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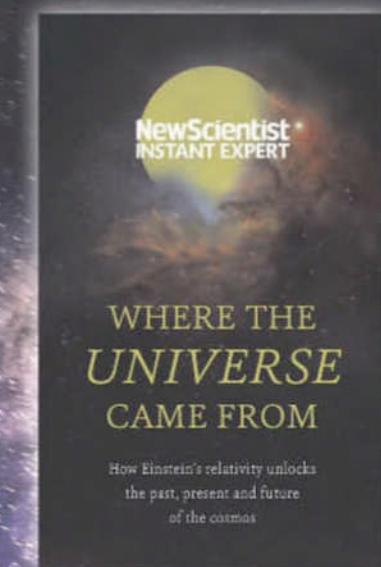
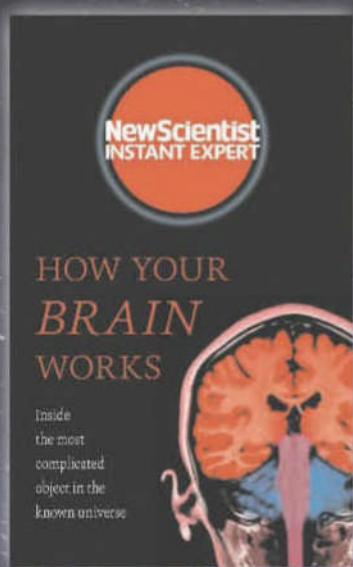


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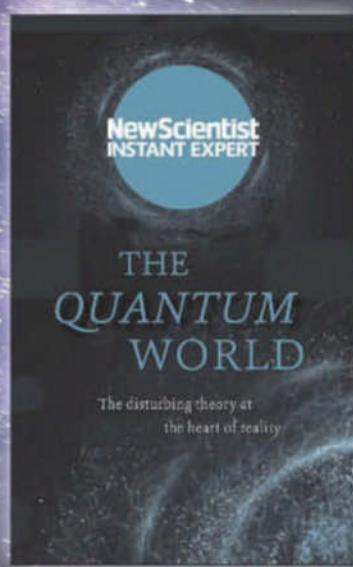
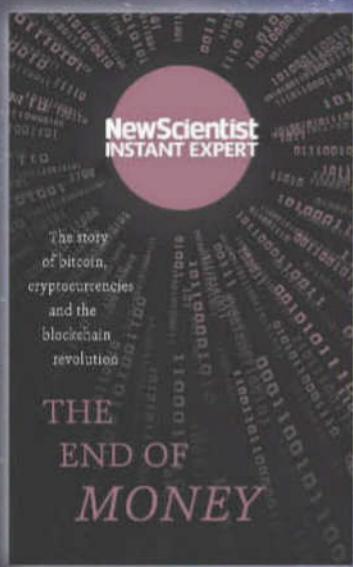


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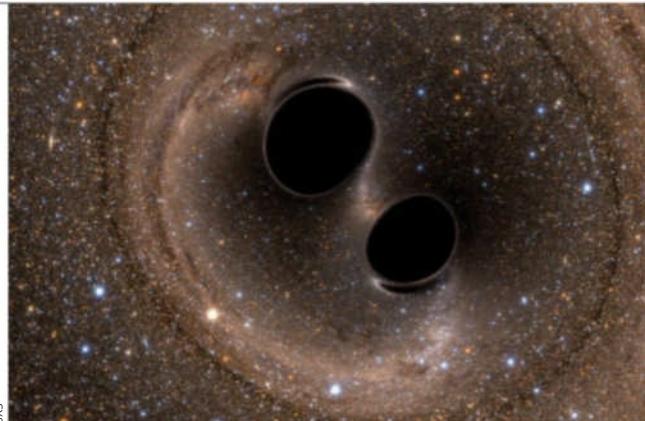
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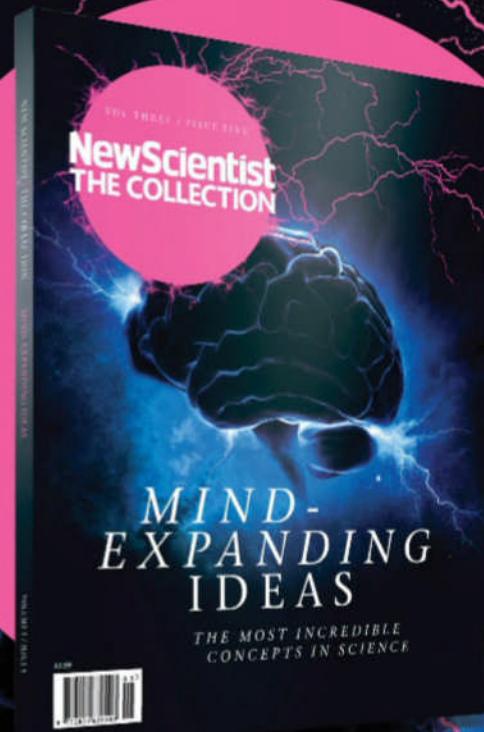
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Poisonous atmosphere

The UK government's attitude to air pollution stinks

ABOUT 40,000 deaths every year. That number is often trotted out as the human cost of air pollution in the UK, and it is shockingly high. It amounts to around one out of every 15 deaths.

