats and small mammals"

Nitrogen pollution, caused by agriculture and the burning of fossil fuels, also seems to accelerate ivy growth, says team member Pieter De Frenne, a bioscientist at Ghent University.

"An increase is... not necessarily a bad thing," according to a statement from the UK's Woodland Trust. "It's great habitat for birds, bats, invertebrates and small mammals. The autumn flowers on ivy are a great late season nectar source for insects and then berries for birds." ▮

Aisling Irwin

Technology

Suspected nuclear weapons facility spotted in Pakistan

Adam Vaughan

SLEUTHING with satellite images on Google Earth has revealed a substantial and undocumented expansion to a suspected nuclear processing plant in Pakistan. Researchers say it is a possible sign of the country ramping up its atomic weapons programme.

Pakistan, known to be a nuclear armed state since 1998, isn't a signatory to key international treaties on nuclear proliferation and tests. The country's secretive weapons programme is closely watched due to tensions with neighbouring India, which also has a nuclear arsenal.

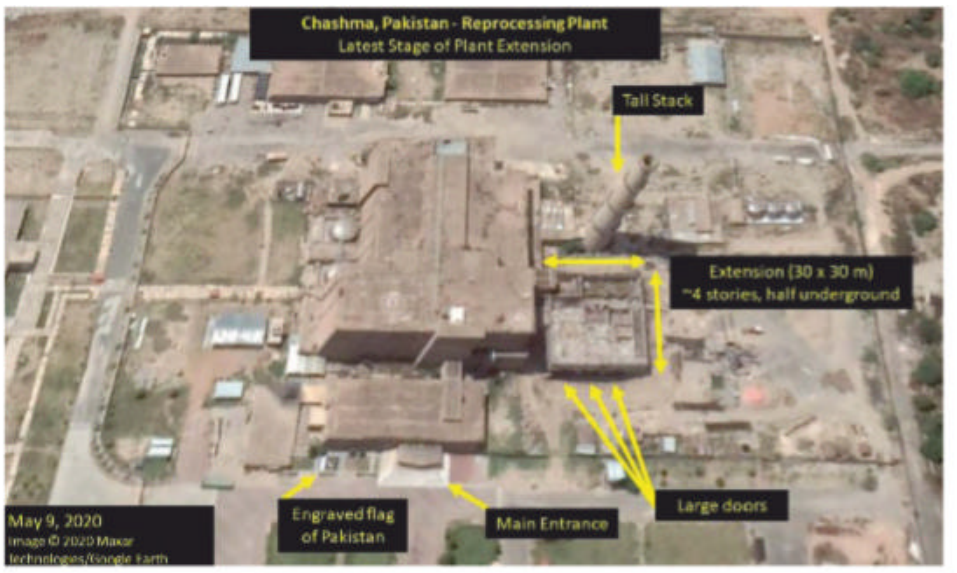
Researchers at the Institute for Science and International Security (ISIS), a US-based non-profit organisation, have previously used satellite images to identify a suspected nuclear facility at Chashma in the country's north, which appeared to start operations in 2015. It is thought to reprocess fuel from nearby nuclear power plants, separating plutonium for use in weapons.

Now, Neil Hyatt at the University of Sheffield, UK, has identified what appears to be a major expansion of the reprocessing plant. Using publicly available satellite images, and working with a team at ISIS to help analyse his discovery, he found that construction of an extension started between April and September 2018. By 9 May 2020, a Google Earth image revealed a new 30 by 30 metre building, right next to the facility's original building.

Without confirmation from the government of Pakistan it is hard to know what this new structure will be used for or whether it is operational, but the scale of the development suggests the country plans a sustained effort of separating plutonium for use in weapons, says Hyatt.

"Pakistan does not have any immediate need to reuse plutonium in MOX fuel [for use in a nuclear power plant] and, because the facility is safeguarded, it seems likely the intention is to use the material in the weapons programme," he says.

Satellite images show an enlarged suspected nuclear site in Pakistan



NEIL HYATT ET AL

Sarah Burkhard at ISIS says the discovery of the facility shows the need to continuously monitor Pakistan's secret nuclear facilities. "Pakistan may be planning to introduce more fuel for reprocessing or improve the operation of the reprocessing plant, in either case possibly building up further its stock of plutonium for use in nuclear weapons," she says.

Researchers regularly model the apocalyptic global consequences of a nuclear war between Pakistan and India. Jeffrey Lewis at the James Martin Center for Nonproliferation Studies in California says while some people assume India has a bigger nuclear weapons stockpile because it is the bigger country, Pakistan's is believed to be the larger of the two.

"Pakistan continues to place enormous emphasis on growing its nuclear weapons programme, and the expansion of the reprocessing facility underscores that," he says.

Pakistan's embassy in London wasn't able to provide a comment before publication. ▮

Materials

Armoured liquid marbles connected to form long chains

DROPLETS of liquid with a protective coating can be joined into long chains that could be useful for chemical reactions.

Liquid marbles consist of droplets covered by one or more layers of solid particles. Many are too soft to be handled and are easily destroyed by mechanical stress – particularly those that are larger than capillary length, a factor relating to gravity and surface tension. At 20°C, the capillary length of a droplet of water is 2.7 millimetres.

Syuji Fujii at the Osaka Institute of Technology in Japan and his colleagues had previously developed liquid marbles that can be picked up and piled on top of each other by hand or using tweezers. These nearly spherical marbles were created by rolling several-millimetres-wide droplets of liquid on a bed of hexagonal discs made of a water-repellent plastic called polyethylene terephthalate, or PET.

Now the researchers have shown that it is possible to join these near-spherical droplets together to form a chain by sequentially prodding two droplets with a small, sharp object, such as a pipette.

They created a 1.7-metre chain by joining around 300 individual liquid marbles together, a process that took more than 10 hours. By using small tools to shape liquid marbles, the team was also able to create chains that looked like all the letters of the alphabet.

The researchers also developed

"They created a 1.7-metre chain by joining around 300 individual liquid marbles together"

liquid marbles consisting of particles of two different sizes by joining a near-spherical liquid marble with a cube-shaped one. This created a micro-pump: liquid flowed from the near-spherical marble into the cube-shaped one (*Advanced Materials Interfaces*, doi.org/fkm9).

Such micro-pumps could be useful for small-scale chemical reactions, says Fujii. "This automatic liquid flow is advantageous to mix the liquids." He says the technology could also be useful for building chemical micro-reactors. ▮

Donna Lu

Artificial intelligence

Protein revolution

Biologists have struggled to predict the shapes of proteins for half a century – now an AI can do it for them, says **Michael Le Page**

AN AI system developed by UK-based company DeepMind has achieved the long-sought-after goal of accurately predicting the shape of proteins from their sequence alone, a key part of understanding how the machinery of life works. In a competition, AlphaFold matched two-thirds of the results achieved by humans doing expensive and time-consuming lab experiments.

"I was really wowed when I saw it," says John Moult at the University of Maryland, one of the competition's organisers. "This is the first time we've come close to approaching experimental usefulness, which is pretty extraordinary."

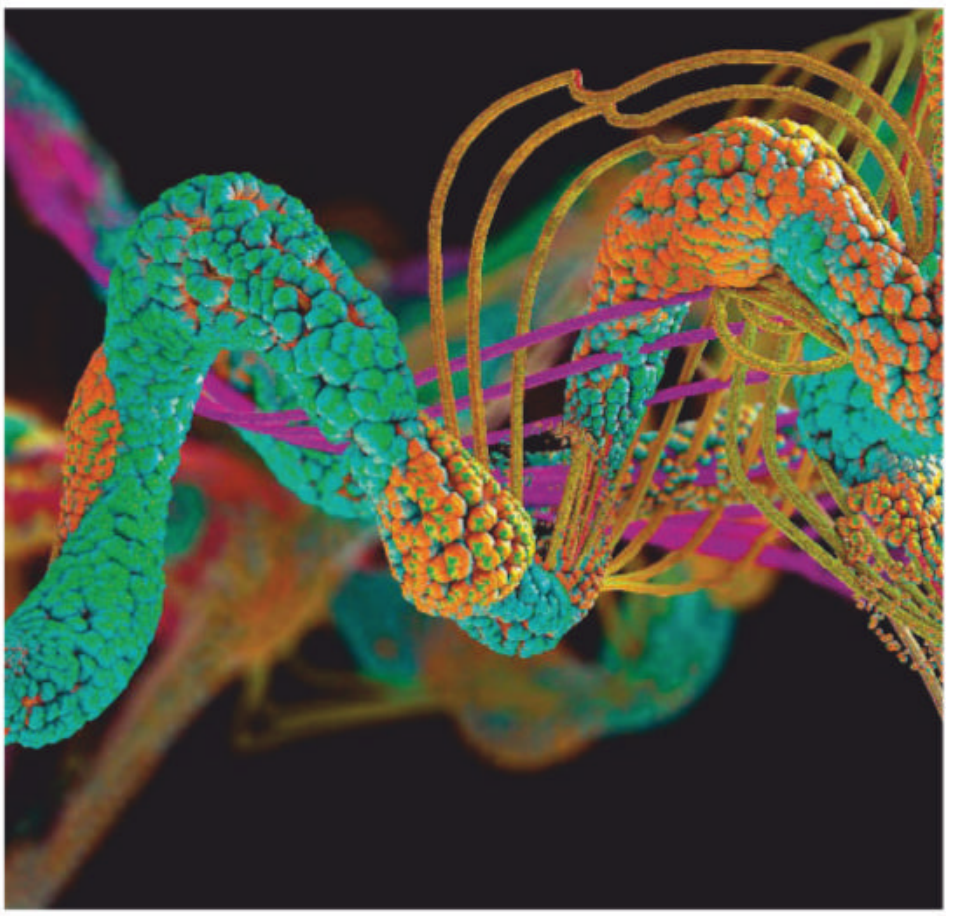
Proteins are vital for life. Cells are full of machines that are built from proteins, and their shapes are crucial. For instance, the coronavirus can enter and infect human cells because a protein on its surface fits into a receptor on our cells, like a key into a lock.

These shapes depend on the sequence of 20 different amino acids that are chained together to make proteins. It is easy to work out the sequence of any protein because this is determined by the DNA that codes for it.

But despite half a century of effort, biologists hadn't previously been able to work out the shape of a protein from its sequence alone. As an alternative, they have had to rely on methods such as X-ray crystallography, which involves analysing the diffraction pattern formed when an X-ray beam is fired at a protein crystal.

"This is exceptionally difficult," says John Jumper, who leads the AlphaFold team at DeepMind. Making crystals of some proteins is hard, and interpreting the diffraction patterns can be tricky.

Using brute-force computing based on physics alone isn't an option because proteins are too complex. Instead, groups including DeepMind have turned to artificial intelligence. For each target protein, researchers look for variants found in related species and feed their sequence and structure into the AI system, along with the target's sequence. The idea is that the system learns to work out the shape of the target protein by looking at patterns linking sequence and structure.



CHRISTOPH BURGSTEDT/SCIENCE PHOTO LIBRARY

Proteins are key to life, but it is difficult to work out their structure

In 1994, Moult and a colleague set up the CASP (Critical Assessment of protein Structure Prediction) competition to judge the performance of computer predictions. Any group that wants to enter is sent the sequences of proteins whose structures have been determined experimentally but not yet published.

Predicted shapes are scored out of 100 based on how close each amino acid is to the position determined by experiment. A score above 90 is considered to be on a par with results obtained by experiments.

In the 2016 competition, the best team got a median score of around 40 in the hardest category. In 2018, the first version of AlphaFold got a median score of nearly 60 in this category. This year, a redesigned AlphaFold got a median score of 87 in the hardest category. Across all categories, it scored above 90 for two-thirds of the proteins.

Top marks

While this result is amazing, there were some clear failures, says Moult. For instance, AlphaFold didn't do well with a protein whose structure is influenced by other proteins that surround it.

This variability could be an issue, but AlphaFold also provides a measure of how trustworthy its predictions are, so scientists will know which ones to rely on, says Jumper. "This is huge."

Separate from the competition, Andrei Lupas at the Max Planck Institute for Developmental Biology in Germany had been trying to work out the structure of a particular protein for a decade until DeepMind offered to help. After a few tweaks, Lupas's team had the final structure within half an hour of receiving AlphaFold's prediction. "It's astonishing," he says. "It's really astonishing."

"Being able to predict how proteins interact with other molecules will totally change medicine"

Lupas thinks that researchers will still need to do some experimental work to check shape predictions over the next few years, but will eventually be able to rely on computation alone. This will make a huge difference, he says, but the real revolution will come from being able to use computers to predict how proteins interact with other molecules.

"This will completely change the face of medicine," says Lupas. For instance, AlphaFold was able to predict the shapes of several coronavirus proteins soon after the virus was first sequenced in January, he says. Even better would be the ability to predict which of the thousands of existing drugs bind to these proteins and might have a therapeutic effect.

DeepMind has revealed few details about AlphaFold so far, but says it will soon publish a paper. The company was unable to say how scientists will be able to get access to the technology, but says it is keen for it to be widely available. "We want to make sure this has the biggest impact," says Pushmeet Kohli at DeepMind. ▮

Technology

AI turns spoken words into sign language videos

Chris Stokel-Walker

AN AI that can produce photorealistic videos of sign language interpreters from speech could improve accessibility by removing the need for humans.

Ben Saunders at the University of Surrey, UK, and his colleagues used a neural network that converts spoken words into sign language. The system, called SignGAN, then maps these signs onto a 3D model of the human skeleton.

The team also trained the AI on videos of real sign language interpreters, teaching it how to create a photorealistic video of anyone signing based off an image of them. By combining this video with the 3D skeleton, the AI is able to covert spoken words into sign language (arxiv.org/abs/2011.09846).

One of the key challenges was accurately generating realistic hand images, given sign languages rely on the positioning of fingers to differentiate words. Since the signers' hands in the training videos could sometimes be blurred, the researchers used an existing AI capable of estimating hand poses from a small patch around the middle knuckle to avoid the system learning to generate blurred hands.

Liam O'Dell, a Deaf journalist and campaigner in the UK, welcomed the work. "Having seen many gloves which have tried to convert sign language into spoken language – often with low levels of success – seeing a proposal for technology which works the other way around is rather refreshing," he says.

But sign language interpretation is a skilled job that may not be ready to be replaced by AI. "It's important that any future development of this work appreciates the many complex elements which make up sign language – such as facial expressions, mouth movements and context – and is co-produced with Deaf people," says O'Dell. ▮

Archaeology

Double climate disaster hit ancient civilisation

Richard Kemeny

DINODIA PHOTOS/ALAMY

Remains of the Harappan civilisation in Pakistan

EVEN for a civilisation as advanced as the Harappan, a second drought was perhaps one too many. A two-pronged climate crisis may be what wiped out this ancient society.

The Harappan arose in the Indus valley between north-east Afghanistan and north-west India about 5200 years ago, peaking around 2600 BC. Much about them is unknown, as their written script remains undeciphered. Yet archaeological remains tell the story of a sophisticated people, skilled in metallurgy and urban planning. Their huge cities, complete with intricate sewer systems, reservoirs and public baths, long predated the Roman Empire.

But by 1900 BC, their society seemed to be in decline, and by 1300 BC, it had collapsed, for unknown reasons. One recent hypothesis pins it to a major northern hemisphere drought that affected summer monsoon rains around 2200 BC.

Nick Scroxton at University College Dublin, Ireland, and his colleagues are now challenging this idea based on 10 recently reported palaeoclimate records. These come mostly from stalagmites from cave sites around the Indian Ocean. Together, they provide a view of the evolving climate during the Harappan's rise and fall.

Scroxton and his team found some evidence of a relatively sudden drought starting around 2240 BC. Rather than affecting summer monsoons though, the analysis suggests the Harappan faced a sharp fall in winter rain first (*Climate of the Past*, doi.org/fkc7).

"Some 300 years later, just as the winter rains were starting to recover, a drought kicked off"

"The civilisation suffered, that's for sure," says Scroxton. But that wasn't the end of the Harappan. Archaeological finds suggest they left their grand cities in the Indus valley and continued living further south in the present-day Indian state of Gujarat. Botanical evidence suggests the Harappan also switched from winter crops like barley and wheat to those like millet that favour summer rain.

Some 300 years later, though, just as the winter rains were starting to recover, a tropical drought kicked off, causing a gradual fall in the summer monsoon rains over several centuries. Scroxton and his colleagues say this second drought transformed the Harappan into a rural society that eventually faded away.

The conclusions are quite plausible and fit with other records from Rajasthan in western India and the Indus river delta, says Peter Clift at Louisiana State University. But he is a little concerned about the study's reliance on stalagmites, pointing to some in China that were shown to be unreliable climate indicators.

Julien Emile-Geay at the University of Southern California says the study offers a more-refined view of the changing climate at that time. ▮

Biology

Grounded by evolution

Birds that rapidly moult feathers are more likely to develop flightlessness

Jake Buehler

FROM ostriches to kakapo parrots, birds have lost the ability to fly many times. Some types end up grounded more often than others. Now it seems that those that moult feathers from both wings at once may be predisposed to evolving flightlessness.

Ryan Terrill at Occidental College in Los Angeles, California, was fascinated by moulting, the process by which birds shed and replace old feathers. As a graduate student at Louisiana State University in Baton Rouge, he was thinking about flightless grebes while conducting fieldwork in Bolivia and realised that every member of this lineage of waterbirds – including the flying species – had something in common: both wings moulted at the same time.

He also noticed that this trait seemed especially prevalent among waterfowl like ducks, geese and rails. These are bird families that have produced a large proportion of the world's flightless species.

"I realised they were all in those families that have simultaneous wing moult, which is really rare," says Terrill, adding that only 3 per cent of bird species shed both sets of wing feathers at the same time.