This figure is back in the news because of the UK government's repeated failure to deal with air pollution, specifically nitrogen dioxide (NO_2). Levels of this toxic gas frequently exceed European Union limits in many British cities. In 2015, the UK Supreme Court ruled that "immediate action" was required. Two years later, the government still hasn't coughed up any meaningful plan to remedy the situation, flouting the legal deadline of 24 April. Last week, it failed to persuade the high court that it should keep its plans under wraps before the general election; it must now publish a draft plan by 9 May (see page 6).

The government says it won't appeal against the latest decision. But it has clearly been dragged to this point against its will. Cutting air pollution would require it to impose restrictions on vehicles that will be unpopular with motorists, the freight industry and certain sections of the popular press with a long and shameful history of resisting sensible environmental policies – all politically unpalatable.

One crumb of comfort is that nobody is still denying that air pollution is a major problem. That is a little surprising, given that the 40,000 UK deaths figure is widely misunderstood. First and foremost, it doesn't mean that 40,000 people die every year as a direct consequence of breathing dirty air. It is an aggregate of the life-shortening effects on the UK population. A more accurate way of putting it is that air pollution

Air pollution is bad for our health and any attempts to dodge rules on reducing it must be resisted

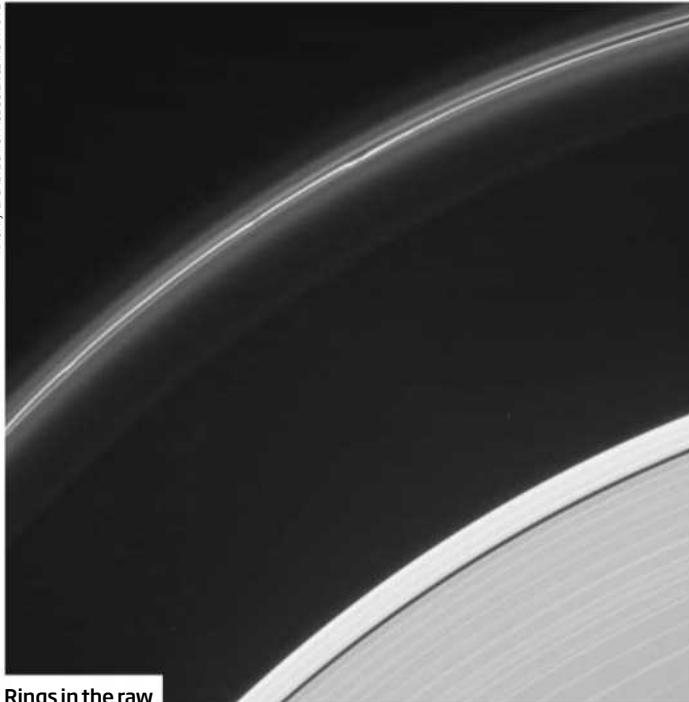
reduces a large number of people's life expectancies by a few months, and worsens quality of life for many more (see page 35).

It also conceals a high level of scientific uncertainty. The 40,000 figure is an estimate made in 2016 by the Royal College of Physicians, based on the latest research on NO_2 and the other main hazard, small particulates called PM_{2.5}. The Department for Environment, Food & Rural Affairs puts the toll at between 44,750 and 52,500; and a third figure is likely to emerge when yet another body, the Committee on the Medical Effects of Air Pollutants, publishes an estimate for NO_2 pollution.

The variation in these estimates is to be expected. It is always hard to put precise numbers on an environmental effect, and disentangling the impacts of different atmospheric pollutants is hard. We also still don't know enough about how air pollution affects health. Research published last week, for example, suggests that the most hazardous particles of all may be far smaller than those currently targeted by the PM_{2.5} rules (see page 20).

So it is clear that we need a lot more science before truly evidence-based policies can be formulated. But that is not an argument for inaction. The big picture is unlikely to change: we know air pollution is bad for human health, and grubby attempts to dodge or delay rules on reducing it must be resisted.

That is especially true of the UK government, which gives every appearance of wanting to drag the process out until it is free of "red tape" imposed by the EU. Nitrogen dioxide pollution is thus a litmus test of the UK government's intentions towards the continuation of EU rules designed to safeguard the health and well-being of citizens. On that score, there are far more than 40,000 lives at risk. The British public cannot breathe easy yet. ■



Rings in the raw

Heart infection risk

PEOPLE undergoing heart surgery may be getting infected with a deadly strain of bacteria, spread by machines used to cool blood.