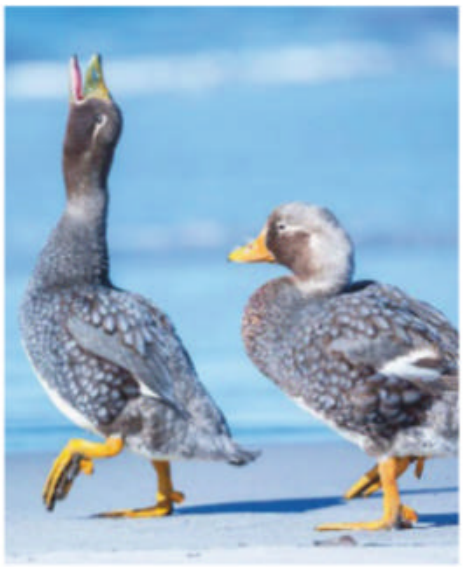
Curious as to whether this meant they were somehow predisposed to evolving flightlessness, Terrill checked if the pattern held across thousands of species of birds. He developed evolutionary trees that included both living flightless and flying birds, and many flightless birds that became extinct in recent millennia. Much of the global flightless bird diversity has been lost to hunting by humans.

"We tend to think of [flightless birds] as kind of weird freaks, but the fossil evidence suggests that there used to be a lot of them," says Terrill. Before people settled on islands throughout the Pacific, the region was probably home to thousands of flightless rail species, he says.

Terrill used computer simulations to estimate how quickly and readily flightlessness evolved in bird groups with and without simultaneous wing moult. He found that more than two-thirds of known flightless birds synchronise their wing moult. Across multiple versions of the evolutionary trees, Terrill found that these simultaneous wing moulters consistently lost flight faster than those with staggered feather replacement.

Birds like geese and rails already excel at finding food and escaping predators while temporarily flightless during their wing moult.

Flightless steamer ducks wander in the Falkland Islands



VISIONS FROM EARTH/ALAMY

So, these birds may be prone to becoming flightless, says Terrill. A bird that can survive brief periods without flight may be primed to lose it entirely, given the opportunity (*The American Naturalist*, doi.org/fkck).

"It makes a lot of sense to me," says Natalie Wright at Kenyon College in Ohio, who wasn't involved with the research. "The things that are required of a bird if it's going to be flightless for part of the year are probably really similar to what's required for that bird to survive if it's going to be flightless all the time." She notes that a lot of the flying birds that experience simultaneous wing moult are using flight primarily during migration and for accessing new habitats.

"A lot of ducks use flight to move from one pond to another, but their flight is not their primary escape mode," says Wright. "It's not how they get their food."

If such birds end up in an island habitat where long-distance movement is no longer necessary to find food, she says, flight becomes superfluous. ▮

Space exploration

NASA to Bold-ly go with space detergent partnership

NASA and Procter & Gamble (P&G) have signed an agreement to develop the first detergent for washing clothes in space – despite a long-standing policy against astronauts doing their own laundry.

People on the International Space Station (ISS) mostly wear ordinary clothes. Once dirty, they are returned to Earth as rubbish or ejected along with other waste in a capsule that burns up in the atmosphere.

Under the new Space Act agreement signed in August, P&G will formulate detergents and systems for cleaning clothing in orbit, which NASA will test. The systems will need to use little to no water, or even utilise the vacuum of space to help shift stubborn stains. The agreement says there could also be spin-off projects for Earth, such as low-toxicity detergents and reduced water usage in washing machines.

Historically, astronauts have worn their clothes "as long as it is tolerable to the crew based on smell and 'crustiness'," according to a 2013 NASA study. That has typically meant three days for underwear and a week or two for shirts. Clothing accounts for about 6 per cent of the mass flown into space for human missions.

Space washing machines just aren't viable yet, says Bergita Ganse at Manchester Metropolitan University in the UK. "It's not just a little washing machine to fly up, the energy it uses and cleaning the water afterwards are big issues."

"Astronauts wear their clothes as long as it is tolerable to the crew based on smell and 'crustiness'"

In study after study, NASA has also highlighted such issues. A recent logistics analysis found that using lightweight clothing could make it more efficient to use disposable clothes for up to a year instead of washable ones.

Those calculations might change if humans go to space for good, says NASA spokesperson Stephanie Schierholz. "We are conducting studies on what a laundry strategy would look like in space, starting with a base on the moon or Mars, where we would benefit from a partial gravity environment." ▮

Mark Harris

Must
~~Nice to~~ have this Christmas

The coming year will see the fight against coronavirus continue, make-or-break international agreements on climate change and biodiversity, and nations continuing to vie for supremacy in space.

And that's just the stuff we know about.

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Botany

Climate change may make autumn leaves fall earlier

TREES may shed their leaves earlier in autumn due to climate change, rather than later as previously thought. The finding suggests that forests will store less carbon than expected as temperatures rise.

Constantin Zohner at ETH Zurich in Switzerland and his colleagues looked at autumn leaf-fall data from 1948 to 2015 for six tree species, including the common oak (*Quercus robur*), across nearly 4000 sites in central Europe.

The group compared trees growing in chambers containing different amounts of carbon dioxide and in different amounts of sunlight to see the effects on leaf-fall timing.

Using the resultant data, the team modelled what would happen by 2100 if carbon emissions stay high. Instead of warmer autumns bringing a longer growing season and a later leaf-fall, Zohner's team found it would probably happen three to six days earlier than now (*Science*, doi.org/fkg9). "The key finding is this huge difference to when autumn happens compared to previous models," says Zohner.

The team's experiments and the 67-year tree record suggest that higher CO_2 levels, temperatures or light levels make leaves more productive in spring and summer, hastening their demise in autumn.

Zohner thinks the results will hold for temperate trees in North America and Asia too.

He says the switch to an advance in leaf-fall amounts to about 1 gigatonne less carbon stored globally each year by temperate forests, roughly a tenth of what we emit annually. "It's a quite huge number," he says. **Adam Vaughan**

Infectious disease

Why some mosquito bites are worse

WHEN a malaria-infected bird is bitten by mosquitoes over the course of 3 hours, the first insects to feed end up carrying fewer malaria parasites than those that feed later. The same may apply when infected people are bitten.

Malaria is caused by microscopic *Plasmodium* parasites carried by mosquitoes. It can cause fever and vomiting and in extreme cases can be fatal: the disease killed nearly 400,000 people in 2018 alone.

Malaria usually spreads when mosquitoes drink the blood of an infected person and pass on the *Plasmodium* parasites in the blood when they later bite someone else.

But some mosquito bites appear to be more likely to lead to infection than others, says Romain Pigeault at the University of Lausanne in Switzerland. To investigate, he and his colleagues exposed malaria-infected Atlantic canaries (*Serinus canaria*) to 100 young, hungry *Culex pipiens* mosquitoes for 3 hours. Each time a mosquito fed on a bird, the researchers trapped the insect and either froze it in liquid nitrogen or held it in isolation for a week. The birds were treated and released into large aviaries.

There were similar numbers of *Plasmodium* parasites inside all the immediately frozen mosquitoes. However, the isolated mosquitoes that had bitten the canaries towards the end of the 3-hour window carried many more parasite eggs in their bodies than the early biting mosquitoes (*Proceedings of the Royal Society B*, doi.org/fkhg).

This suggests that later-biting mosquitoes are more likely to spread malaria in birds if they go on to bite an uninfected individual. A similar phenomenon might also occur in humans, says Pigeault. **Christa Lesté-Lasserre**

Archaeology

Melting ice reveals ancient arrow hoard

A HUGE number of arrows dating from the Stone Age to the medieval period have melted out of an ice patch in Norway in recent years because of climate change.

Lars Holger Pilø at the Department of Cultural Heritage, Innlandet County Council, Norway, and his colleagues have gathered up 68 arrow shafts, some with arrowheads still attached or nearby, and many other artefacts.

GLACIER ARCHAEOLOGY PROGRAM, INNLANDET COUNTY COUNCIL

Almost all were found on an area of mountainside in Jotunheimen, southern Norway.

The oldest arrows date from around 4100 BC and the youngest from roughly AD 1300. The dates aren't evenly distributed, raising questions about whether environmental conditions during some periods were more likely to preserve fallen arrows. Peaks and troughs in hunting activity could also have played a role.

In some cases, arrowheads of various materials have also survived, including bone, slate, iron, quartzite and one made of mussel shell (*The Holocene*, doi.org/fkhd).

As the ice that locked the artefacts away has shifted over time, the arrows have moved from where they originally fell. That makes it hard to infer too much about the activity associated with them, says Pilø. "The ice is an artefact-preserver but it is also at the same time a destroyer of history," he says. **Chris Baraniuk**

Really brief

REICHEL, NEIL, SHEN & HOLDERIED

Moth wings could inspire sound tech

Earless moths have sound-absorbent wings that act as acoustic camouflage from bats. The moth wings have an ultra-thin layer of scales (3D representation pictured) that absorb sound and could be adapted for noise-cancelling tech (*PNAS*, doi.org/fkgb).

Hawaii's buried fresh water

A huge cache of fresh water found beneath the sea floor off the western coast of Hawaii's Big Island could lift the threat of drought for people living there. The water is contained in porous rock reaching at least 500 metres beneath the sea floor (*Science Advances*, doi.org/fkgc).

Huge plant database blooms

Researchers at the Leipzig Botanical Garden in Germany have compiled the largest ever list of scientific names for plants. The Leipzig Catalogue of Vascular Plants includes 1.3 million scientific names, covering more than 350,000 plant species, and will help botanists ensure they all use the correct names (*Scientific Data*, doi.org/fkgd).

Planetary science

Young Earth had a toxic atmosphere

WHEN Earth was young, its surface was probably covered in a seething magma ocean, and the gases rising from it could have provided it with an atmosphere nearly identical to the toxic one on Venus today.

Earth's early magma ocean was probably created by a collision with a Mars-sized object that melted much of the young planet and created the moon. As the magma ocean cooled, some compounds would have evaporated out of the molten mix and formed an atmosphere.

To figure out what this atmosphere would have been like, Paolo Sossi at ETH Zurich in Switzerland and his colleagues floated a small pellet of rock on a jet of gas while heating it to about 1900°C with a laser to melt it.

"This little melted marble floating at almost 2000 degrees is sort of a miniature Earth in its molten state," says Sossi. The gas flowing around it behaves as if it were a tiny atmosphere.

The researchers then repeated the experiment, altering the compounds in the jet of gas to try to find the likely make-up of the atmosphere of the young Earth. The oxygen levels in the melted sample changed depending on the composition of the gas. They compared these molten marbles to samples of rock from Earth's mantle to find what mix of gases produced the best match with the geological record we have.

They found that this was a dense atmosphere full of carbon dioxide and with relatively little nitrogen, similar to the atmosphere on Venus today (*Science Advances*, doi.org/fkg6). **Leah Crane**

Animal behaviour

HOUSE ET AL (2020)

Wasps endanger planes by building nests in them

KEYHOLE wasps have been shown to build nests in crucial devices for measuring the airspeed of planes. Blockages in these pitot tubes can make pilots misread airspeed and have led to fatal crashes.

Alan House at consulting firm Eco Logical Australia and his colleagues have studied keyhole wasps (*Pachodynerus nasidens*) at Brisbane Airport over three years.

The research was triggered by safety incidents, including one in which a plane had to land soon after departing because the pilots recognised an airspeed discrepancy, says House. A blocked pitot tube was found to be the culprit. "It's not a Mayday emergency but it's the next level down, and it closes the runways," says House.

To identify what might be responsible for the blockages, House's team 3D-printed replica pitot tubes and set them up across Brisbane Airport for 39 months. They found that 93 probes became fully blocked during that period, all by nests made by keyhole wasps. The wasps preferred tubes wider than 3 millimetres in diameter (*PLoS One*, DOI: 10.1371/journal.pone.0242063).

Pitot tubes are now covered when aircraft arrive at Brisbane Airport. Donna Lu

Medicine

Fluid between cells could reveal illness

THE fluid between our cells could be used to diagnose and monitor health conditions. A patch made of tiny needles can sample this liquid and could be easier and less invasive than normal blood tests.

Interstitial fluid surrounds our cells, delivering essential nutrients and removing waste products.

Mark Prausnitz at the Georgia Institute of Technology and his colleagues have developed a patch made of five stainless steel microneedles that create small punctures in skin. They tested the patch on 21 people, taking small amounts of interstitial fluid out of the body and comparing the results with those from blood samples.

There were similar levels of key compounds in both samples, including glucose, caffeine and vitamin D (*Science Translational Medicine*, doi.org/fkg3). The team says the approach could be used to test for these compounds and diagnose health problems such as diabetes related to their levels. The skin can heal from the needle punctures within a day.

As well as being an alternative to blood tests, patches like this could be used to continuously monitor compounds in the body. **Karina Shah**

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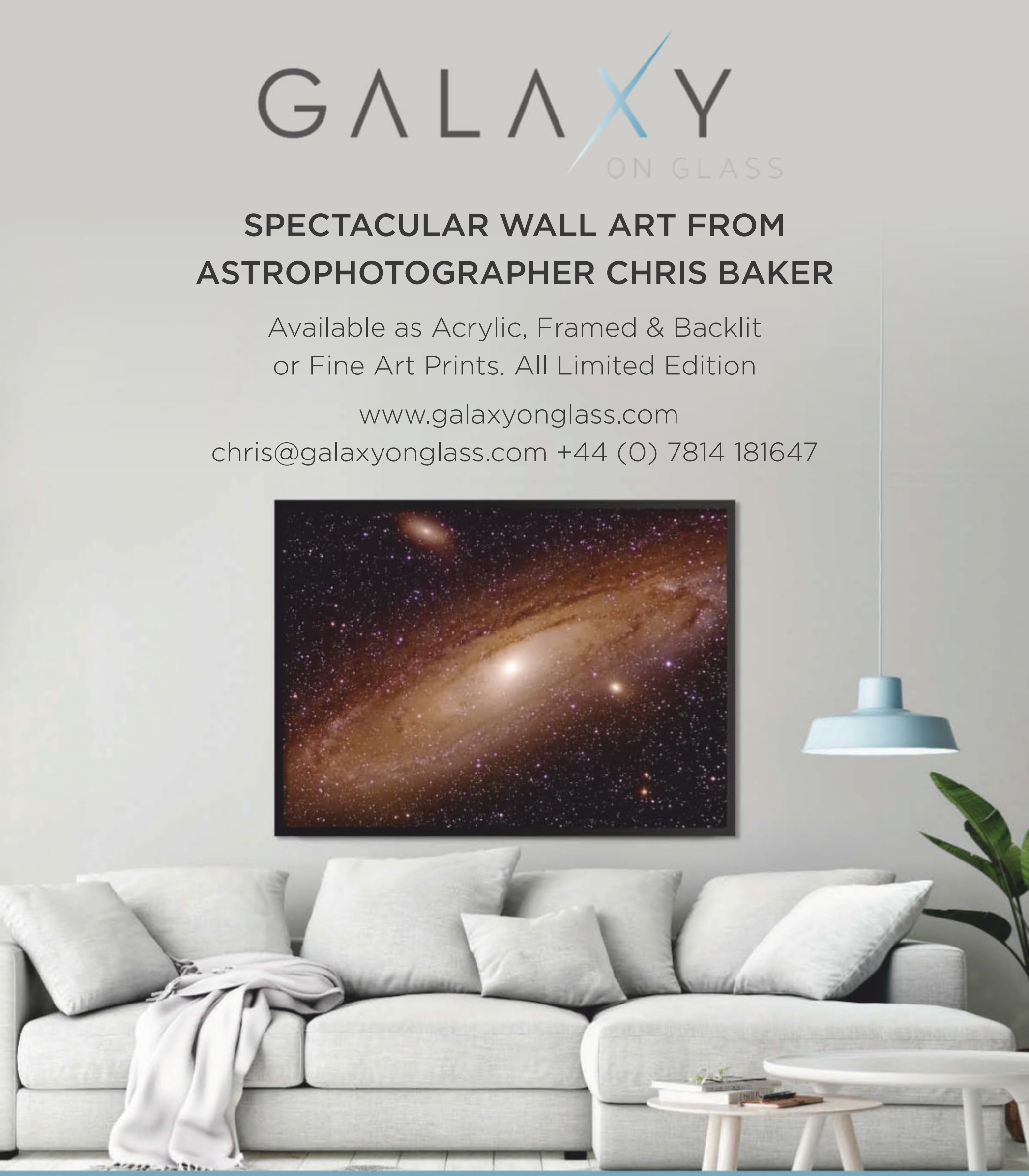

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Views

Comment

Covid-safe celebrations

If you plan to meet people over the festive season, there are many ways you can reduce the risk of spreading coronavirus, says **Clare Wilson**

Clare Wilson is a medical reporter at *New Scientist*
@ClareWilsonMed

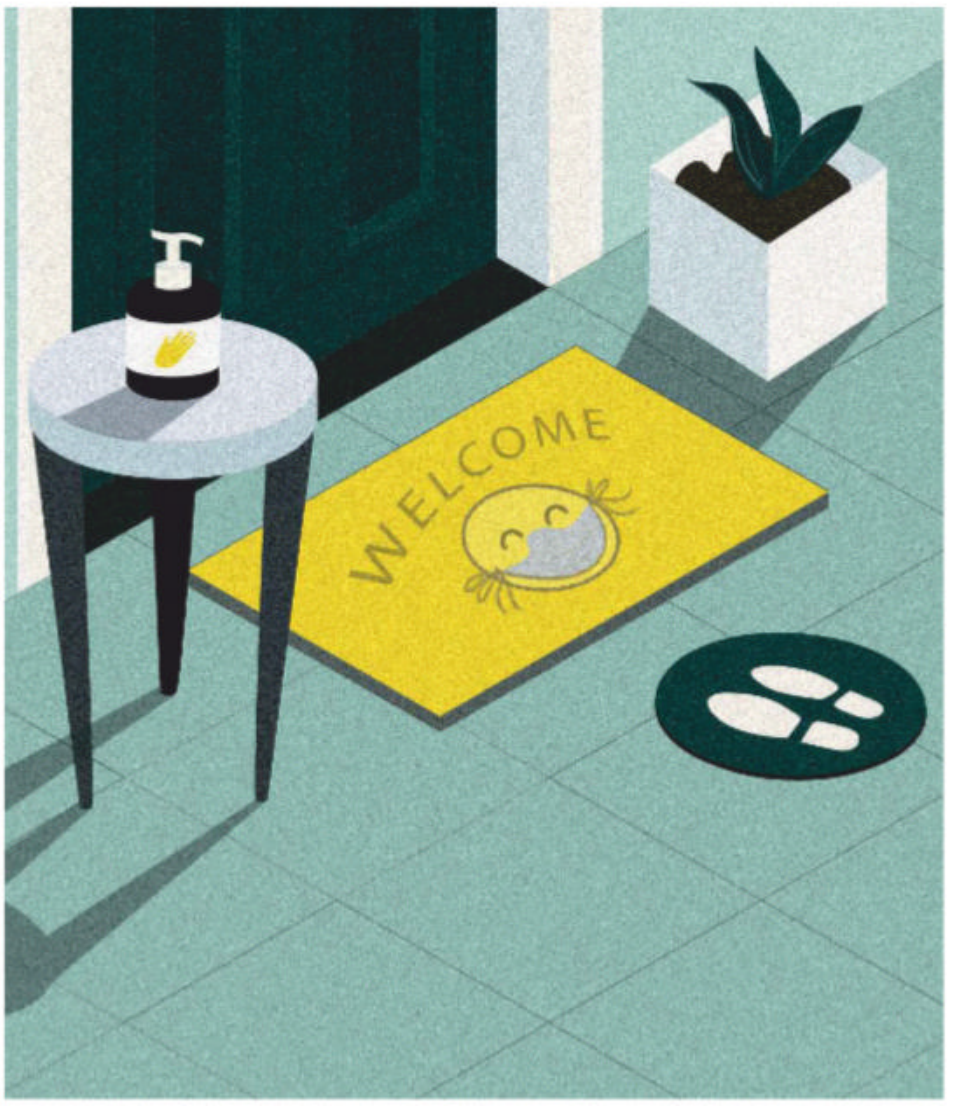
THE question of how to safely celebrate the holiday season this year is currently occupying a lot of people's minds. In the UK, up to three households will be able to meet indoors at private homes for five days over Christmas in most of the country, and for seven days in Northern Ireland.

The news sparked widespread cheer, but some scientists have warned against the "Christmas truce", predicting it will lead to a surge in coronavirus infections. So what can people do to reduce their risks?

The UK isn't the only country where people are pondering this question. France and Germany have just announced similar loosening of restrictions, although the details differ, showing that the science is unclear on the right approach. People in the US, where Thanksgiving fell on 26 November, have already been wrestling with the same dilemma.

Some people – such as Anthony Fauci, director of the US National Institute of Allergy and Infectious Diseases – believe it isn't worth the risk to meet with other households even when it is legally allowed. Studies of how the virus spread in January and February suggest that the biggest risk comes from indoor gatherings, especially ones involving drinking alcohol and eating.

For those set on face-to-face meet-ups, remember they don't have to be all or nothing. It may sound obvious, but it is well worth ploughing on with the same hygiene measures that have been advised from the start, like handwashing and keeping your distance from people.



MICHELLE D'URBANO

It isn't easy to do so in winter, but opening windows and doors as much as possible would increase the chances of virus particles drifting away on air currents. And sorry to sound puritanical about it, but hugging and kissing anyone not in your household should be a no-no.

There are also preventive measures to consider beforehand. In Germany, it looks like people will be advised to self-isolate for several days before mixing with other households. But that isn't possible for everyone, including those who work outside the home or go to school. In the UK, there are calls for schools to switch to online lessons for the last two weeks of term. And it isn't in any official advice, but if I were planning to visit more than one household in separate outings, I would schedule my trips to see anyone more vulnerable first of all, to lower the risk of bringing the virus into their house.

Another option is to have coronavirus tests, but these aren't the get-out clause that might be imagined. In the UK, they are generally available through the National Health Service only for people with covid-19 symptoms. When bought privately, a test can cost over £100. Unfortunately, they also come with a risk of false negatives: telling someone they don't have the virus when they really do. One estimate from June placed the rate of false negatives at more than 1 in 5. So while a positive test result means you should have a *Home Alone* Christmas, it would be unwise to see a negative result as licence to act as if you are virus-free.

It may seem Grinch-like to have to consider these issues when the media is currently abuzz with excitement about the possible festivities. But I'm getting more excited about the prospects that vulnerable people may soon start to be vaccinated.

While many unknowns remain about the potential vaccines, it seems likely that, if we can just get through the next few months, family get-togethers will soon look a lot more normal. I'm saving up my hugs and kisses for Easter.

Field notes from space-time

Invisible haloes

Many galaxies seem to have bubbles of dark matter enveloping them, but finding out if every galaxy is like this is an ongoing area of research, writes **Chanda Prescod-Weinstein**

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

Chanda's week

What I'm reading
Stakes is High: Life after the American dream *by Mychal Denzel Smith.*

What I'm watching
Although it was imperfect, as a long-time chess fan, I really loved The Queen's Gambit.

What I'm working on
I'm helping to lead the US particle physics community in the process of determining the next decade of priorities for the field.

This column appears monthly. Up next week: Graham Lawton

IF YOU ever visit a nature reserve that has worked with the International Dark-Sky Association to preserve its view of the stars, then on a clear night you can see the Milky Way. Although we are certain our home galaxy is a spiral, to the naked, uninformed eye, it looks like a curved strip made up of many little dots of light. There are so many stars that they can seem uncountable.

Although those little lights seem mystical, they can also feel familiar, like a distant street lamp. We now know that they are far away suns, made up mostly of hydrogen with some helium and other heavier elements in the mix. Stars are made of the same stuff as us. That might make you think that most of the stuff in our galaxy comprises the same kind of matter as we find in our bodies, but actually it doesn't.

As I've discussed in previous columns, stars rotate around the centre of galaxies faster than we would expect because the galaxies seem to be more massive than the number of stars indicates. There appears to be more matter in galaxies than the stuff we can see. This has often been called the missing matter problem, with the missing stuff being labelled "dark matter".

In reality, it seems that most of the matter in our galaxy is this unfortunately named dark matter. As I have written before, my issue with the name is that dark matter – if it is real – isn't really dark at all. It is transparent. Or invisible, if you prefer.

So, it turns out that when we look at the Milky Way at night from a dark-skies nature reserve, we aren't seeing most of our galaxy. We are just seeing the luminous, visible part.

At this point, dark matter is just hypothetical. We have never seen it because it doesn't radiate light. We only know of it because we can infer its existence from observations. For example, sometimes we use our telescopes to look at galaxies that appear to have strange features encircling them. This is a result of something known as gravitational lensing, and it is caused by massive objects bending the space-time between us and a distant galaxy, leading to distortion of the image of that galaxy. It is hard to explain gravitational lensing in some cases without the existence of dark matter.

This isn't even our strongest evidence for dark matter. What is? Observations of the cosmic microwave background radiation (CMB), a phenomenon I discussed in last month's column.

"Most of the matter in the universe is invisible – visible matter like stars, and us, is unusual"

Although photons from the CMB originated in the early universe, their journey through space-time has been affected by its contents, including dark matter, which has left an identifiable imprint on patterns in the CMB. The CMB is just one example in a litany of data that points to one conclusion: not only does dark matter exist, but it also makes up most of the matter in the universe.

In other words, it turns out that when we look at the stars, we aren't seeing what is typical in the universe. We are seeing what is atypical about it. Most of the matter in the universe is invisible to us – and visible matter like stars, and us, are what is unusual, accounting for only about 20 per cent of the matter in the universe, with dark matter making up the other 80 per cent.

The implications of this for our galaxy and others are quite literally massive. We have deduced from looking at the way that stars move that each galaxy lives in a dark matter bubble that we call its dark matter halo.

I posted this bit about dark matter haloes on social media recently, and a follower asked me the astute question: "Does the number of haloes match the number of galaxies?" In other words, do galaxy numbers, and the properties of galaxies, correspond directly to halo numbers and halo properties?

This is what is known in the cosmology community as the galaxy-halo question, and it is an exciting topic of research because we don't know the answer. My most recent research paper, a preprint that I worked on with my student Noah Glennon, is helping us make progress on this question in relation to my favourite dark matter candidate, the axion – a hypothetical elementary particle.

In the paper, we explored how dark matter haloes made of axions can be modelled with simulations using computer code that Noah helped build. For our follow-up efforts, we are lucky enough to be working with world-leading galaxy-halo expert Risa Wechsler and her group at Stanford University and the SLAC National Accelerator Laboratory in Palo Alto, California.

In the midst of a difficult year, I've often been asked how I can possibly find meaning in the work that I do. There are certainly times when I have doubts. But, for now at least, the night sky is still a busy place, and it turns out that there is more to it than we thought. ▮

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2012-Ad-NS

Editor's pick

Plentiful views on the great population debate

14 November, p 34

From Louise Doswald-Beck, Geneva, Switzerland

Is there no scientific analysis of how many people the world can sustain for everyone everywhere to have a healthy, decent standard of living without overcrowding, while restoring biological diversity at the same time? With such information, we could talk about the best way to achieve this equitably. Attitudes can slowly change when the facts are clearly stated. Scientists are best placed to do this without bias.

From Iain Climie, Whitchurch, Hampshire, UK

Fewer people would be helpful, but there are two key caveats to this. Firstly, Paul Ehrlich went on to qualify his book *The Population Bomb* by noting that a well-off US family could have the same impact on resources as a Bangladeshi village. Secondly, deaths have to exceed births – we can all moan about others' kids, but few of us would reject longer, healthy lives.

The amount of waste in the world beggars belief. We need to tackle this.

From Peter Reid, Plymouth, Devon, UK

Investing in education for girls is vital. It leads to women who have a bigger say in the number of children they have. For many high-income countries, pure self-interest is enough to aim for spending the recommended 0.7 per cent of GDP on foreign aid.

From Andy Bebington, London, UK

Referring to wealthier nations, you write about a "slow-burn issue of a growing 'dependency ratio': a large, ageing, economically inactive population supported by tax receipts from a dwindling band of working people".

Presumably this is because we oldies, who do a lot of volunteer work, don't get paid for it, so are "economically inactive"? Who runs charity shops, food banks, neighbourly care schemes and community halls, all of which saves the state untold amounts?

From Ernest Ager, Exmouth, Devon, UK

The importance of general education in reducing the overall birth rate is clear. However, an additional element of education is generally missed. If it can be agreed that a continually rising population isn't good for Earth as a whole, then a directed worldwide programme of education on this point should be implemented.

From Tim Mead, St Keverne, Cornwall, UK

During my life, global population has tripled. This goes against the idea, raised in the leader related to your feature, that we know what works to limit population growth, which should perhaps carry the caveat "if it weren't for human nature". What chance is there that human nature will change, that we will overcome our instincts?

From David Richardson, London, UK

You point out that many nations will soon have falling populations. Let us rejoice in this.

For the record

In our population feature, the source of the cholera outbreak in Soho, London, in 1854 was the contaminated water from a communal pump, not the pump handle itself.

A tribute

Bernard Dixon (1938-2020)

WHEN Bernard Dixon became the editor of *New Scientist* in 1969, the magazine was struggling, sharing tatty offices in London with two equally troublemaking titles, the *New Musical Express* and *New Society*. By the time Bernard left 10 years later, the publication occupied the 26th floor of a shiny new skyscraper and was one of the most successful and profitable parts of its parent company's sprawling portfolio of mostly consumer magazines.

During his time in charge, Bernard turned *New Scientist* into a publication that bore many of the features that you see today: colourful covers and articles written to appeal to a wide audience, for instance.

Not long before Bernard's regime, the magazine's covers were essentially monochrome slabs of text. As budgets allowed, fuelled by a booming income from recruitment advertising, colour infiltrated the pages and Bernard enlisted one of the best art departments in the UK, which won numerous awards.

***New Scientist*'s philosophy during Bernard's time is summed up in the book *What Is Science For?*, which he wrote early on in his editorial spell. The magazine didn't glorify science and certainly wasn't an unquestioning mouthpiece for everything that scientists did. To Bernard, science was as much a process and a culture as it was a flood of papers that needed translating for a larger audience.**

He recruited mostly young writers, often escapees from research who had little editorial experience but weren't afraid to ask hard questions and had a passion for digging science up by the roots to see how it worked.

One example typifies how Bernard guided *New Scientist* and its coverage. His background in biomedicine meant that he rubbed shoulders with eminent players in the field, and he listened to their concerns about the non-medical uses of antibiotics.

Unlike the health regulators and the agrichemical and farming communities, Bernard could appreciate the danger of growing antibiotic resistance. *New Scientist* campaigned about this abuse of science and the threat that it would leave humans susceptible to illnesses.

At the same time, the magazine led the way in reporting environmental issues. It covered the threat to the ozone layer, tapping the knowledge of people like James Lovelock. Articles on climate change, health and safety, nuclear power and the rise of "alternative technology" sat alongside James Randi debunking "spoon benders".

As the responses to his passing showed, another feature of Bernard's reign was the magazine's role as a nursery for talent. He recruited and nurtured young writers who went on to fill key posts at the *Financial Times*, *The Daily Telegraph*, *The Independent* and *The Guardian*. By laying these foundations, Bernard paved the way for a magazine that, to this day, sees science as an essential cultural and intellectual activity.

Michael Kenward, editor of New Scientist *after Bernard Dixon*

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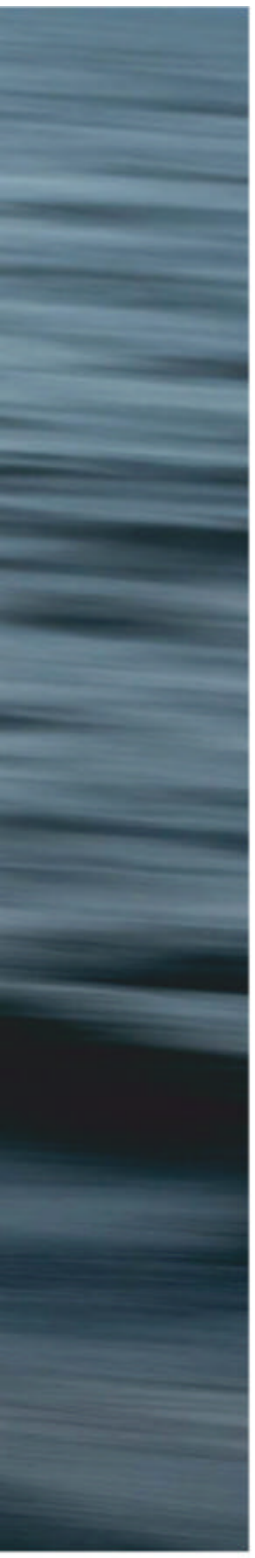


CLOCKWISE FROM TOP LEFT:
THE ART OF FLIGHT BY ALWIN HARDENBOL
ANT TALE BY UPAMANYU CHAKRABORTY
HATCHING BY PICHAYA LERTVILAI
MOUTH BY ROBERTO GARCIA ROA
MIMICRY BY GABOR POZSGAI
ROAD RISK BY PETER HUDSON

Natural wonders

British Ecological Society's 2020 "Capturing Ecology" photography competition award winners

THESE striking photos celebrate the beauty and diversity of the natural world. Taken by ecologists and students from around the world, the images are among the winners, runners-up and highly commended entries in the British Ecological Society's 2020 "Capturing Ecology" photography competition.

The overall winner was Alwin Hardenbol at the University of Eastern Finland for his shot of a Dalmatian pelican (top, far left), the largest type of pelican and one threatened by the loss of breeding colonies and aquatic habitats.

Runner-up images include a procession of weaver ants (top, right) carrying younger colony members to safety, taken by Upamanyu Chakraborty, a researcher at the Wildlife Institute of India. Immediately below it is an image of Verrill's two-spot octopus larvae emerging from their egg sacs, a shot that also won Pichaya Lertvilai at the University of California, San Diego, a runners-up spot.

Roberto García Roa at the University of Valencia, Spain, won in "The Art of Ecology" category for his Cope's vine snake (bottom, right) pictured using its open mouth to scare predators.

The final images, from the highly commended list, show a perfectly camouflaged *Oiticella convergens* moth (middle, bottom) captured by Gabor Pozsgai, who is at China's Fujian Agriculture and Forestry University; and a coyote (bottom, far left) taken by Peter Hudson of Pennsylvania State University.

Gege Li

The cream of 2020

Hunting aliens, arguing with racists, meeting Murderbots, rethinking drones or catching up with covid-19 – ***New Scientist*** picks the best books for Christmas

The End of Everything (Astrophysically Speaking)

by Katie Mack

For a bit of seasonal giving, why not look to the end of the universe? Thankfully, *The End of Everything* (Scribner) by Katie Mack is no apocalyptic vision but an engrossing and often funny tour of all the ways our cosmos might come to a close. Mack's enjoyment of physics stands out – and is contagious. She describes primordial black holes as "awfully cute in a terrifying theoretical kind of way", antimatter as "matter's annihilation-happy evil twin" and the universe as "frickin' weird". All true, and Mack's explanations are entertaining and informative. *The End of Everything* is a fascinating diversion from the problems of the present day into the grand destruction of the distant future.

Leah Crane, reporter, *New Scientist*

They Are Already Here

by Sarah Scoles

Need a politics-free holiday gift for someone with a taste for *The X-Files*? Try Sarah Scoles's *They Are Already Here* (Pegasus Books), a tour of the world of UFOs and aliens. The first flying saucers were reported in 1947 and became part of popular culture despite the lack of scientific evidence for their existence. Scoles rides Nevada's Extraterrestrial Highway (actually Route 375), which leads to the science-fiction hotspot Area 51, visits the UFO Watchtower in Hooper, Colorado, and listens to enthusiasts explain why they keep searching. She finds a community of people sharing curiosity and camaraderie as they explore the unknown. It makes for a good story with worthwhile insights about humans, but sadly no real space aliens.