The design of blood-cooling machines is flawed, Daniel

Blood-cooling machines are an infection risk that has been hiding in plain sight for decades"

Diekema at the University of Iowa told the European Congress of Clinical Microbiology and Infectious Diseases in Vienna, Austria, last week. "This was an infection risk that was hiding in plain sight for decades," Diekema said.

The problem arises during open-heart surgery to insert a device, such as a valve or blood-vessel graft. This process requires a machine to cool and later warm up the blood. During the operation, machines contaminated by the bacteria can blow them out into the operating room, where they can land on the devices to be implanted.

It was thought that the microbe, called *Mycobacterium chimaera* and common in soil and water, was present in only a certain brand of blood-cooling machine. But doctors are now reporting that other machines are affected too, and there is no known way of decontaminating them.

The problem is causing alarm among doctors worldwide, because *M. chimaera* infection is difficult to treat. There are 110 known cases of this happening in heart patients so far, and half of those infected have died.

ASTRID RIECKEN/GETTY



Message to Trump

Cassini takes first plunge

WE'RE getting up close and personal with Saturn, thanks to Cassini. The NASA spacecraft has made the first of its 22 planned dives between Saturn's rings, taking it closer to the gas giant than any probe before.

These Grand Finale orbits, each taking only six days, will yield a wealth of information about Saturn. The image on the left shows the rings as Cassini rocketed through at more than 100,000 kilometres an hour.

The picture appears as it was received from the spacecraft. In the coming days and weeks, researchers will process each set of images, sharpening them and adding colour using data from Cassini itself.

Before swooping down toward the planet, Cassini flew high over its north pole, snapping images of the pole and

rings. Cassini also took images of Saturn's tiny icy moon, Enceladus, as well as storms in Saturn's atmosphere. It will map the planet's gravity and magnetic fields, giving scientists a window into the planet's interior.

As Cassini travels between the planet and its rings, it will sample the particles drifting from the rings into the atmosphere, measuring how much dust and ice the rings really have.

The end of the Grand Finale mission in September will also be the end of the Cassini spacecraft. Low on fuel, it will crash into Saturn in order to protect the planet's moons from contamination by any Earth microbes that may have hitched a ride all these years.

UK's pollution woes

THE UK government has lost yet another court case over its failure to tackle air pollution.

The UK was supposed to unveil the latest plans to tackle nitrogen dioxide pollution on 24 April.

In many towns nitrogen dioxide often exceeds legal limits that came into effect in 2010 as part of EU regulations. The government was told to produce plans for reducing it after losing two court cases brought by campaign group ClientEarth.

But on 21 April, the government

made a last-minute application to delay publication until after the general election on 8 June, claiming it would violate election rules should plans be unveiled earlier.

Its application was largely rejected on 27 April. The judge ruled the plans might affect local elections being held on 4 May, but said the draft plans must be published by 9 May. The government has said it will comply with the ruling.

ClientEarth is also threatening to take the UK to court for failing to slash its greenhouse emissions.

Climate march

ANOTHER weekend, another march. The People's Climate March on 29 April brought an estimated 200,000 people to Washington DC. Sister marches also took place around the world.

The main march began at the US Capitol and ended at the White House, where demonstrators held a sit-in and rally while President Trump was inside. The event was held on his 100th day in office and billed as a way to push back on the

administration's climate policies.

A November poll from the Chicago Council on Global Affairs found that 71 per cent of respondents, including 57 per cent of Republicans, believe the US should stick with the Paris climate agreement.

Many activists appeared at the Washington march, including Leonardo DiCaprio, former vice president Al Gore and Amariyanna Copeny, also known as Little Miss Flint. The 9-year-old made headlines after writing to President Obama about the toxic levels of lead in the drinking water in Flint, Michigan.

US science reprieve

SCIENCE has dodged a bullet, for now. US government science spending will stay mostly unchanged for the rest of 2017 despite extreme cuts proposed by Donald Trump earlier this year.

Last week, the US Congress announced a \$1 trillion deal to fund the government until the end of September. The National Institutes of Health budget will rise by \$2 billion. NASA will get \$19.7 billion, including \$1.9 billion each for Earth science research and planetary science, a 2 per cent rise on last year. Funding for the National Science Foundation will remain at \$7.5 billion.

Even agencies subject to budget cuts may be able to breathe a brief sigh of relief. The Environmental Protection Agency, whose funding Trump has proposed to cut by 31 per cent in the 2018 fiscal year, will be getting \$8.1 billion, a decrease of 10 per cent.