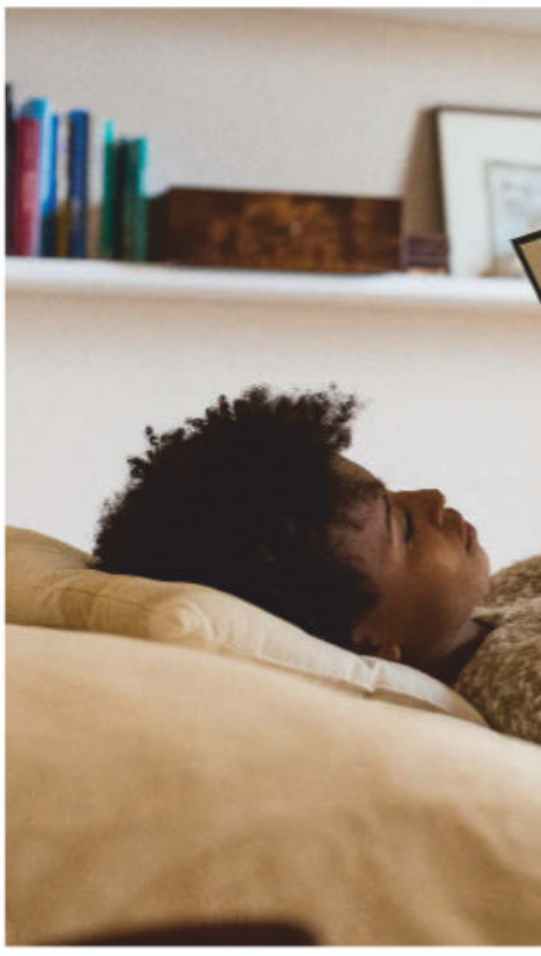
Jeff Hecht, consultant, *New Scientist*

Less Is More

by Jason Hickel

In our world, gross domestic product is king: it is the metric we strive to increase. But GDP is a blind measure of economic activity, and doesn't care whether that activity comes from a destructive source. So if you clear vast tracts of forest for timber and cattle, GDP goes up. In the eye-opening and passionate *Less Is More* (William Heinemann), Jason Hickel shows how the insatiable drive to increase GDP has caused the ecological crisis, reveals the historical and colonial roots of capitalism and argues that an ecologically sensitive economic system based on "degrowth" is essential for us to flourish.

Rowan Hooper, podcast editor, *New Scientist*



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Murderbot series

by Martha Wells

Have yourselves A Very Murderbot Christmas with Martha Wells. Two parts *Terminator* to one part *My So-Called Life*, her Murderbot series (Tor.com) is pulp fiction for the 21st century. In between the festivities, hunker down and enjoy, in order, *All Systems Red*, *Artificial Condition*, *Rogue Protocol*, *Exit Strategy* and *Network Effect*. They are action-packed, addictive and centred on the exploits of a socially anxious, philosophising (yet murderous) robot who is among the most human and relatable the genre has delivered. Take a break from Zoom and Netflix to spend a covid Christmas with Murderbot.

Sally Adee, freelance writer

Kindred

by Rebecca Wragg Sykes

For a fresh and exciting look at the discovery and evolving understanding of our ancient Neanderthal relatives, try *Kindred* (Bloomsbury Sigma). In it, Rebecca Wragg Sykes sets out to separate such valid questions as "why aren't Neanderthals around any more?" from the prejudice that casts them as "dullard losers". Neanderthals aren't cadet versions of us, and she reveals their needs,

Covid-19, the lessons so far

The pandemic has a long way still to run, but we can now start feeling confident of better days ahead. It is a good time to think past masks, hand sanitisers and grim stats to ask: what did this disaster reveal about us, what did we get wrong and how do we ensure we never end up here again? For answers, try these three excellent, but very different books.

The brilliant **How Contagion Works** (Weidenfeld & Nicolson) by Italian physicist Paolo Giordano was the earliest book on the pandemic, written as Italy was the first European country to be overwhelmed. Giordano saw "anger, panic, indifference, cynicism, disbelief, resignation". But he urges us to be kind and see the pandemic not as an accident or a scourge, but as foreseeable, and proof of how our world has become inextricably interconnected. The outbreak's origins reside with us, the planet's most invasive species.

For deep understanding of the years of policy mistakes, the ignored warnings and the viruses lurking as we invade ever more ecosystems, turn to Debora MacKenzie's magnificent **Covid-19: The pandemic that never should have happened, and how to stop the next one** (The Bridge Street Press). Read about the Nipah virus and see what a civilisation-threatening pandemic might be like. Be afraid.

MacKenzie's call to action is complemented by Richard Horton's **The Covid-19 Catastrophe** (Polity), which offers a greater focus on the failures of Western governments to respond effectively. The global story of covid-19 is inevitably half-told. Nations like the UK and US are still performing poorly while others, such as China and New Zealand, have seen few deaths. We need honest explanations. Horton, the editor of *The Lancet*, helps us to begin that painful reckoning.

Alun Anderson, emeritus editor, *New Scientist*

urges, pleasures and strategies for survival. Fascinating stuff.
Simon Ings, freelance writer

Hunker down with a clutch of great books and enjoy a holiday reset

How to Argue with a Racist
by Adam Rutherford

Some family gatherings may well find Adam Rutherford's *How to Argue with a Racist* (Weidenfeld & Nicolson) a great asset. It not only shows what science really says about race, ancestry and genetics, but also helps us argue against the idea that certain people are biologically inferior and encourages informed conversations about race. It targets surprisingly prevalent racist beliefs, from the notion that men from certain groups have larger or smaller penises than average to the idea that people from different racial groups are more or less intelligent than average. In the end, Rutherford has to face the issue at the core of many racist stereotypes: is race truly a biological classification? This book's gift is to use science to talk about a pseudoscience.
Layal Liverpool, reporter, *New Scientist*

There Are Places in the World Where Rules Are Less Important than Kindness
by Carlo Rovelli

Feted as the "poet of physics" for his previous bestsellers, including *Seven Brief Lessons on Physics* and *The Order of Time*, Carlo Rovelli's latest book is a collection of assorted essays (Allen Lane) in which the Italian quantum gravity researcher casts his net wider. Roving across physics, philosophy, cultural history and anthropology, he touches on themes from the cosmological revolution created by Copernicus and Galileo to literary giant Vladimir Nabokov's passion for butterflies and his own research into black holes. Illuminating, thought-provoking and suffused with a passion for knowledge and ideas, it is an eclectic and far from conventional science read or gift.
Richard Webb, executive editor, *New Scientist*

The Ministry for the Future
by Kim Stanley Robinson

In Bogotá, Colombia, the world's biggest climate conference sets up a new UN body to advocate for the world's future citizens and defend "all living creatures present and future who cannot speak for themselves". This body is at the heart of *The Ministry for the Future* (Orbit), Kim Stanley Robinson's latest science-fiction epic. Soon after, millions die in an Indian heatwave – a tragedy conveyed in visceral detail at the start of this disturbing book. How should the new body (or any of us) respond to climate disasters? Can individual or state-sanctioned ecoterrorism help save the planet? *Ministry* asks tough questions, using a multi-perspective approach to create a complexity that mirrors climate change and its possible remedies. Give it to everyone you know.
Liz Else, culture editor, *New Scientist*

What Stars Are Made Of
by Donovan Moore

How many women scientists have gone unsung? *What Stars Are Made Of* (Harvard University Press), a biography by Donovan Moore, tells the tale of Cecilia Payne-Gaposchkin, a British astronomer and astrophysicist who helped overturn a basic assumption about the universe. In the 1920s, she analysed the spectral pattern of stars, discovering they held about a million times more hydrogen than previously thought, making it the most abundant substance in the cosmos. Four years later, a male scientist (who had previously dismissed her finding as "clearly impossible") got the credit for the discovery. This deeply researched and illuminating biography would make a heart-warming present.
Donna Lu, reporter, *New Scientist*

The Drone Age
by Michael J. Boyle

In everything from commerce to warfare, spy craft to disaster relief, our menu of choices "has been altered or constrained by drone technology itself", says Michael J. Boyle in *The Drone Age* (Oxford University Press), a concise and comprehensive overview of the world the drone made. Grounded in just the right level of technical detail for drone lovers, its scope is wider, describing not so much the machines, but the kind of thinking they have ushered in. This turns out to be an approach to problems that no longer distinguishes between peace and war. A few careful drone strikes under President Obama (and even more so under President Trump) proliferated into a global, counter-insurgency air platform. "It is hard to feel like a human... when reduced to a pixelated dot under the gaze of a drone," writes Boyle. As the pool of gathered information expands to swallow us all, where is the positive? In finding out how deep the rabbit hole goes. If you want to give one book about drones, this is it.
Simon Ings, freelance writer

"Katie Mack describes primordial black holes as 'awfully cute in a terrifying theoretical kind of way'"

The games column

Randomly generated recruits

In *Watch Dogs: Legion*, you can play as or team up with any of the characters of the game, and strolling around its digital version of London is a real treat, says Jacob Aron

Jacob Aron is *New Scientist*'s deputy news editor. He has been playing video games for 25 years, but still isn't very good at them. Follow him on Twitter @jjaron

UBISOFT

Key London landmarks like The Shard appear in *Watch Dogs: Legion*

NEW SCIENTIST closed its offices on 13 March, a week or so before the UK went into national lockdown. Since then, I have spent most of this year in a small radius around my north London flat and have been into the city centre only a handful of times.

As a native Londoner, it is strange to be so cut off from the city, which is why the opening moments of *Watch Dogs: Legion* took my breath away. As the camera panned over incredibly realistic looking versions of the London Eye, Buckingham Palace and even a lovingly rendered Brixton tube station, I felt homesick for the city I'm living in.

But this isn't really London as I know it. The game is set in the near future, the streets full of driverless cars and the skies bristling with drones. A private police force, Albion, has taken over security around the city, its logo daubed over major landmarks. It is hinted, but never directly stated, that this heightened security is the result of a post-Brexit crackdown on immigrants and a rise in authoritarian nationalism.

At the start of the game, you play as Dalton, a member of a hacking group known as DedSec, as he investigates a threat to Parliament. After a gun battle over the green benches of the House of Commons, things go badly as bombs go off around the city, and Dalton is killed. Planted evidence points the finger at DedSec, and the group effectively disbands.

> **"I end up walking familiar streets, and spent my first few hours on a melancholic tour of old haunts"**

From there, the game takes an unusual turn. You choose from a selection of randomly generated characters, each with their own benefits and backstory. I ended up going with Jessica Okello, a barista with a vendetta against Albion, but I could have chosen Vivek Mittal, an internet celeb with a motorcycle, Lyes Ait, a software engineer who runs a dark-web forum, or many others.

That is because the gimmick of *Watch Dogs: Legion* is that you can play as anyone in the game. The remnants of DedSec, including an annoyingly chipper AI called Bagley, task you with rebuilding their ranks. Walk up to someone and your in-game smartphone will reveal their skills, and you can start a mission to recruit them. I have everyone from a builder to a spy to a living statue on my team.

All of this is randomly generated, and the system works impressively well. For example, when attempting to recruit a doctor, I had to access a National Health Service server by breaking into a hospital. This in turn led to me discovering that some gangsters were stealing organs. After I had shut down their scheme, the doctor was happy to join the team.

Most of the missions in the game boil down to a few basics like this – go here, hack that, try to get out unnoticed – but playing in digital London is a real treat that completely elevates the game. In my first outing as Jessica, I found myself in Chinatown. I was able to navigate to nearby Covent Garden by following the eerily familiar landmarks, and ended up at a strikingly accurate copy of the *New Scientist* office building, a place I haven't seen in months.

Although shops, pubs and so on don't match up with their real-world counterparts, I constantly end up walking familiar streets, and spent my first few hours with the game on a slightly melancholic tour of old haunts. The novelty eventually wears off and the game becomes a fairly standard entry in the open-world genre, but for Londoners, it is a must-play as an antidote to lockdown. ▮

Game

Watch Dogs: Legion
Ubisoft
PC, PlayStation 4 and 5, Xbox One, Series X and S

Jacob also recommends...

Games

Tomb Raider III
Core Design
PC, PlayStation
This 1998 game is hopelessly outdated, but it was my first experience of a graphically rendered London, with Lara Croft navigating abandoned tube lines to break into the Natural History Museum.

Marvel's Spider-Man
Insomniac Games
PlayStation 4 and 5
For people across the pond, this recent Spider-Man game is the most realistic video game depiction of New York City (well, Manhattan) yet.

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Two brain circuits explain the unique human capacity for invention – an insight that may also shed light on the evolution of autism, says researcher **Simon Baron-Cohen**

Our restless minds

DESCENDING the ladder into Hohle Fels cave, I felt like I was going back through layers of time. At the bottom, Nicholas Conard, archaeologist and director of the nearby museum in Blaubeuren, Germany, pointed to a layer of rock. "Right here is 20,000 years ago," he said. Then he pointed about a metre lower. "Here, we are at 40,000 years ago."

I was in awe, suddenly aware that I was standing where our early human ancestors lived and breathed so long ago. But it was what they invented that inspired my trip. Hohle Fels is where, in 2008, Conard and his colleagues discovered the earliest known musical instrument, a flute carved from a vulture bone that is thought to be about 40,000 years old.

It is the product of what I argue are parallel revolutions in human cognition. In my career studying the human brain through the lens of understanding autism, I have devoted a lot of time to understanding empathy, its role in our evolution and how it still underpins human interaction today. But around the same time that the brain changes arose that enabled us to use empathy, another equally critical set of changes took place: the evolution of a pattern-seeking brain network, what I refer to as the systemising mechanism, that provides the foundation for human invention – including that of musical instruments.

The consequences of this dual revolution for humanity were profound. What's more, my recent research suggests that the pattern-seeking network is more highly tuned in autistic people and may help explain why autistic traits often overlap with an extraordinary capacity for invention.

If we take the long view of human evolution, simple tool use dates back more than 2 million years. There is evidence of some advancements in early technology – the emergence of more sophisticated hand axes around 1.7 million years ago, for instance. But among early hominins, for about 2 million years, stone tools mostly had just a few basic functions: to smash, cut and scrape. There was little change, no sign of "generative" invention. Our ancestors had largely made just one change and stuck with it for millions of years, and didn't show how they could invent continuously, with each change building on the last, and they didn't show a range of inventions.

When our species, *Homo sapiens*, first emerged around 300,000 years ago, we begin to see signs of more invention with tools and specific kinds of blades. However, we start to see an explosion of invention in the archaeological record about 100,000 years ago, with evidence of the first engraving and the first examples of jewellery. Around 70,000 years ago, we see the first signs that modern humans were using "stealth weapons" such as the spear and bow and arrow.

Sewing needles appeared 60,000 years ago. By 44,000 years ago, we see the ›

BRIAN STAUFFER

earliest known evidence of counting, engravings on a bone that look like a tally. And in this fast-moving area of research, new artefacts are being discovered all the time. What most impressed me, though, is the earliest musical instrument: the bone flute excavated in Hohle Fels cave.

Empathy and systemising

After my visit to the cave, Conard played me a recording of a replica flute. It was profoundly moving. I was hearing the same notes our ancestors would have heard 40,000 years ago. The bone flute has five holes, an indication that it was used to play melodies using the pentatonic scale still prevalent in many musical traditions today. Our ancestors weren't just inventing complex tools, but complex systems – music itself.

This explosion of artefacts in the archaeological record is a sign that modern humans had developed the capacity for generative invention. Between 40,000 and 10,000 years ago, we see the emergence of sculpture, cave painting, agriculture and night-sky gazing. By 5000 years ago, there are signs of writing, mathematics, religion and the wheel. We are still inventing unstoppably – most recently vaccines against covid-19.

So what changed? In my new book, *The Pattern Seekers*, I argue that two circuits in the brain that drove this cognitive revolution began to evolve, surprisingly about the same time, between 100,000 and 70,000 years ago.

One of these circuits, the empathy circuit, enabled a raft of new behaviours, including the ability to deceive others, teaching, self-reflection, social "chess" and flexible communication that relied on shared reference, including storytelling. These explain why modern humans could make stealth weapons and jewellery: we were keeping track of what others might think, know, intend, feel, want and believe.

With my colleagues, I have been studying the empathy circuit for the past 35 years, and we now know that it recruits a complex network of at least 10 brain regions. Empathy has at least two components: cognitive empathy, also known as theory of mind, which is the ability to imagine another's thoughts; and affective empathy, the drive to respond to another person's mental state with an appropriate emotion. Although we see some evidence of empathy in some non-human animals, there is no convincing evidence that other animals can attribute false beliefs to another animal or that they engage in flexible deception and teaching, for example – unlike a 4-year-old child.