When President Trump released his budget proposal for 2018 in March, it included major funding cuts for climate science, medical research and energy projects across government. Congress is likely to approve this budget in a future vote. So the present deal marks a respite, but not necessarily an escape from those cuts.

Cancer drugs

A FUND that was intended to widen access to cancer medicines in England has been found to have provided little clinical benefit.

The Cancer Drugs Fund, which paid for expensive new drugs not routinely available from the National Health Service, ran from 2010 to 2016 and cost more than £1 billion. Now researchers have analysed its impact by examining 29 of the drugs it made available in January 2015.

They found that only 18 of these were supported by research showing they would extend life.

The average increase in survival was just over three months. When quality of life and side effects were also considered, the study found that most of the drugs showed no evidence of meaningful clinical benefit (*Annals of Oncology*, doi.org/b6m3).

"The old Cancer Drugs Fund was always just a sticking plaster," says Paul Workman at the Institute of Cancer Research in London, who wasn't involved in the study. "It was too expensive, unsustainable and provided little certainty to patients and their doctors."

Space suit shortage at NASA

NASA is running out of space suits, and new ones are years away from being flight-ready. This was the finding of an audit released on 26 April by the NASA Office of Inspector General, relating to the agency's three next-generation spacesuit development projects.

Future missions may send humans further into space than ever before, so new suits need to be designed to handle the challenging conditions. Recent efforts, which have not been linked to a specific mission, have cost nearly \$200 million since 2007, but have yet to produce a viable deep-space option.

The suits currently used during spacewalks from the International Space Station, called Extravehicular

Mobility Units, were designed more than 40 years ago and were only intended to last 15 years. NASA currently uses 11 of the 18 original backpack-like life support systems, which were updated in the 1990s.

US involvement on the ISS is funded until 2024. It will be a challenge for NASA to maintain the current EMUs until then if the new designs aren't ready, the report warns.

A lack of clear strategy could be to blame. Over the past decade, NASA's focus on developing new spacesuits has been split between three programmes with different needs. One of them was designed for use in the Constellation Program, which was cancelled in 2010.



Nearly unsuitable

SpaceX launches spy

On 1 May, SpaceX launched its first major US military payload: a spy satellite for the National Reconnaissance Office. After the satellite was placed in orbit, the first stage of the Falcon 9 rocket returned to land safely at Cape Canaveral in Florida, marking SpaceX's ninth successful booster return.

Massive iceberg in sight

One of the biggest icebergs ever recorded may be about to calve from the Larsen C Ice shelf in Antarctica. A large rift there has been widening and a second branch of the rift, some 15 kilometres long, has been spotted moving towards the edge of the ice on satellite images. Calving will leave the ice shelf even less stable.

Twitter news

Twitter is making the move from 140 character messages to 24/7 rolling news coverage. The firm has announced live-streaming partnerships with Buzzfeed, VoxMedia and Bloomberg among others. They will provide news reports for the social media company's as-yet unnamed online channel starting later this year.

Blood type heart link

People with a non-O blood group are more likely to experience a heart attack, according to a review of nine studies covering 1.3 million people presented at the World Congress on Acute Heart Failure in Paris. Those with A, B or AB blood types may be at greater risk because they have higher levels of a blood clotting protein.

Plan to regrow a glacier

A move to stop a glacier retreating by blowing artificial snow on it is shaping up in Switzerland. Following preliminary studies, presented at the European Geosciences Union meeting in Vienna last week, the scheme is being tested at the Morteratsch glacier, a popular tourist destination, to see if its retreat can be halted or even reversed.

Echoes of extra dimensions

Gravitational waves could hint at hidden dimensions, says **Leah Crane**

HIDDEN dimensions could cause ripples through reality by modifying gravitational waves – and spotting such signatures of extra dimensions could help solve some of the biggest mysteries of the universe.

Physicists have long wondered why gravity is so weak compared with the other fundamental forces. This may be because some of it is leaking away into extra dimensions beyond the three spatial dimensions we experience.

Some theories that seek to explain how gravity and quantum effects mesh together, including string theory, require extra dimensions, often with gravity propagating through them. Finding evidence of such exotic dimensions could therefore help to characterise gravity, or find a way to unite gravity and quantum mechanics – it could also hint at an explanation for why the universe's expansion is accelerating.

"It would stretch or shrink space-time in a way that standard gravitational waves would never do"

But detecting extra dimensions is a challenge. Any that exist would have to be very small in order to avoid obvious effects on our everyday lives. Hopes were high (and still are) that they would show up at the Large Hadron Collider, but it has yet to see any sign of physics beyond our four dimensions.

In the last two years, though, a new hope has emerged. Gravitational waves, ripples in space-time caused by the motion of massive objects, were detected for the first time in 2015. Since gravity is likely to occupy all the dimensions that exist, its waves

are an especially promising way to detect any dimensions beyond the ones we know.