"Our capacity for empathy explains what we invent, but not how we came to invent"

DANIEL MAURER/AP/SHUTTERSTOCK

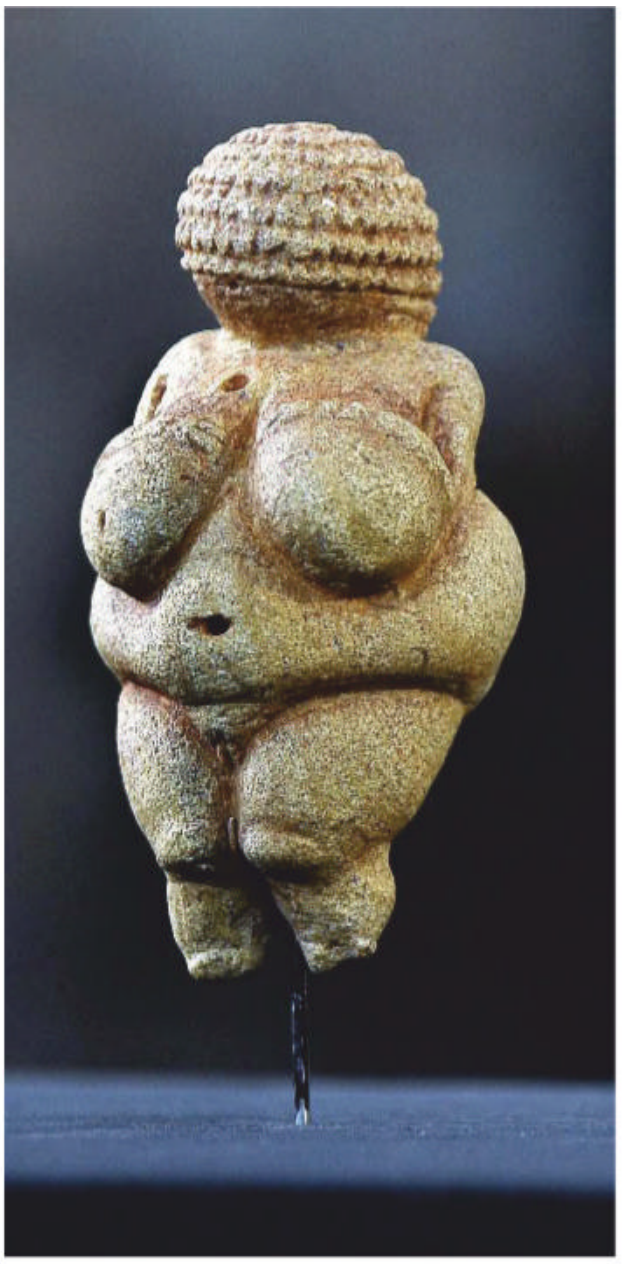
This 40,000-year-old bone flute is the earliest known musical instrument

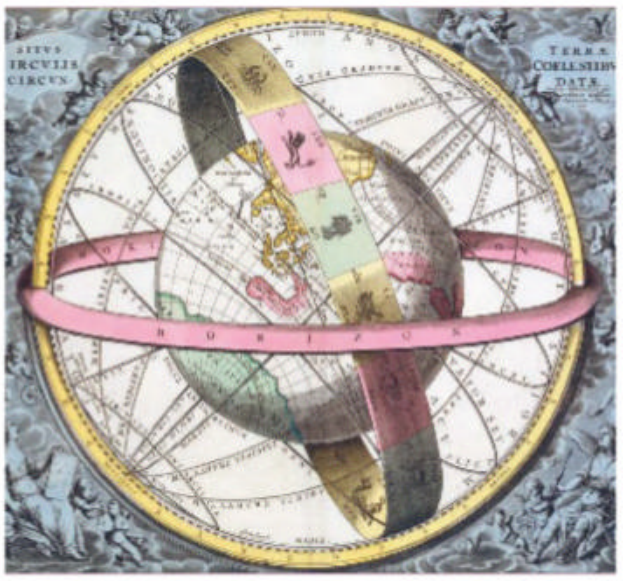
The other discovery we have made is that genetics influences this ability. Differences in empathy fall on a bell curve, with most people in the middle of the distribution and a tiny percentage at the extremes. In recent studies with up to 80,000 people, our international group of collaborators looked at the associations between common genetic variants and particular traits, finding that certain genes are associated with where each of us falls on the curve.

While upbringing and our early experiences undoubtedly influence how much empathy an individual has, the finding that empathy is even partly genetic is a clue that it was the result of natural selection. It is easy to see why it might have been highly adaptive. It would have helped people build traps into which prey would fall, for example, or to read the mind of preverbal infants to attend to their emotional and physical needs so that they survived to the age of reproduction, to pass on genes.

However, the empathy circuit isn't enough. It can explain why we see jewellery, musical instruments, sculpture and cave paintings in the archaeological record – we were thinking about an audience and what they might be interested in. But it isn't enough to explain how modern humans became capable of these sorts of inventions in the first place. To fully explain the cognitive revolution in our capacity for invention, humans must have developed a second new brain circuit.

This is where the systemising mechanism comes in. This allowed us to seek patterns in the world in a new way. Our hominin ancestors could see simple patterns using





BARBARA GINDL/EPA/SHUTTERSTOCK; SEPIA TIMES/UNIVERSAL IMAGES GROUP VIA GETTY; ROYAL ASTRONOMICAL SOCIETY/SCIENCE PHOTO LIBRARY

Clockwise from far left: the 30,000-year-old *Venus of Willendorf* sculpture, a roughly 2000-year-old Mesopotamian cuneiform tablet and the 17th-century star atlas *Harmonica Macrocosmica* are products of the uniquely human capacity for invention

associative learning: A is associated with B, or using a hammer to crush a nut is associated with getting the tasty reward, for example. This enabled them to make simple tools. But modern humans were looking for more complex if-and-then patterns. This allowed them to invent advanced tools, and still enables us to do so today.

I borrow the if-and-then idea from the 19th-century logician George Boole, whose analysis of how we think logically is credited with the invention of the modern computer. In engineering terms, if-and-then patterns are the equivalent of input-operation-output patterns: if I take an input and I perform (or observe) an operation on the input, then I see a change in the output. An operation could be a wide range of actions, but the most interesting of these are causal operations, ones that change the input to a new output for a reason. The "and" in the if-and-then algorithm is the magic word.

The systemising mechanism enabled us not only to find such if-and-then patterns, but to confirm their truth through repetition. This is where generative invention arises. Humans became experimentalists.

It was the beginnings of music: if I blow down this hollow bone, and I cover one hole, then I make sound A. Changing the "and" variable leads to invention: if I blow down this hollow bone, and I uncover one hole, then I make sound B. Beautiful musical sequences of notes, riffs and rhythmic patterns emanate from an engine in the brain that enables invention. You can see the same exquisite logic underlying the invention of any complex tool.

"There may be genetic differences in pattern seeking, just as with empathy"

Pattern seekers

The invention of stealth weapons like the bow and arrow that could kill from a distance was based on the following logic: if I attach an arrow to a stretchy fibre and release the tension in the fibre, then the arrow will fly. The invention of agriculture: if I take a tomato seed, and plant it in moist soil, then I get a tomato plant. Medicine: if I have a headache and I eat the bark of a willow tree, then my headache goes away. And so on.

The critical role of this pattern seeking in the story of human progress led me to wonder: with the empathy circuit, we know that there are individual differences in how dominant this ability is, and that they correspond to genetic differences. Is this true for systemising as well, indicating that it, too, was actively selected for in our evolution?

It might well be. When my colleagues and I looked at more than 630,000 people as part of our Brain Types study, we found individual differences in systemising that are distributed across a bell curve. To determine whether these differences corresponded to genetic differences, last year we did an analysis of 50,000 people. As with empathy, we found that common genetic variants were associated with where each of us falls on the systemising curve: whether we are barely interested in if-and-then patterns, are average at systemising or systemise non-stop – so called hyper-systemisers.

The fact that how much we tend to ›

What's your brain type?

To study the balance between empathy and systemising in individuals, my colleagues and I ask participants to complete short versions of two surveys: the Systemising Quotient (SQ) and the Empathy Quotient (EQ). In both, people are asked to choose whether they strongly agree, slightly agree, slightly disagree or strongly disagree with a list of 10 statements. For the SQ, these include "I am interested in knowing the path a river takes from its course to the sea" and "When I listen to a piece of music, I always notice the way it's structured". For the EQ, they include "I can't always see why someone should have felt offended by a remark" and "I can tune into how someone feels rapidly and intuitively".

We score these to see where a person falls along these two dimensions. This research has shown that the human spectrum of neurodiversity can be divided into just five types of brain, and that there are typically trade-offs between empathy and systemising: that is, the higher you score on one, the lower you score on the other.

Type E: people whose empathy is at a higher level than their systemising. This group makes up roughly 30 per cent of the population.
Type S: people whose systemising is at a higher level than their empathy. Again, roughly 30 per cent of people.
Type B: those who show no difference in their drive to empathise or to systemise. Also roughly 30 per cent of the population.
Extreme Type E: people whose empathy circuit is tuned super high and who empathise non-stop, but their systemising mechanism is tuned to average levels or below. These comprise about 3 per cent of people.
Extreme Type S: people whose systemising mechanism is tuned super high and who systemise non-stop, but their empathy circuit is tuned to average levels or below. They also comprise about 3 per cent of the population.

We recently built an online tool to enable people to take these surveys at home, so that they can contribute to our research. We will be able to use this data to explore a range of significant questions: do the five brain types vary by culture, age, gender, neurology, occupation, biology and experience? And what advantages does each brain type confer? To join in our research, please go to yourbraintype.com

systemise is even partly genetic means that, again, this ability was the product of natural selection. It isn't difficult to imagine how hyper-systemisers might have had adaptive advantages that enabled them to survive and pass on their genes. They could have been the person people would go to when their child was sick, for example, or to fix a gadget; or those who could invent new and better ways of doing things, amassing significant resources.

The data revealed another intriguing facet: we also found that most people are biased either towards systemising or empathy, instead of striking an equal balance of the two. That suggests that being more dominant in one or the other might have been adaptive in different ecological niches (see "What's your brain type?", left).

All of this starts to add up to a new idea about how our inventing minds evolved. But it may also tell us something about autism, which I have spent most of my career studying.

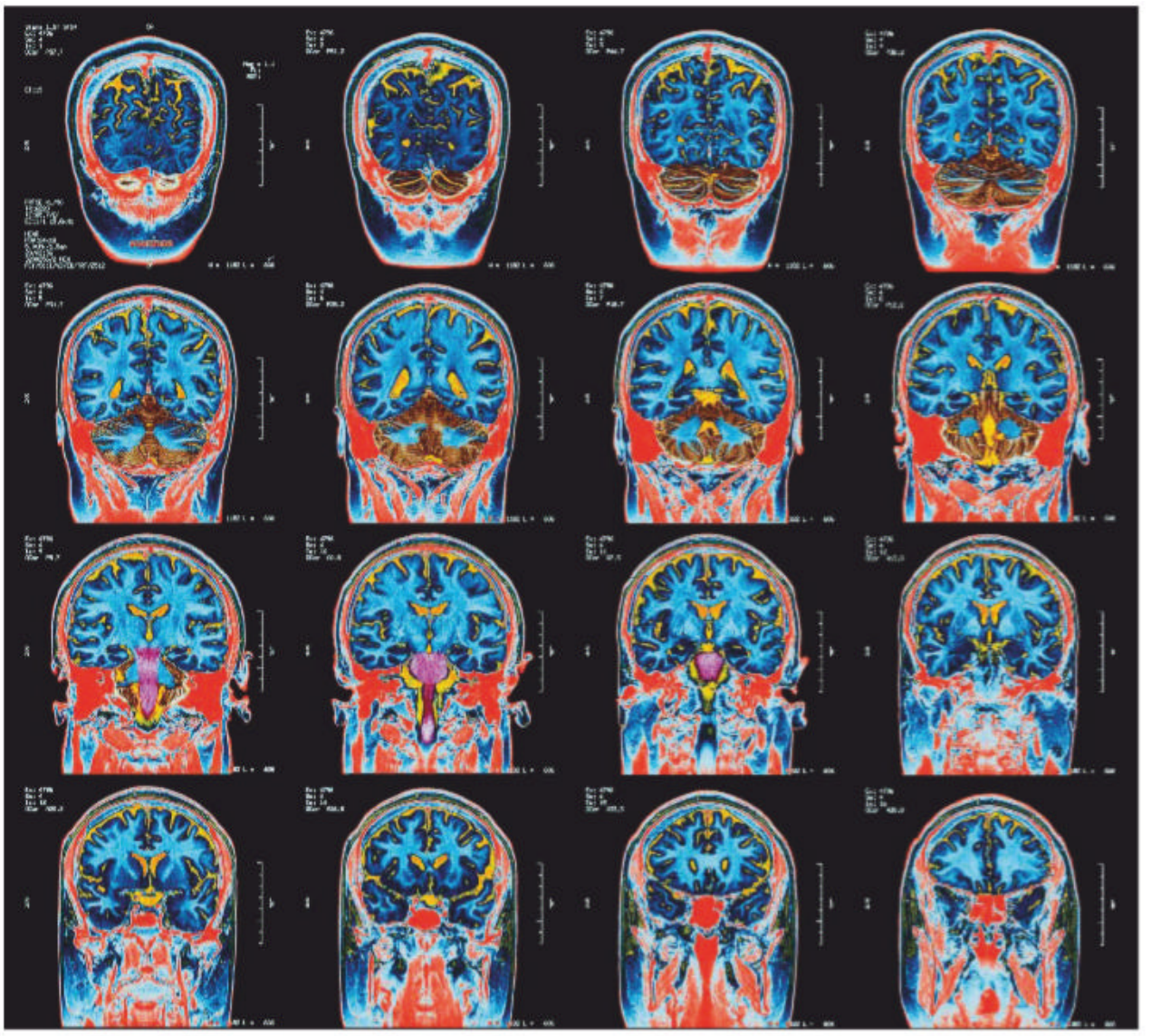
Among the people I call hyper-systemisers, I would place some of the most famous inventors in history such as Thomas Edison, Isaac Newton and Nicholas Tesla.

According to their biographers, Edison became so immersed in his experiments that his wife moved a mattress into his study for him to sleep, while Newton continued to give his lectures at Trinity College, University of Cambridge, even if no students attended, because it was in his job contract. Both could use their talent at systemising in a niche where it was valued. Unfortunately, that is too often the exception – a point I shall return to.

Autistic talent

These examples are at best suggestive that these historical figures may have had elevated autistic traits. But I wanted to better understand this link. When we looked more closely at our Brain Types study, we found that the 36,000 participants who had been diagnosed as autistic were more likely to be systemisers or hyper-systemisers and this was true of both men and women.

We also found that among the 600,000 people in the study who didn't have an



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MRI scans can reveal details of how different brains work

autism diagnosis, those working in science, technology, engineering or mathematics (STEM) roles had a higher number of autistic traits than those who weren't. In studies of mathematicians at the University of Cambridge, we have found an elevated rate of diagnosed autism compared with people in the humanities or the general population.

On average, autistic people outperform non-autistic people on tests of pattern recognition and mechanical reasoning. This link between autistic traits, autism diagnosis and systemising appears to be genetic. Parents of autistic children are over-represented in STEM, and show superior pattern-recognition skills.

All of these associations are compelling, but to truly pin down the link between autism and systemising we conducted another large-scale, genetic association study. Sure enough, there was an overlap between the common genetic variants associated with autism and those associated with hyper-systemising. It was 26 per cent. That means that some of the genes for autism aren't just coding for autism, but also for talent at systemising.

"Hyper-systemisers have driven human invention for 70,000 years"

This insight matters. It suggests that autism isn't genetic happenstance, but that it is entwined with our capacity for invention and has been actively selected for in our evolution. Too often, autistic people have been marginalised, stigmatised and excluded. This was the focus of my 2017 speech at the United Nations, on the subject of autism and human rights. Worrying studies from our lab have shown that two-thirds of adults with autism have felt suicidal, one-third have attempted suicide and the majority have poor mental health such as high levels of anxiety and depression.

Let's be clear: mental health struggles aren't inherently part of autism. They are a sign of a lack of support and inclusion into society. Unemployment levels of autistic adults are unacceptably high, and it is well established that unemployment can undermine our sense of inclusion, autonomy and value to society.

I am hopeful that discovering the connection between autism and invention will contribute to the growing movement to respect and celebrate the diversity of our human brains. Hyper-systemisers are part of the neurodiversity we find in any population, and this brain type and the genes associated with it have driven human progress through the evolution of invention for more than 70,000 years.

We have a civic duty to support autistic people into work, both for the sake of their well-being and to maximise the likelihood of future human innovation. ▮

Simon Baron-Cohen is director of the Autism Research Centre at the University of Cambridge. His book *The Pattern Seekers: A new theory of human invention* is out now

Need a listening ear? UK Samaritans: 116123 (samaritans.org). Visit bit.ly/SuicideHelplines for hotlines and websites for other countries

Warm inside

Facing a combination of winter and covid-19 restrictions? Simply changing your attitude can make it more bearable, **Kari Leibowitz** tells David Robson

ROCIO MONTOYA

WHEN health psychologist Kari Leibowitz moved from the US to the Norwegian town of Tromsø, more than 300 kilometres north of the Arctic circle, her research became personal. Inspired by recent findings on the ways in which people's attitudes influence their mental and physical health, she wondered whether this might be the secret to coping with the long, dark Nordic winter. Her research revealed that many Norwegians have a winter mindset that allows them to thrive in conditions she was dreading. Now back in the US at Stanford University, Leibowitz believes her findings hold lessons for us all, especially for people living in the northern hemisphere who, as the nights draw in, face the dual challenges of winter and a stressful pandemic.

David Robson: What are "mindsets" and why are they so important?
Kari Leibowitz: I think of mindsets as a framework that helps us simplify information and make sense of the world. And we're really just at the beginning of unpacking the ways that they can shape our health and well-being.

A lot of my research now is looking at how we can use mindsets in clinical practice. In one of the last studies that I did, we tested the effects of changing people's mindsets – even without treatment. We brought our participants to the lab and we pricked them with histamine, triggering a minor allergic reaction that looks a bit like a mosquito bite. For some people, a doctor just examined their arm; for the others, the doctor examined their arm and said: "OK, from now on, the itch and irritation will feel better and your rash is going to start to go away." That single sentence reduced people's symptoms. It is a really tangible example of the ways that using mindsets can help patients feel better.

How can the mindset we have help us cope with stress?
I am all for things like getting enough sleep, meditating, exercising and taking walks with friends. But so much of the stress management framework tells people that they have to reduce their stress, and that if they can't then it's going to lead to higher blood pressure and heart disease and cancer. Unfortunately, most of the stresses that we experience aren't things that we can actually reduce. You need to find ›

ways to channel the energy.

Research on stress mindsets shows that when we view stress as being useful for our health and performance and mental well-being, it actually creates a self-fulfilling prophecy. One of my favourite studies – a huge survey of 30,000 people in the US – found that those who experienced a lot of stress but didn't think that it was bad for them had better outcomes than people who experienced less stress but perceived it as damaging. Having a little bit of stress can keep you engaged with life.

You examined the mindsets of people living in Norway during the cold, dark winter. What did you find?

In many countries, seasonal affective disorder, or wintertime depression, is relatively common. But in Norway, rates of seasonal affective disorder are quite low, even though people experience some of the coldest, darkest winters on Earth. They thrive despite the extreme seasonal changes. And their ability to thrive in winter seems to be connected to their winter mindset.

Based on our upbringing or past experiences, we might have certain mindsets like "winter is dreadful". But you can also view it as a cosy time, with lots of opportunity for recreation, and with lots of fascinating changes happening in nature. Many people in Norway have this more positive winter mindset, and the more positively they viewed winter, the higher their life satisfaction and the better their mood. Interestingly, the further north people live, the more positive their winter mindset.

How did you change your own attitudes and behaviour while living in a place where the sun doesn't rise for two months every winter?

We tend to associate the polar night with darkness, but it also can be viewed as a soft, peaceful light rather than just a dark and depressing thing. And so I would go out and take walks, either with my headlamp or just with street lights. I also tried to do things inside; we hosted a lot of potlucks with friends and we had lots of holiday gatherings. It was much easier to love the winter in Tromsø, because the people around me loved winter.

Do you think that anyone can change their attitudes in this way?

One hundred per cent! Most people just don't realise that these beliefs are subjective. If you are someone who hates winter, you just think: "This is who I am, this is how I've always been, and there's nothing I can do about it." But mindsets can be shaped in adaptive ways, and once you introduce the idea that mindsets exist and that you can control them, that understanding can be tremendously powerful.

How to think positively in a pandemic winter

Winter can be a difficult season, and the covid-19 pandemic only adds to the stress. Drawing on her own and other's research, Kari Leibowitz offers five steps to achieve a mindset that will help you meet these twin challenges.

1 Recognise the message behind your stress

We only become anxious when we care about something. "The stress response evolved to indicate what we value and then to pay attention to it," says Leibowitz. Simply recognising that is better for us than wallowing in how bad we feel or trying to escape our feelings completely. It is the first crucial step to developing a healthier stress mindset. If, for example, you are anxious about not being able to see family members for long stretches of time, "take a moment to tap into what is the real core value underlying that stress", she says. "In this case it's that I love my family, and I want my connection to them to be strong."

2 Look for things you can control

Once you have recognised the values that underlie your stress, you can look for ways to act on them. The aim isn't to ignore the reality of the situation and the difficulties you may face, such as the danger of covid-19 and the risk of unemployment; the evidence suggests this will only make things worse. "Thinking of stress as an opportunity to engage with your values doesn't mean that you have to deny those things are true. It just means that you are figuring out what parts of the situation are within your control," says Leibowitz. If you are upset about not seeing your family, for example, you might look for other ways to express your love, such as sending a handwritten letter or a home-made gift.

3 Embrace small pleasures

In winter, it is easy to focus on all the things that we can't do, rather than acknowledging that the season itself can bring pleasures that would be difficult in summer, such as the cosiness of curling up under a blanket with a hot chocolate as we read a novel or watch our favourite TV series. "Look for the things that make winter special, that you would not be able to do at other times of the year," says Leibowitz. This can reduce the feelings of helplessness that sometimes come with harsher weather.

> "Understanding that mindsets exist and you can control them is tremendously powerful"

4 Avoid being overambitious

Less travel and socialising during the covid-19 pandemic has freed up time for some people. However, Leibowitz is sceptical of the numerous media articles during its first wave encouraging people to use it to develop ambitious goals. "There was this sort of 'hustle mentality', like, it's a global pandemic and so now's the time to write your bestselling novel," she says. "That's garbage! Now is a crazy time to get things like that done." If you are facing a winter with fewer opportunities to get out and socialise than you might like, you should have realistic aims, recognising ways to use the time constructively without putting yourself under additional pressure.

5 Watch what you talk about

During the winter months, moaning about the rain and cold reinforces a negative winter mindset, with a direct effect on your mood, says Leibowitz. It is important to share your feelings honestly, but if such negative chat becomes too much of a habit, try directing your conversations to some of the more positive ways you have been coping with winter's challenges. "When you say something out loud, it really changes the way that you think about it and the things that you focus on," she says. "I encourage people to be positive wintertime mindset ambassadors."

JOHN HEMMINGSEN/GETTY IMAGES

Can an understanding of mindset help us deal with the stresses arising from covid-19?
Let me first say that mindset is not a cure-all. There's a fricking global pandemic! People are out of work, and they can't visit family or take care of ageing relatives. That being said, we can make it harder for ourselves by really dwelling on all of the ways that it feels like the world is falling apart. Or we can see it as a time to lean in to some of the things that maybe we haven't had space or time for previously.

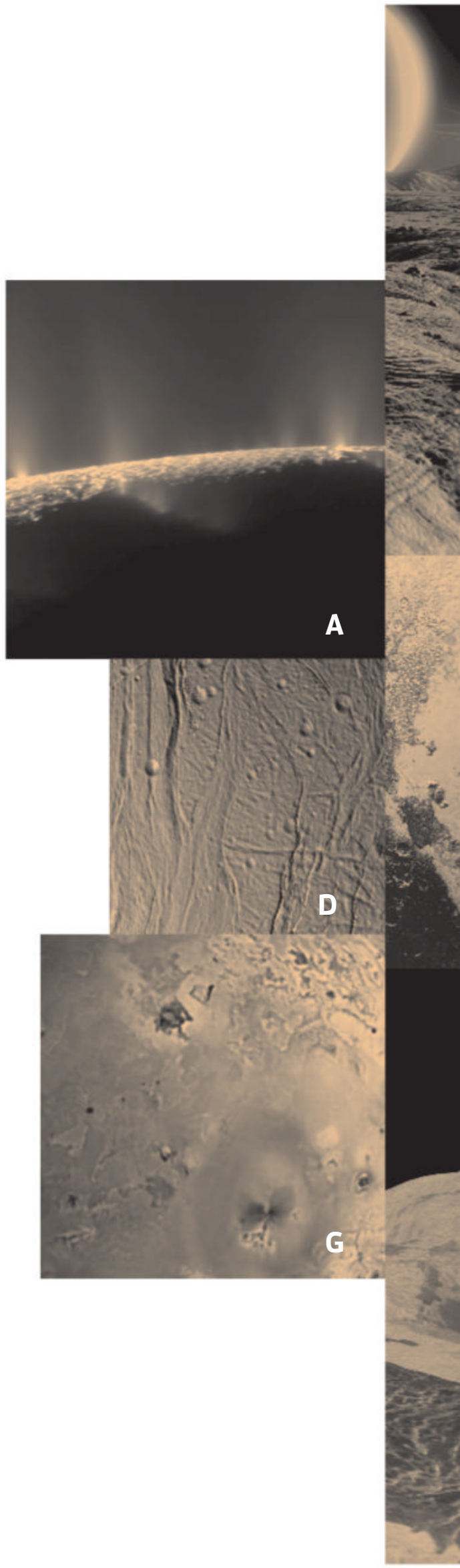
Has the experience of living in Tromsø helped you cope during the pandemic?
I think living in Norway was one of those positive stress experiences. It wasn't just living through the polar night that was stressful, it was moving to a new country where I didn't know anyone, where I didn't speak the language, and living in this environment that was so different for me. On hard days, I think to myself that if I could do that, I can do anything. And my time in Norway really taught me how to be by myself and to enjoy spending time home alone – lessons that made me well suited for being a homebody during the lockdown. ▮

An aurora is one of many winter pleasures to be had in Norway

David Robson is the author of *The Intelligence Trap: Revolutionise your thinking and make wiser decisions*. His website is davidrobson.me

Alien volcanoes

Bizarre volcanoes erupt on many planets and moons in our solar system. **Natalie Starkey** takes a tour to investigate what they mean for life beyond Earth



ONE OF the most exciting moments of my life was when I stood on the summit of Kilauea volcano in Hawaii looking out over its crater. I was several kilometres from the edge, but I could see orange liquid bubbling and sputtering inside. I was awed by the extraordinary power inside this planet of ours – capable of turning rock to liquid.

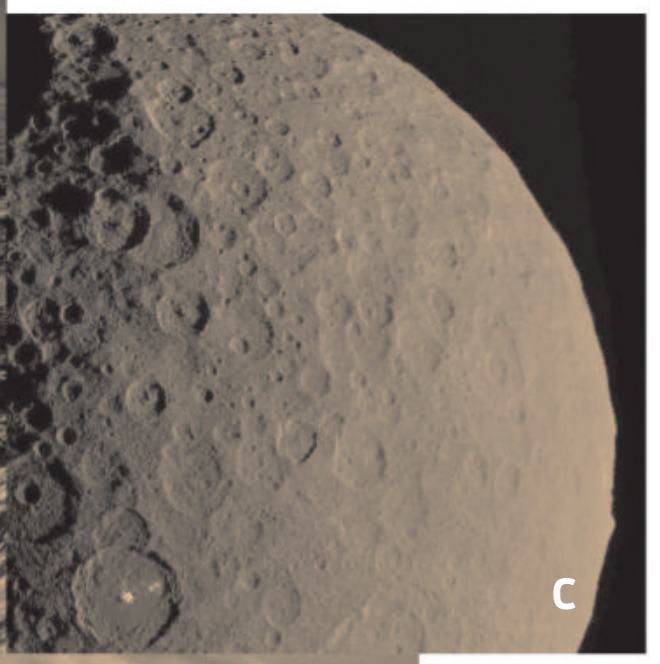
Kilauea is just one of many impressive volcanoes. About 60 have erupted on Earth this year alone. Before we had the ability to explore beyond Earth, many assumed that this planet was where it stopped; that you could never stand atop an active volcano on another world in this solar system because they just weren't out there. The rest of our solar system seemed geologically dead.

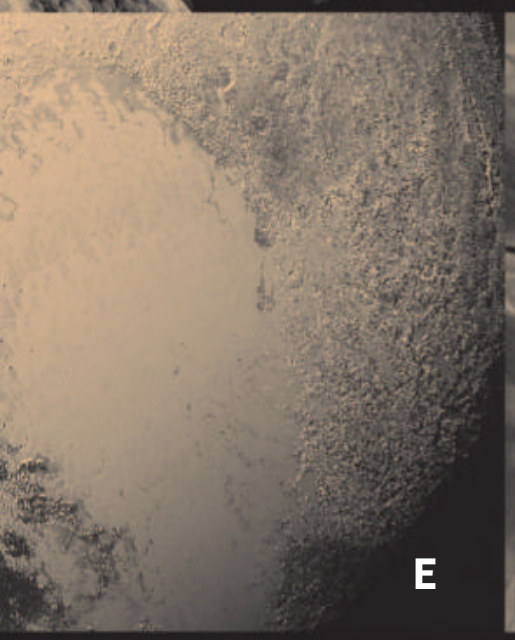
We now know that is far from true, and have evidence that volcanism exists beyond Earth in strange forms and in the most unexpected places. There are plumes spurting into space around Saturn and ice volcanoes on Pluto. Even lumps of rock in the asteroid belt produce their own unusual brand of lava. Finding these fascinating features – and how they came to exist – gives us a window into the innards of the solar system's most mysterious worlds.

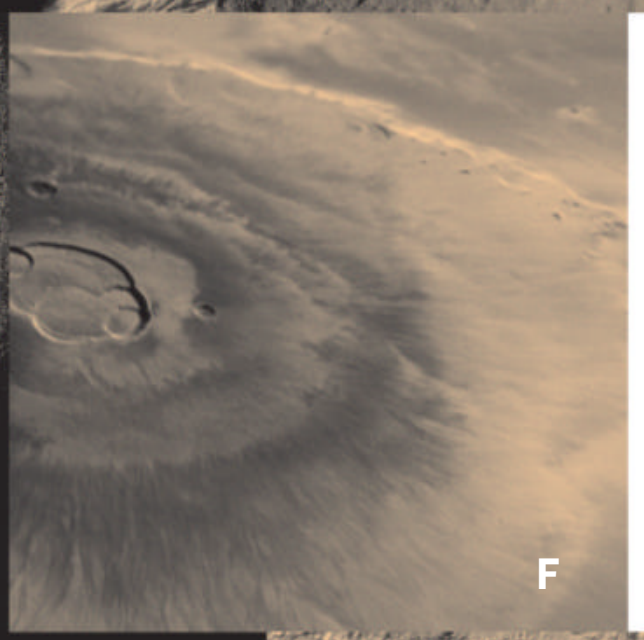
There is more at stake than extreme geology. There is a consensus that a source of energy is required to kickstart the chemistry essential for life and, on Earth, a prime candidate for that is volcanic activity, particularly at the bottom of the ocean. So, if volcanoes are common across the cosmos, does that mean life could be too?

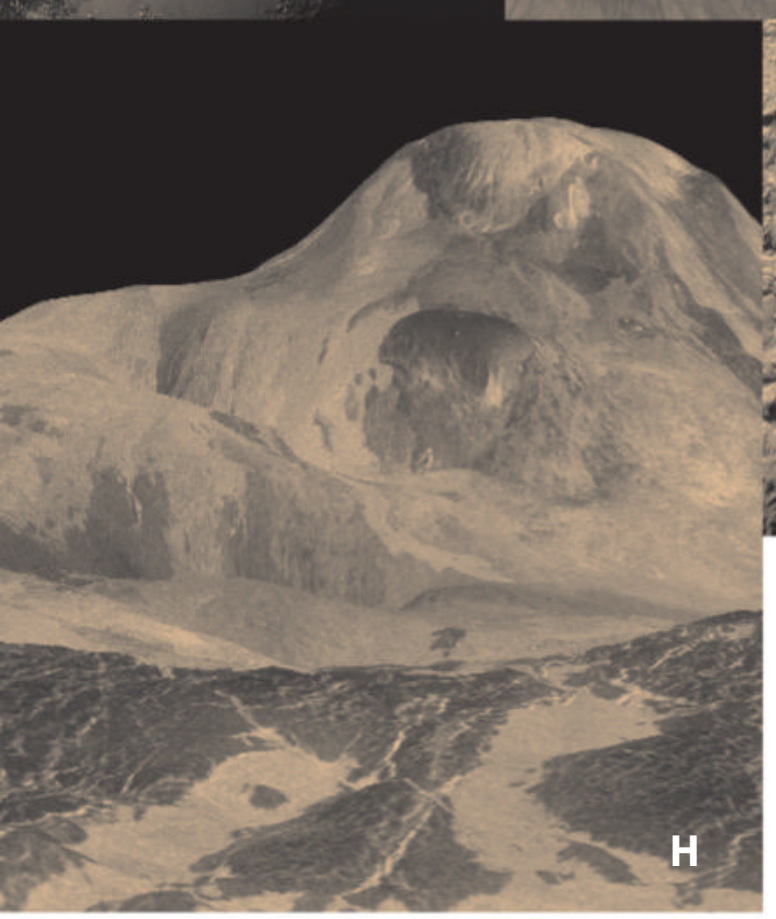
We typically think of a volcano as an opening in Earth's crust where hot liquid rock, or magma, bubbles upwards. Explosive eruptions can blow the magma into tiny fragments, forming clouds of volcanic ash. And magma can ooze onto the surface – at which point we call it lava.

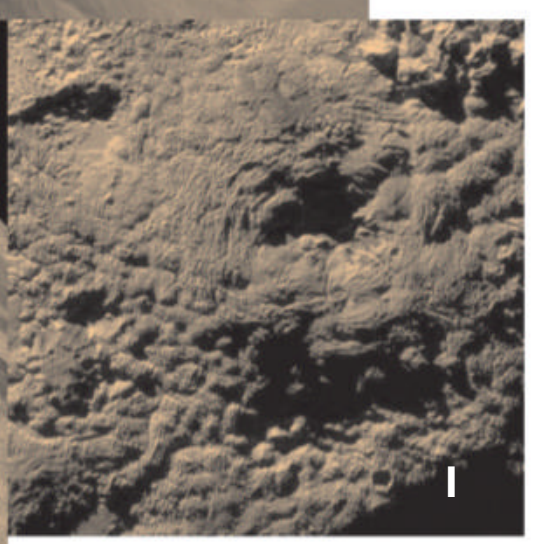
On our planet, volcanoes often form at the boundaries between tectonic plates. They can also appear in the middle of them, where tall natural chimneys called mantle plumes are thought to carry magma to the surface. The heat that keeps all this going











A Plumes on Enceladus
B Geysers on Triton
C Volcanic craters on Ceres
D The icy crust of Enceladus
E Pluto's rugged surface
F Olympus Mons, an extinct volcano on Mars
G Volcanoes on Io
H Maat Mons, a volcano on Venus
I Wright Mons, an ice volcano on Pluto

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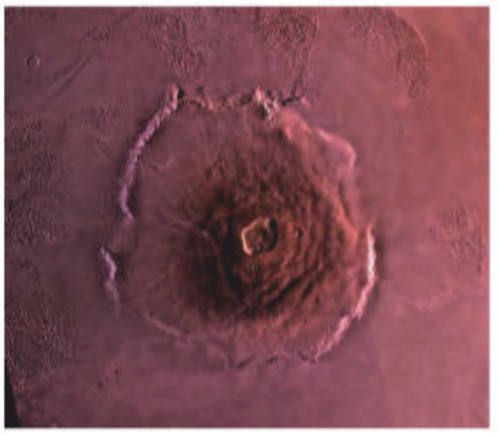
comes from radioactive elements that were locked away inside Earth as it formed some 4.5 billion years ago.

The other rocky planets, Mercury, Venus and Mars, formed at the same time and in roughly the same place as Earth and so also had a radioactive heat source inside. However, Mars is about 15 per cent the volume of Earth and Mercury is smaller still, so almost all the warmth has radiated away from these planets. Their surfaces are covered in the relics of ancient volcanism but now stand quiet. Only Venus, just a shade smaller than Earth, still has active volcanoes.

Beyond Mars comes the frost line where temperatures drop and the solar system is starkly different. The planets out here were formed mainly from what planetary scientists call ices – grains of substances that would normally be liquids or gases on Earth, like water, ammonia and carbon dioxide. It is so cold in this region that these compounds are solids, even in the low pressure of space. You wouldn't expect volcanoes on such chilly worlds. ›

Exotic eruptions

The solar system is home to many volcanoes and strange blasts. Here are some of the biggest beyond Earth

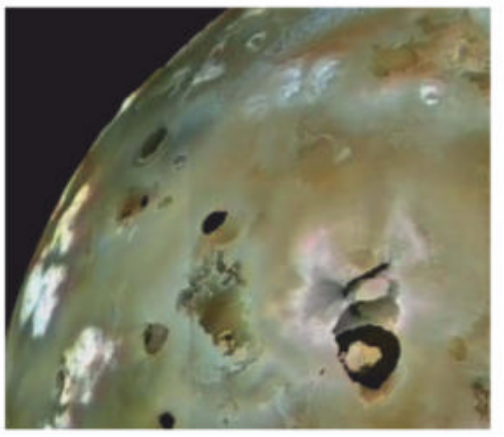


NASA/JPL/USGS

OLYMPUS MONS
MARS

Size: 25 km high

At about 2.5 times the height of Mount Everest above sea level, this is the solar system's highest volcano. It probably formed as a tall chimney of magma rose up from the planet's core. It last erupted 25 million years ago.