"If there are extra dimensions in the universe, then gravitational waves can walk along any dimension, even the extra dimensions," says Gustavo Lucena Gómez at the Max Planck Institute for Gravitational Physics in Potsdam, Germany.

Gómez and his colleague David Andriot set out to calculate how potential extra dimensions would affect the gravitational waves that we are able to observe. They found two peculiar effects:

extra waves at high frequencies, and a modification of how gravitational waves stretch space.

As gravitational waves propagate through a tiny extra dimension, the team found, they should generate a "tower" of extra gravitational waves with high frequencies following a regular distribution.

But current observatories cannot detect frequencies that high, and most of the planned observatories also focus on lower frequencies. So while these extra waves may be everywhere, they will be hard to spot.

The second effect of extra dimensions might be more detectable, since it modifies the "normal" gravitational waves that we observe rather than adding an extra signal.

"If extra dimensions are in our universe, this would stretch or shrink space-time in a different way that standard gravitational waves would never do," says Gómez.

As gravitational waves ripple through the universe, they stretch and squish space in a very specific way. It's like pulling on a rubber band: the ellipse formed by the band gets longer in one direction and shorter in the other, and then goes back to its original shape when you release it.

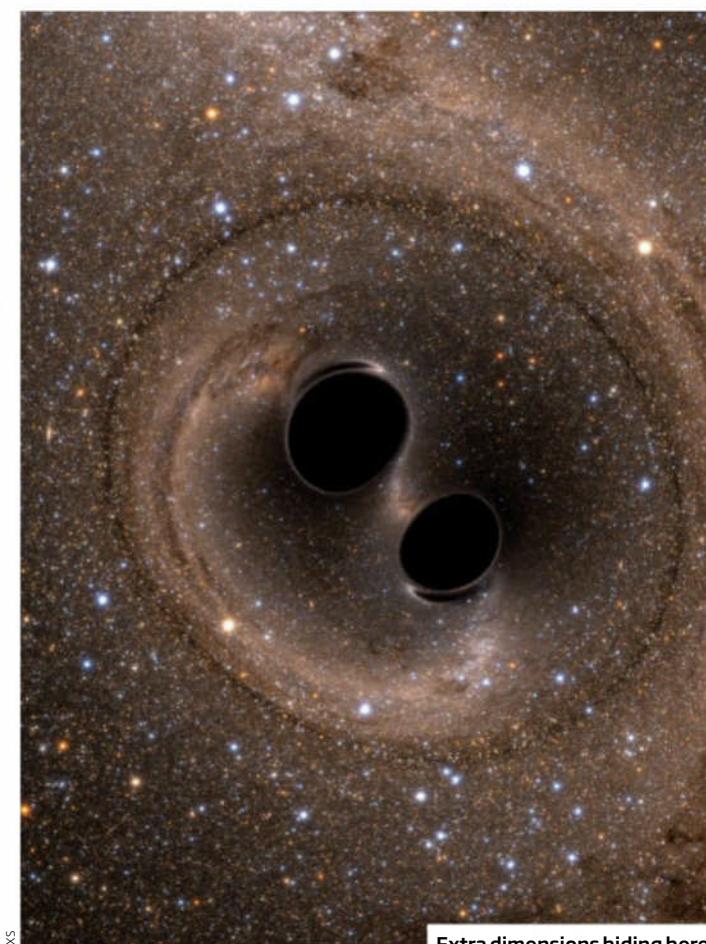
But extra dimensions add another way for gravitational waves to make space shape-shift, called a breathing mode. Like your lungs as you breathe, space expands and contracts as gravitational waves pass through, in addition to stretching and squishing.

"With more detectors we will be able to see whether this breathing mode is happening," says Gómez.

"Extra dimensions have been discussed for a long time from different points of view," says Emilian Dudas at the École Polytechnique in France. "Gravitational waves could be a new twist on looking for extra dimensions."

But there is a trade-off: while detecting a tower of high-frequency gravitational waves would point fairly conclusively to extra dimensions, a breathing mode could be explained by a number of other non-standard theories of gravity.

"It's probably not a unique signature," says Dudas. "But it would be a very exciting thing." ■



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Desk lights stop busy minds being bothered

IT'S annoying being interrupted when you're deep in thought.

To stop this happening in the office, a desk-mounted traffic light system automatically measures how hard a person is working to tell would-be interrupters when to stay away.

The FlowLight system tracks keyboard strokes as well as mouse clicks and movement to detect whether a worker is in the zone or can be disturbed. If a person's combined keyboard and mouse activity is within the top 9 per cent of their average range then an LED attached to their desk glows red, warning colleagues not to disturb them.

If the worker drops below the 9 per cent activity threshold, their LED turns green, indicating they are more open to interruptions at that point.