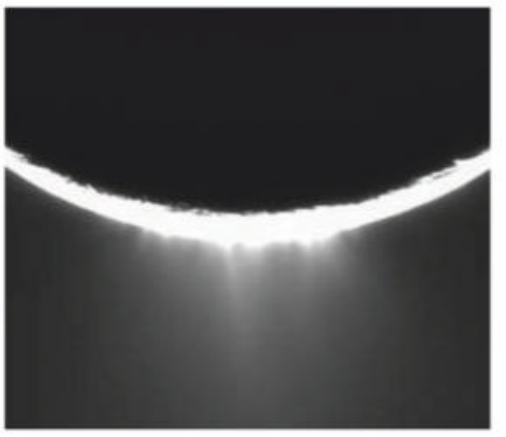


NASA/JPL/USGS

LOKI PATERA
IO

Size: 200 km wide

This is a horseshoe-shaped lava lake on the solar system's most volcanically active object. It seems continuously active, bubbling away on the surface of this moon of Jupiter since it was spotted in 1979.



NASA/JPL/SPACE SCIENCE INSTITUTE

PLUMES
ENCELADUS

Size: Extending into space

Several plumes of water and ice spurt from Enceladus's south pole. Grains of ice then drift away to form one of the rings of Saturn, the planet this moon orbits. The plumes also contain salts and organic compounds.

At least, that was the prevailing view in 1979 as the Voyager 1 spacecraft approached Jupiter. But when it reached the planet's innermost moon Io, which is only slightly bigger than Earth's moon, it snapped pictures of volcanic plumes 100 kilometres high. Io's shiny yellow surface is pockmarked with more than 400 volcanoes and their eruptions glow blue. The biggest, Loki Patera, isn't immediately recognisable as a volcano. It is a 200-kilometre-wide depression, part-filled with a horseshoe-shaped lake of bubbling lava. We don't see Loki explode, but the lava lakes periodically warm up and cool.

What is driving this activity on such a small, freezing world? Just a few days before Voyager 1 arrived at Io, scientists published a hypothesis, predicting that Io is continually squeezed and warmed by the force of gravity. Io orbits Jupiter in a such a way that it gets pulled in different directions at intervals by the giant planet and some of its other moons. "Io is caught in a tug of war," says Rosaly Lopes at NASA's Jet Propulsion Laboratory in Pasadena. This tidal heating squeezes Io like fingers warming up a squash ball.

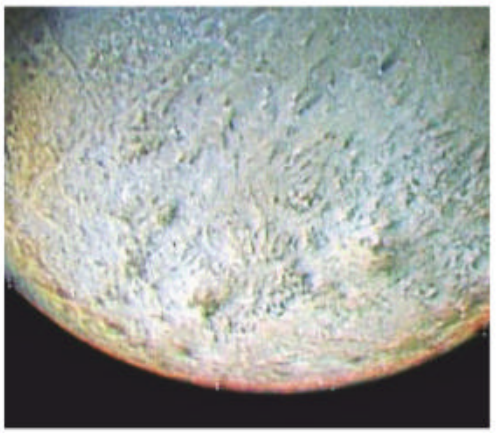
Yet Io is an outlier. It seems to have formed closer to its parent planet than many of the other moons beyond the frost line. In this colder part of the solar system, most moons are made principally of ices with smaller rocky cores. Surely they would be devoid of volcanic activity?

Voyager 1 and its sister probe Voyager 2 approached Saturn and its satellites in the early 1980s and soon swooped past one moon, Enceladus, which is just 500 kilometres across. It was expected that, like Earth's moon, Encedalus would be covered in craters caused by comet and asteroid impacts. But that wasn't the case. Voyager 2 revealed this world's surface to be bright white, with smooth areas.

> "Io's shiny yellow surface is pockmarked with more than 400 volcanoes and their eruptions glow blue"

We had to wait a quarter of a century to find out why. When the Cassini spacecraft looked closer at Enceladus in 2005, it became clear this moon was pumping plumes of water into space. "It was a jump-out-of-your-seat moment to see water coming out from such a tiny object that everybody thought was boring and dead," says Nozair Khawaja at the Free University of Berlin. It turns out that these plumes come from a salty, liquid water ocean hidden below Enceladus's icy surface. The pristine smooth areas are a result of the snow raining down from these plumes.

The subsurface ocean is kept warm by the same mechanism that melts Io's insides, tidal heating caused by the gravitational tug of nearby bodies. These forces also open and close fissures on Enceladus's crust allowing the plumes of water to shoot out.

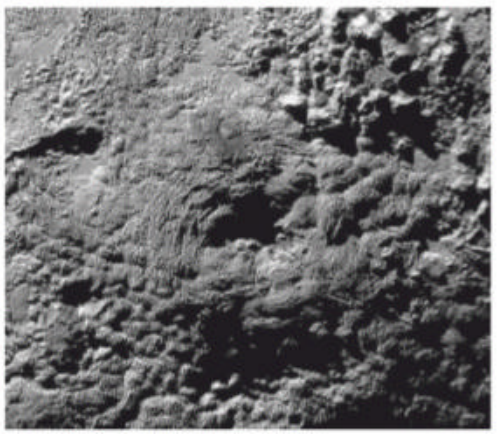


NASA/JPL

LEVIATHAN PATERA
TRITON

Size: 80 km wide

On Neptune's largest moon, a crater sits within a 2000-kilometre-wide volcanic dome. This is the second largest volcano in the solar system by area – and is connected to currently inactive cryolava lakes.

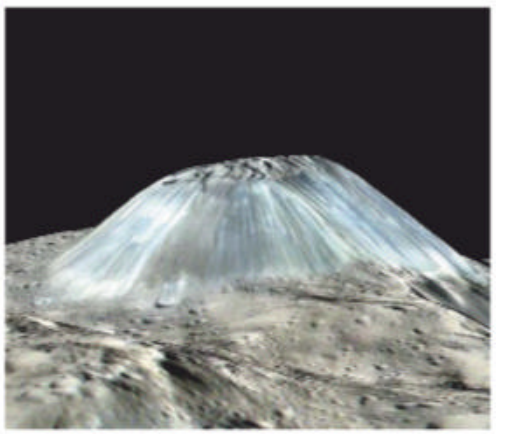


NASA/APL/SOUTHWEST RESEARCH INSTITUTE

WRIGHT MONS
PLUTO

Size: 150 km wide, 4 km high

This low, wide mountain has an obvious depression at its summit and its sides are streaked with red material. It is probably a volcano that once erupted a slurry of water ice spiked with ammonia.



NASA/JPL-CALTECH/UCLA/MPS/DLR/IDA/SPL

AHUNA MONS
CERES

Size: 4 km high

The largest mud-and-brine volcano on the dwarf planet Ceres in the asteroid belt. This is volcanism in slow motion: the last eruption on Ceres was 200 million years ago and the next isn't expected for millions more.

When Cassini flew right through these plumes, it revealed that they contained mineral grains, sodium salts and complex carbon-based molecules. All of this indicated that there must be a rocky floor at the bottom of Enceladus's hidden ocean – much like the sea floor on Earth, with its underwater hydrothermal vents that are a popular candidate for where life got started. "If we're looking for life elsewhere, we would like to see liquid water, organic molecules and an energy source that can trigger reactions. All these criteria are present at Enceladus," says Khawaja. "The chances are there for life."

There is impressive activity at even colder reaches of the solar system. The only time we have visited Neptune and its moons was a Voyager mission in 1989. That far out, the sun is a dot of light and everything should be frozen solid. The surface of Triton, Neptune's largest moon, is a frigid -235°C. Yet Voyager 2 saw geyser-like plumes erupting, throwing material 8 kilometres above the surface. "To find activity so far away in such a cold place was just remarkable," says Candice Hansen at the US-based Planetary Science Institute. "What is the energy source?"

One possible explanation is related to a layer of dark material below Triton's translucent nitrogen ice caps. These areas are expected to absorb the small amount of sunlight that reaches this part of the solar system, creating a kind of underground greenhouse effect that warms the subsurface ice. This causes nitrogen gas to build up, becoming pressurised to the point of explosion.

Rethinking volcanoes

Findings like this are forcing scientists to reassess what makes a volcano a volcano. The geology on Enceladus is referred to as cryovolcanism because it involves similar processes to those on Earth, but with materials that can flow at far lower temperatures. In the case of Triton's geysers, however, that term doesn't easily fit because the explosions may not be fuelled by internal heat – it is a form of explosive geology unlike anything seen elsewhere.

The geysers weren't all that Voyager 2 spotted on Triton. It also pictured an 80-kilometre-wide crater called Leviathan Patera with two enormous depressions nearby that are thought to have once been frozen lava lakes. Elsewhere, Triton's surface is smooth, probably thanks to the eruption of icy lavas. These features suggest that there must be warmth within Triton. It may come from tidal heating as well as radioactive decay within its rocky core – we still aren't sure.

More recently, probes have voyaged even further, all the way to the dwarf planet Pluto. If you had a craft that could travel at the speed of light, it might get from Earth to Neptune in about 4 hours 15 minutes. Pluto's distance from us varies but it would usually take more than an extra hour to get there – it is a distant and deeply mysterious place.

When NASA's New Horizons probe flew past it in 2015, we had little idea what to expect. The craft revealed that Pluto's crust is made of ice so hard that it acts like rock, allowing for a wondrous variety of ice geology. There are mountains and smooth, crater-free plains, including a heart-shaped area known as Tombaugh Regio. There are even dunes made of frozen methane. But one thing immediately screamed volcano. ›

DOUGLAS PEEBLES/GETTY IMAGES

A lava fountain erupts spectacularly on the slopes of Kilauea volcano in Hawaii

"Some of the mountains, such as Wright Mons, looked strange – they have a hole in them," says Carly Howett at the Southwest Research Institute in Boulder, Colorado. "On Earth, mountains with a hole are typically volcanoes." These features were geological flags telling us that Pluto is an active world, with the strong possibility that it contains a liquid ocean below the surface that fuels its cryovolcanoes.

You might wonder how water can flow at such extremely low temperatures. It turns out that it is probably down to a splash of ammonia. Just 5 per cent of it in water ice can lower its viscosity by a factor of 100,000, turning solid ice into a slurry that flows like liquid rock.

Even so, Pluto must have some heat to fuel its activity. But the explanations that served us before are out. This distant world has several moons, but none is big enough to provide significant tidal heating. And the dwarf planet itself is tiny, with a volume less than 1 per cent of Earth's. This means that the heat from any radioactive elements within ought to have dissipated long ago.

Our best explanation is that Pluto's icy crust includes a layer of planetary bubble wrap. This could be a substance called clathrate hydrate, which is composed of tiny molecular cages that trap methane gas inside them. The layer of gas is a poor thermal conductor and so locks heat inside the planet.

As we explore the solar system, we see wild and wonderful volcanism almost everywhere we look. What does this mean for the chances of life beyond Earth? Well, we know life needs a world with internal energy to support chemical processes. Having volcanoes doesn't mean a planet will have life. But they are a sign that a world is geologically alive, which boosts the chances of it supporting the right conditions for life.

That is particularly relevant when we look at the hundreds of rocky planets that we have discovered orbiting other stars. Take the exoplanet 55 Cancri e, which is expected to be molten in places, a sure sign of an energy-filled interior. Then there are the moons that could be orbiting larger exoplanets. These are hard to spot because they are so small and distant, but one exoplanet called WASP-49 b is thought to have an Io-like rocky moon that is erupting into space. Finds like this hint that there are probably many volcanically active worlds out there where life might have had the spark it needed to get going.

However, one of the biggest volcanic mysteries is closer to home. In 2015, NASA's Dawn spacecraft went into orbit around the dwarf planet Ceres, the largest known asteroid in our solar system, beaming back pictures of a mountain called Ahuna Mons. It had bright streaks running down its sides that looked suspiciously like lava. It seemed that even this mini world – its diameter is only as long as Britain – has a cryovolcano.

> "Volcanoes are a sign that a planet is geologically alive, which boosts the chances of it supporting the right conditions for life"

We now know it has dozens of them, which, according to a growing body of evidence, may all be fed by an underground ocean. When active, these volcanoes collectively splurge out an average of 10,000 cubic metres of muddy brine a year. "At -40°C you already have liquid brine and possibly mud flowing upwards to build mountains," says Ottaviano Ruesch at the University of Münster in Germany. As yet, we have no idea what could be powering these eruptions. It just goes to show that, when it comes to volcanoes, the solar system can still spring a surprise or two. ▮

Natalie Starkey is a science writer based in Cambridgeshire, UK. Her book *Fire and Ice: The volcanoes of the solar system* is out in 2021

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The back pages

Science of cooking

Home smoking

Smoke doesn't just preserve food, it provides excellent flavour too. A technique called dhungar works well at home, says **Sam Wong**

Sam Wong is social media editor and self-appointed chief gourmand at *New Scientist*. Follow him @samwong1

What you need

An onion
A small piece of lumpwood charcoal
Clarified butter or ghee
Long metal tongs

SINCE the Palaeolithic period, people have used smoke to preserve food. It does this thanks to antioxidants that slow the development of microbes and rancid flavours in meat and fish, as well as antimicrobial compounds such as formaldehyde. Yet smoke also imparts a wonderful flavour.

Food can be hot-smoked in the presence of burning wood, which cooks the food at the same time, or cold-smoked, in which smoke is directed to the food in a separate chamber so it remains raw.

When organic matter burns, the main products are carbon dioxide and water. Yet some carbohydrates, proteins and lipids aren't fully oxidised: instead, they decompose into a range of compounds that create a smoky flavour.

Wood consists of polymers such as cellulose and hemicellulose, which are comprised of chains of sugar molecules. These effectively caramelise when burned, creating sweet and fruity aromas. Lignin, another polymer in wood, is made up of phenolic molecules, which produce a range of aromatic compounds that contribute to the distinctive flavour of smoke, including guaiacol and syringol.

Many other substances are used as fuel for smoke, including corn cobs for smoking bacon in North America, dried sheep dung for smoking meat in Iceland and peat for smoking barley malt to produce Scotch whisky.

In India, cooks use a technique called dhungar to add smokiness to food and it is easy to carry out in a home kitchen. I learned of the method from *The Flavor Equation*, a new book by Nik Sharma that includes explanations of scientific concepts used in the kitchen alongside mouth-watering recipes.

THE FLAVOR QUESTION/NIK SHARMA

The source of the smoke is ghee: butter that has been clarified by evaporating off the water and removing the milk solids, which scorch and produce unpleasant flavours at around 150°C. Sharma uses the technique as a finishing touch for dal makhani, a rich and buttery lentil stew, but you could try it on almost anything. Smoke flavour is contained in both hydrophobic and hydrophilic compounds, so dishes containing oil or fat will capture more of it.

Take half an onion and hollow out the inside so you are left with a bowl shape. Alternatively, use a small metal bowl. Using your long metal tongs, grab a small piece of lumpwood charcoal, around 3 to 5 centimetres long, and hold it over a flame until mostly white.

Place your bowl or onion inside a pot with your food – it will happily sit on top of a stew. This method doesn't cook the food, so make sure to do that first. Put the charcoal in the onion, then drop a spoonful of ghee onto the charcoal. It will give off a lot of white smoke, so you should do this somewhere well-ventilated, away from smoke detectors, and immediately cover the pot with a lid. Keep it covered for about 5 minutes, then remove the lid and discard the charcoal and onion or bowl safely.

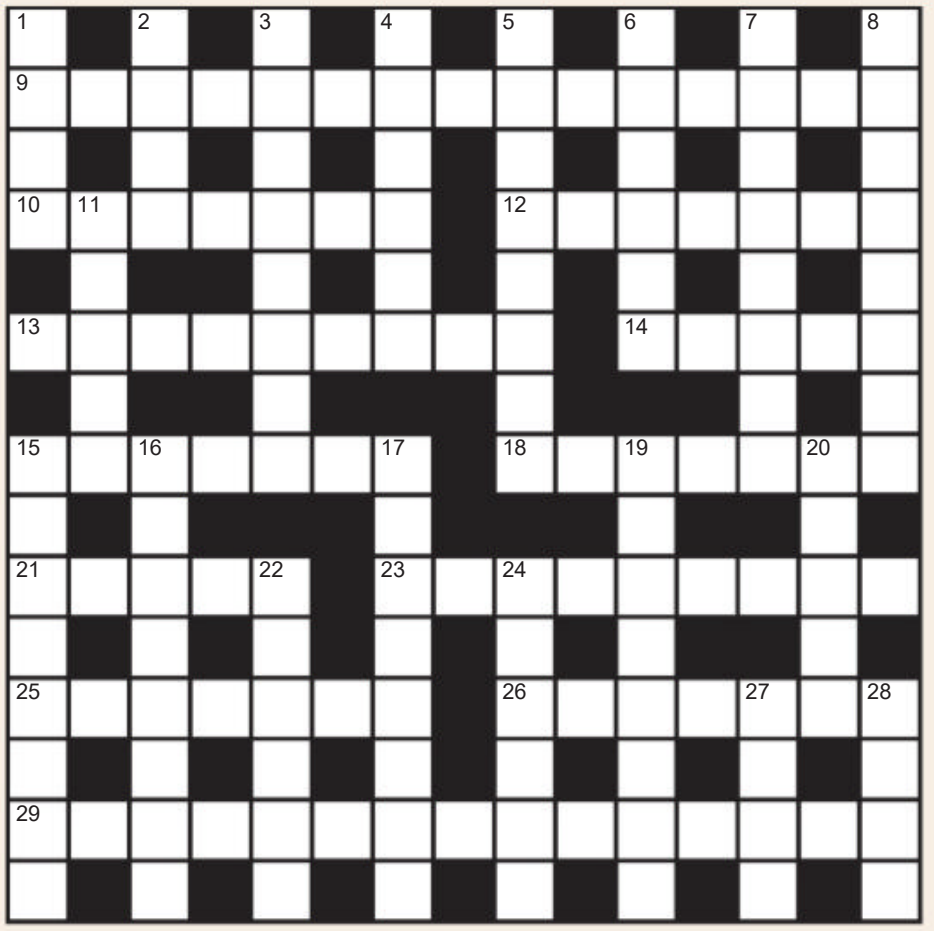
These articles are posted each week at newscientist.com/maker

Science of cooking appears every four weeks

Next week

Stargazing at home

Quick crossword #72 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

9 Mass × velocity × radius (7,8)
10 Cuts in two (7)
12 Baby born before term (informally) (7)
13 UK university city, home to the Cavendish Laboratory (9)
14 Term for technologically themed or speculative fiction (3-2)
15 Soviet satellite launched in 1957 (7)
18 < 0°C (3-4)
21 Ration, allocation (5)
23 Covid-19 preventative slogan (4,1,4)
25 Treatments to induce vomiting (7)
26 To determine the concentration of a solution (7)
29 Radiation phenomenon first detected at the Lebedev Institute in 1934 (9,6)

DOWN

1 Starch-rich food (informally) (4)
2 Ova (4)
3 Particle, beta minus (8)
4 Rubbed out (6)
5 God of sleep; character in *The Matrix* (8)
6 Niche; dent (6)
7 Old term for alkaloids such as putrescine and cadaverine (8)
8 Bacterial skin infection (8)
11 Contained within a game or application (2-3)
15 Primary structure of a biopolymer; series (8)
16 Rain gauge (8)
17 Japanese manufacturer of motorcycles (8)
19 Launch (of a rocket) (5,3)
20 Start again (5)
22 Derivatives of ammonia (6)
24 Not inert (6)
27 Peak (4)
28 Ethylenediaminetetraacetic acid (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #80

1 Which US geneticist discovered genetic transposition, the ability of genes to change position on chromosomes?

2 What name is given to a point of equilibrium in space at which a small body, gravitationally influenced by two large bodies, will remain at rest relative to them?