David Shepherd at industrial engineering company ABB devised the system to keep the firm's software engineers on track. He enlisted the help of Thomas Fritz and his team at the University of Zurich in Switzerland to build a system that could cut down the number of times the software engineers were interrupted.

Fritz tested the system with 449 employees across ABB offices in 12 countries, finding that people typically experienced 46 per cent fewer interruptions when using the FlowLight system.

The results of the study will be presented at the ACM Conference on Human Factors in Computing Systems that starts this week in Colorado.

It might not seem like it, but FlowLight isn't intended to make people feel guilty about slacking when their light switches from red to green, Fritz insists. To reduce the risk of this, he designed the system so the light is only red for 13 per cent of each day, no matter how hard the person is working. And the system doesn't discriminate between clicking for work and scrolling through Facebook or doing online shopping, for example.

Matt Reynolds ■

CAROLYN DRAKE/MAGNUM PHOTOS



HIV hides in white blood cells

Immune war with donor cells may wipe out HIV

HAVE we had it all back to front? Ten years ago, a man known as the Berlin patient was cured of HIV. It was thought that a bone marrow transplant he received for cancer, from a person immune to HIV, had eradicated the virus from his body. But evidence from a new group of people suggests an immune reaction provoked by the transplant may actually have been responsible.

The cancer therapy is so harsh that it wouldn't be given to people who don't have that disease, but if confirmed, the finding gives us a new insight into how to fight HIV.

The Berlin patient – Timothy Brown – is still the only person who seems to have remained free from HIV for a long period. A few other people have been "functionally cured" – although they have some dormant virus in their cells, they no longer need to take antiviral therapy.

HIV targets immune cells, leaving people defenceless against other infections if it goes untreated. The standard view was that Brown was cured by a bone marrow transplant he

received to treat his leukaemia.

The bone marrow came from someone with a genetic mutation in the CCR5 gene that makes immune cells resistant to HIV. But some believe that a side effect of the transplant may actually have been at least partly responsible for wiping out the virus in his body.

Known as graft-versus-host disease, it is caused by immune

"Some believe that a side effect of the bone marrow transplant killed off the virus in the body"

cells from the donor attacking those of the recipient. Brown's bone marrow transplant triggered this, causing his own immune cells – and the HIV they contained – to be killed.

Six more people with HIV and cancer who have been treated in the same way as Brown now seem to have no trace of the virus in their system, says Javier Martínez-Picado from IrsiCaixa AIDS Research Institute in Barcelona, Spain. Only one of the six received bone marrow from a

person with the CCR5 mutation – however, all six developed graft-versus-host disease.

We won't know if the six people have completely cleared their bodies of HIV until they stop taking their anti-HIV drugs. That may happen for the first person within the next year, says Martínez-Picado.

"If the theory is right, that would be tremendous," says Annemarie Wensing of the University Medical Center Utrecht in the Netherlands, who presented data on two of the six at the European Congress of Clinical Microbiology and Infectious Diseases in Vienna last week. All HIV tests on the six have been negative for more than two years.

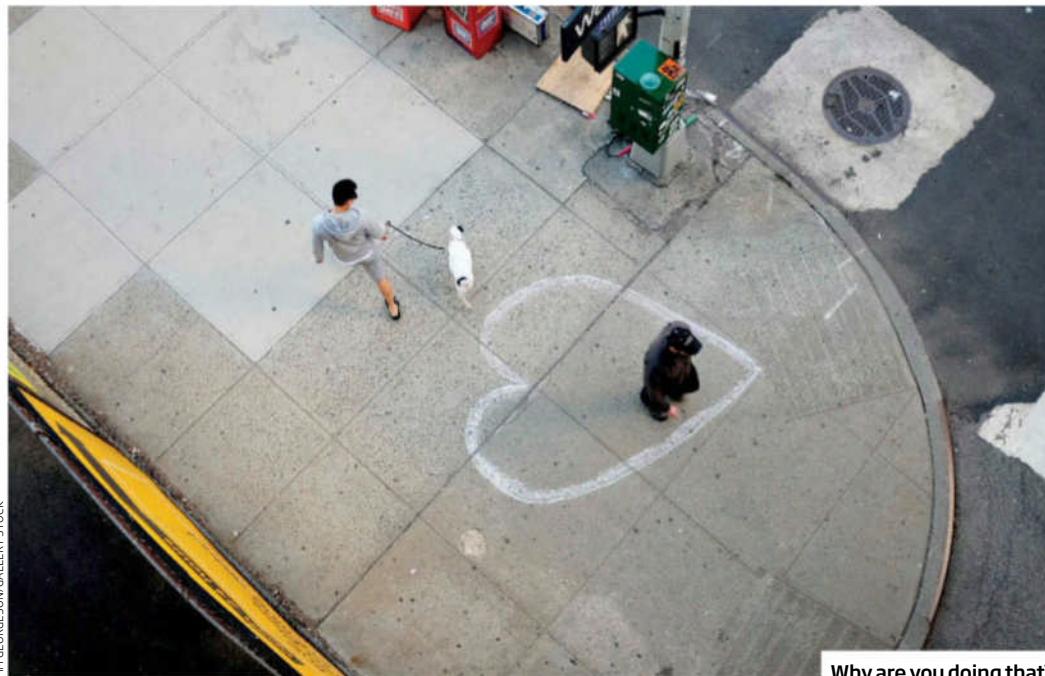
A different approach for treating HIV has recently shown promise. Known as "kick and kill", this treatment wakes up dormant virus that has been hiding in a person's cells and then targets it. This has enabled five people to stop taking anti-HIV drugs, but the virus is still present in some of their immune cells.

That's not so for Brown or the six newer cases, who come from various countries.

If graft-versus-host disease does turn out to wipe out HIV, doctors would be reluctant to deliberately provoke this potentially fatal condition in people. An international consortium of researchers, including Wensing and Martínez-Picado, has been following 23 people with HIV who received bone marrow transplants to treat cancer. So far, about half have died – either from the transplant, or their cancer.

Current anti-HIV drugs mean that people in rich countries can largely keep HIV under control, so inciting graft-versus-host disease wouldn't be a desirable option.

But the consortium is studying the transplant recipients to learn more about where HIV hides. This should help develop a cure without the need for a bone marrow transplant, says Martínez-Picado. Clare Wilson ■



TIME/GEORGESON/GALLERY STOCK

Feeling your heartbeat helps read others' minds

YOU really should listen to your heart. People who are more aware of their heartbeat are better at perceiving the emotions of others – a finding that might help some people with autism.

To generate emotions, it is thought that we first need to interpret our body's internal state – a process called interoception. So if we see a rabid dog, we feel fear only once we recognise an increase in our heart rate or feel our palms get sweaty.

Researchers have also suggested that interoception is important for understanding what other people are thinking and even guessing what they think a third person might be thinking. The idea is that if we have trouble distinguishing our own emotions, we might also find it hard to interpret the emotions and mental states of others.

To investigate, Geoff Bird, now at the University of Oxford, and his team asked 72 volunteers to count their heartbeats without

using their fingers to take their pulse – a measure of interoception.

The participants then watched videos of social interactions. After each clip, they were asked multiple-choice questions testing their ability to infer the characters' mental states.

“People who were better at counting their own heartbeat were more empathetic”

For instance, one scene showed a man called Tom trying to flirt with a girl called Gemma, who was clearly interested in a second, shyer man, Barry. Some questions required an understanding of the emotions of a certain character – for example, “Is Gemma feeling annoyed?” Participants who were better at counting their own heartbeat performed better on such questions (*Cortex*, doi.org/b6m2). “They were more empathetic,” says Bird.

But there was no link between

interoceptive ability and accuracy on theory of mind questions that didn't involve any emotions, such as “What does Barry think Gemma thinks Tom's intentions are?” This suggests our ability to interpret signals from our own body only helps us understand other people's thoughts when emotion is a factor.

“These relations are likely to be highly complex, so it would be interesting to look also at other dimensions of interoception, like breathing,” says Anil Seth at the University of Sussex, UK.

Bird says that interoceptive difficulties probably play a role in some features of schizophrenia and autism. For instance, some people with autism find loud noises upsetting. Perhaps, he says, they have trouble distinguishing the internal signals that arise from the noise – a raised heartbeat, say – from those related to pain.

There's some evidence that looking in a mirror can improve interoception. “It's not yet been shown whether interoception training also improves empathy, but it's an experiment we'd like to try,” says Bird. Helen Thomson ■

Chimp tool use spreads like a family tradition

SIX years ago, a chimpanzee had the bright idea to use moss to soak up water, then drink from it, and seven others soon learned the trick. Three years later, researchers returned to the site in Budongo Forest, Uganda, to see if the practice had persisted.

They found the technique has spread, and it has mostly been learned by relatives of the original moss-spongers. This adds to evidence that family ties are the most important routes for culture to spread in animals.

The latest experiment involved providing moss and leaves at the clay pit where the chimps had shown the technique before. Then the researchers watched to see whether apes would use leaves – a more common behaviour – or moss to soak up the mineral-rich water from the pit.

Most of the original moss-spongers used moss again, and so did another 17 chimps, showing the practice had become more widespread. The researchers wondered what factors influenced which individuals adopted it: were they connected socially, or through families, for instance?