3 How many living species of orangutan are there?

4 Which part of *Yi qi*, a dinosaur specimen discovered in China in 2015, makes it potentially unique?

5 In 1902, Ronald Ross won the Nobel prize for physiology or medicine for his work on the transmission of which disease?

Answers on page 55

Puzzle
set by Zoe Mensch

#88 Rifling the draw

Members of the Rackemup rifle club are tired of Pat Perfect winning the annual shooting tournament every year. She always hits the bullseye. To spice up the contest, this year she has agreed to be blindfolded. Even so, during practice she still hits the target four times out of five. In the first round she competes against Kate, who, even when fully sighted, only hits two times in five.

To give Kate the best chance of a fluke win, the contest will involve just a single shot each. The two competitors fire, but only one of them hits the target. "I reckon it's a 1 in 3 chance that's yours Kate," says the referee as he strides up to inspect whose bullet it was. But he is wrong about the odds. What is the chance that Kate is the victor?

Answer next week

Information loss

It is a rule of physics that information can't disappear. So what happens to the information in my brain when I die?

Lewis O'Shaughnessy
Nottingham, UK
Physics tells us that while the physical structures that encode information can never be destroyed, they can be altered. Importantly, they can be changed in such a way that it is practically impossible to recover the information, even though it remains a technical possibility.

If you ran a computer's hard drive through an industrial shredder several times over, for example, it would theoretically be possible to stick every fragment back together in exactly the same way as before, although such a feat could never be achieved.

"If I write something on a piece of paper and burn it, the information, in physics terms, hasn't been lost"

Much the same thing occurs in the brain after death. The information we store there is encoded primarily by the connections of synapses, but after we die, these start to degrade. In theory, you could stick every atom back exactly where it originated, but this obviously isn't possible in practice.

When we die, the brain structures that hold information are changed beyond recognition. The information is still there, but it is practically irretrievable.

Penny Jackson
Barrow-in-Furness, Cumbria, UK
"Information" doesn't have quite the same meaning in physics as the everyday use of the word. In physics, it means information about the properties of fundamental particles – their charge and whether they are a lepton or a quark, for instance, as well as more classical properties such as energy and momentum.

Particles can change, but certain symmetries must be observed. For example, an electron (charge -1, lepton number +1) can annihilate with a positron (charge +1, lepton number -1) to create a pair of photons, but not with a proton (charge +1, lepton number 0).

No ordinary process, including the decay of human bodies, violates this. The one possible exception is when matter disappears into black holes. Stephen Hawking famously made a bet that information is lost when black holes evaporate, but later conceded that it probably is preserved.

If I write something on a piece of paper and then burn it, the information (in everyday terminology) has been lost, but in physics terms, it hasn't. Chemical reactions happen to the paper and ink, but no fundamental particle properties change, with a possible exception if I were to toss the ashes into a black hole.

John Williams
Norwich, Norfolk, UK
Can information disappear? It all depends on the definition of information that is used. I use the definition that information is what determines how two entities interact, be they two hydrogen atoms or a person and a bus timetable. Information in the properties of a hydrogen atom may not be destroyed unless you split up the hydrogen atom. Brain information is created by us and therefore, on death, can be destroyed.

Moira Jamieson
Chudleigh, Devon, UK
Many people who have near-death experiences describe having a life review, backwards from the present. Could this be a download into a block universe in a higher dimension, updating it ready for the next universe cycle? No information lost, merely stored away for future use. Just a thought.

THE GOOD BRIGADE/GETTY IMAGES

This week's new questions

In step **When I go walking with my wife, six of her paces are equivalent to five of mine. Does this mean she gets more exercise than me?** ***Derek Shotton****, Havant, Hampshire, UK*

Plastic pong **If plastic is inert, why does it have a taste and smell? Plastic bin bags have a strong smell when first opened and water left in plastic bottles can acquire a distinct taste.** ***Louis Chambers****, London, UK*

Take a bet **Why do some people like gambling so much? What is the evolutionary root of this behaviour?** ***Sergey Kasatkin****, San Francisco, California, US*

Is a person who takes more steps getting more exercise?

Squeaky bite

Why does halloumi cheese "squeak" against your teeth when you bite into it? I don't know of any other food that does this, including other cheeses.

David Muir
Edinburgh, UK
Cheese curds, sometimes eaten as a snack, have a springy, rubbery texture rather like halloumi. They also have a tendency to squeak when bitten, so in places where they are eaten, they are often called squeaky cheese. The fresher the curd, the better the squeak. Undercooked green beans are another squeaky-bite food.

The explanation for the squeak is the alternate "stick and give" of the food's elastic surface against the inflexible enamel of teeth. This phenomenon is called stick-slip and is responsible for the squeal of car brakes and the screech of a braking car's tyres on the road.

You can feel stick-slip by dragging your finger along an inflated balloon or a piece of polystyrene. You can enjoy stick-

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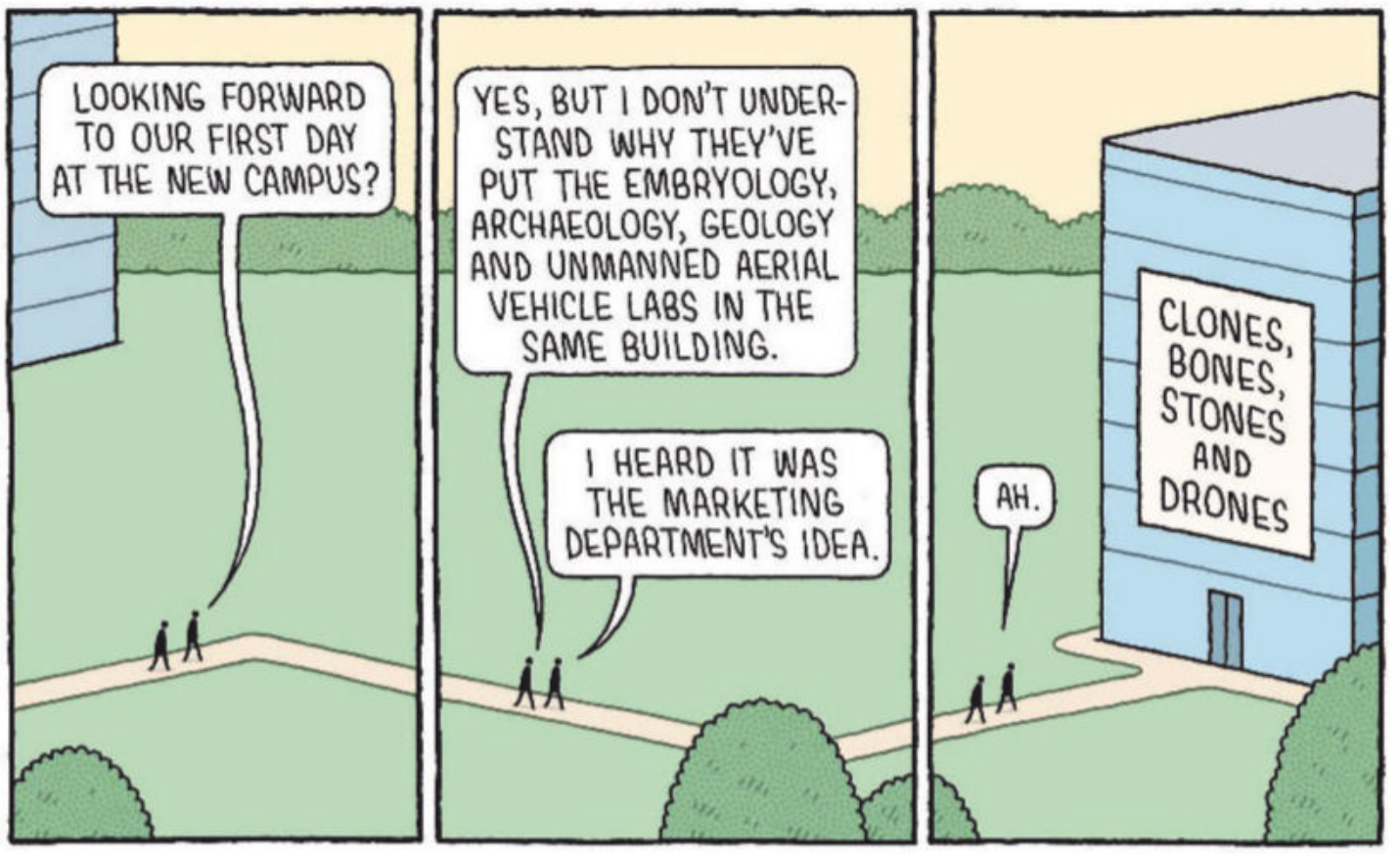
Tom Gauld
for New Scientist



slip by listening to a bow being drawn across the strings of a cello.

Adrian Bowyer
Foxham, Wiltshire, UK
Human food has a vast range of textures, but elastic, rubbery foods are quite rare. Halloumi is one of them, and because of its texture, it squeaks when it rubs on our teeth. Other cheeses tend to be crumbly or hard (in other words, not elastic) or soft (and therefore more viscous).

The squeak is a friction phenomenon called stick-slip: the cheese sticks to your teeth, slips a bit, sticks again and so on. When cheese and teeth are stuck, the friction between them is high, and the cheese stretches, increasing the spring force in the cheese. Eventually, this spring force exceeds the friction force and the cheese starts to slip, so the motion continues as the spring in the cheese relaxes.

Eventually, the cheese's spring force drops to the point that the friction force overcomes it and the cheese sticks again. Then the whole process repeats, producing an oscillation – the squeak.

"The squeak when biting halloumi cheese is caused by stick-slip, the same thing that causes the squeal of car brakes"

So why doesn't Turkish delight, another rubbery food, squeak? The reason is its high sugar content, which forms a film of syrup against your teeth. This viscous layer negates the stick-slip effect, just as the presence of viscous oil stops sliding metals squeaking.

Decades ago, I spent some years researching stick-slip, with the result that my daughter introduces me thus: "This is Dr Bowyer. He has a PhD in squeaks."

Photis Papademas
Cyprus University of Technology, Limassol
Squeaking against the teeth is a characteristic of halloumi's texture. The reason why lies in the fact that it contains a large amount of the milk protein casein in its intact form, which creates a dense network. This is because, unlike many cheeses, halloumi has a high pH, as no starter cultures are used in its production.

It seems that when this dense casein network "rubs" against the enamel of the teeth, it produces a squeak. Other cheeses usually have a lower pH, which tends to make the casein more fragile.

Halloumi is made by coagulating sheep or goat milk, then leaving the curds to drain in moulds (the collected whey is used to make a cheese called anari). The curds are then cooked at a high temperature, around 90°C. Finally, the cheese is folded while still hot and salt is then added to the surface.

Sue Thompson
Bury St Edmunds, Suffolk, UK
Our (home-grown, not overcooked) French beans squeak, to the extent that our children called them squeaky beans. ▮

Answers

Quick quiz #80 *Answers*

1 Barbara McClintock

2 A Lagrange, or Lagrangian, point

3 Three: the Bornean orangutan (*Pongo pygmaeus*), the Sumatran (*Pongo abelii*) and the Tapanuli (*Pongo tapanuliensis*)

4 Its wings, which appear to have had a skin membrane, making them similar to those of bats and flying squirrels

5 Malaria

Cryptic crossword #45 *Answers*

ACROSS 1 Satin, **4** Curate, **8** Ammeter, **9** Serif, **10** Ill-timed, **11** Code, **13** Turing, **14** Liskov, **17** Cowl, **19** Bindings, **21** Acorn, **22** Prairie, **23** Apathy, **24** Midst

DOWN 1 Statistician, **2** Tumbler, **3** Nutrient, **4** Career, **5** Rash, **6** Torso, **7** Effervescent, **12** Wind farm, **15** Kindred, **16** Dimply, **18** Whoop, **20** Gnat

#87 Poll position *Solution*

There will always be a house from which, if you start the polling there, a Red majority can't emerge. Imagine scoring +1 for every Blue voter and -1 for every Red voter. Start at any point and keep score as you go clockwise. Since there are equal Blues and Reds, when you get back to where you started, you will be at zero. However, there will be some house on the tour when your score is the most negative. If you start the poll at the neighbour to the right (clockwise) of this, your score on the tour will always be positive or zero. In other words, Red will never be in the majority.

This is not an item

Fear of catching something nasty has made Feedback more than usually shy of human interaction, and so we have taken to getting our daily bout of exercise through nocturnal perambulation. Roaming one evening rather further than is our wont, we are arrested by a parish noticeboard (merely figuratively; we appreciate your understanding on this occasion, officer, and won't do it again).

"THIS NOTICEBOARD IS NOT IN USE", a single notice on the noticeboard asserts, before continuing in a less shouty, but no less forthright, vein: "No notice will be displayed on this noticeboard until further notice". For the avoidance of doubt, "This is due to the escalating coronavirus pandemic".

Perhaps it was the lateness of the hour, but we found ourselves plunged back to those days, usually now relived only in sweat-drenched dreams, when the admonition "THIS IS A BLANK PAGE" stared up at our quite-blank mind from the pages of official school examination papers. Further than that, we feel a deep, almost spiritual connection to that 2500-year-old logical chestnut: what is the truth of the statement "this statement is not true"?

Answers on a noticeboard, please.

Twisteddoodles *for New Scientist*

Got a story for Feedback?

Send it to feedback@newscientist.com or
New Scientist, 25 Bedford Street, London WC2E 9ES
Consideration of items sent in the post will be delayed

Back down to earth

Perhaps we should just get out less. What we need for better night-time slumber, we realise courtesy of an advert recently served up to reader Fred Riley on Facebook, is an earthing sheet, thus joining "thousands of people across the UK who are choosing to sleep grounded".

An earthing sheet, we discover by displaying too much curiosity, "uses highly conductive materials such as pure silver and copper combined with innovative Earthing technology to transfer free electrons straight from the Earth to you". The, errrmm, grounds for needing such a thing being that baleful accoutrements of modern life like rubber-soled shoes and synthetic flooring materials have stopped the little critters from crawling up our legs in the usual fashion.

We have never been accused of lacking in negativity before, and we have always thought of ourselves as reasonably well grounded. Still, there is science on this-there webpage, and links to scientific papers – although not from what we would characterise as first-tier scientific journals.

Maybe that's just a lack of electrons talking, though. There is also the startling revelation, which we shan't pepper with [sic]'s for fear of further charge build-up, that "for every meter (3.28 feet) you are above the ground, 300 volts of charge will build up in the body. This means if you are in a second story bedroom, your charge would be 1,000 volts, on average".

All we can say is, if you are up there, possibly stay up there if you value non-singed turn-ups, and definitely don't try grounding yourself. Meanwhile, we aren't taking any chances, and are stepping out, gingerly, to our nearest farrier for some metal shoes.

They live!

In Feedback's mind, Charles Darwin was last seen pottering about the dingly dells of Down House in what was formerly Kent, poking about at earthworms. In common with other figures of greater or lesser repute, however, it seems he absconded to South America – at least according to his profile on Google Scholar, which, Twitter user Mike Cook notes, currently claims he is affiliated with the National University of Rosario in Santa Fe, Argentina.

A further startling revelation of the longevity of evolutionary biologists, meanwhile, plops into Paul Buckland's inbox. "The name 'Buckland, P' was mentioned in 1 PDF recently found by Academia, including one written by Jean Baptiste de Lamarck," he is informed. It must be all that fresh air.

A glorious thing to bee

Another interesting development on the evolution front as the California Fish and Game Commission appears in court defending a decision to list four species of bumblebee under the state's Endangered Species Act on the basis that they are fish.

We can only wish them luck: we recall that modern, genetically based ideas of evolution have revealed that "fish" is a rather loosely defined term. Indeed, all land vertebrates might be considered fish, on the basis of being descended from one (*New Scientist*, 26 September, p49). If there is any place that definition can be extended to the fluffy invertebrates buzzing around above us, it is in a US courtroom.

Ignoble omission

Finally, a late objection delivered from Laab im Walde, Austria, to our characterisation of Andre Geim as the only person to have won both a Nobel and an Ig Nobel prize (19 September). Not so, says Andrew Parker: "A former colleague of mine, Bart Knolls, has also won both, the Nobel peace prize as a staff member of the International Atomic Energy Agency and the Ig Nobel for investigating foot odour and Limburger cheese as mosquito attractants."

Ever the stickler for accuracy, we are happy to bring Knolls's achievement to wider attention, and contentedly add a second entry to the relevant pile in our extensive piling system.

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