It turned out that time spent together wasn't a good predictor of which chimps would use the moss sponge. Instead, adopting this tool was strongly correlated with having moss-sponging relatives. And, the chimps didn't only learn from their parents: it was spread between any family members in either direction. “It's like the family is the crucible where the behaviour is transmitted,” says Thibaud Gruber of the University of Geneva, Switzerland, one of the study authors (*Science Advances*, doi.org/b6h8).

“This is a wonderful contribution to the study of animal cultures,” says Andrew Whiten at the University of St Andrews, UK. “The accumulated evidence suggests that chimpanzees pass on scores of different traditions across Africa, but being able to see any of them originate and then spread is very much rarer.” Sam Wong ■

Complexity marks the spot for aliens

Bob Holmes, Mesa, Arizona

HOW can we search for life on other worlds when we don't know what it might look like? One chemist thinks he has an easy answer: just look for sophisticated molecular structures, no matter what they're made of. The strategy could provide a simple way for space missions to broaden our hunt.

Until now, the search for biosignatures in space has tended to focus mostly on molecules like those used by earthly life. Thus, Mars missions look for organic molecules, and future missions to Europa may look for amino acids, unequal proportions of mirror-image molecules, and unusual ratios of carbon isotopes – all hallmarks of life here on Earth.

But if alien life is very different, it may not show any of these. "I think there's a real possibility we could miss life if [resembling Earth life is] the only criterion," says Mary Voytek, who heads NASA's astrobiology programme.

Now Lee Cronin at the University of Glasgow, UK, argues that chemical complexity could

be a biosignature that doesn't depend on any assumptions about the life forms that produce it. "Biology has one signature: the ability to produce complex things that could not arise in the natural environment," Cronin says.

Obviously, an aircraft or a cellphone could not assemble spontaneously, so their existence points to the living – and even intelligent – being that built them. But simpler things like proteins, DNA molecules or steroid hormones are also highly unlikely to occur without being assembled by a living organism, Cronin says.

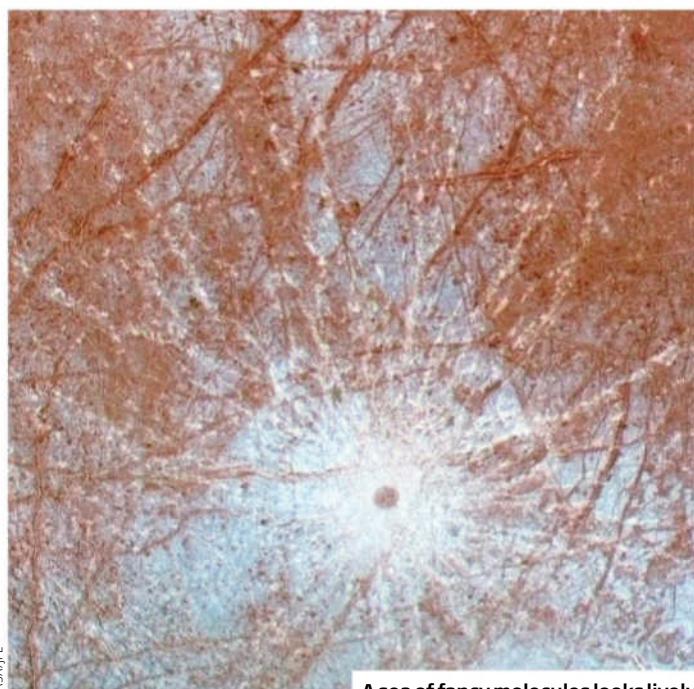
Cronin has developed a way to measure the complexity of a molecule by counting the number of unique steps – adding chemical

side groups or ring structures, for example – needed for its formation, without double-counting repeated steps. To draw an analogy, his metric would score the words "bana" and "banana" as equally complex, since once you can make one "na" it is trivial to add a second one.

Any structure requiring more than about 15 steps is so complex it must be biological in origin, he argued last week at the Astrobiology Science Conference in Mesa, Arizona. And Cronin thinks he may be able to simplify that criterion further, by specifying a maximum molecular weight for compounds that can assemble spontaneously.

Astrobiologists have welcomed Cronin's suggestion. "I appreciate Lee for developing a biosignature that has minimal assumptions about the biology," says Voytek. In practice, though, a detector compact enough to travel on an interplanetary mission would probably need to be designed to seek carbon-based life, she says.

Even if Cronin's method is valid, no scientist would risk claiming to have found extraterrestrial life on the basis of just one line of evidence, says Kevin Hand, project scientist for the Europa Lander mission now being developed by NASA. That means future missions will still need to look for multiple biosignatures. ■



A sea of fancy molecules looks lively

Talkative bots offer their take on the news

EVEN robots want to talk politics these days. Chatbots could soon be reading news articles and then discussing them with us.

Voice-activated assistants such as Amazon's Alexa or Apple's Siri can check the weather but are left stumped by more complicated conversations, says Alan Black at Carnegie Mellon University in Pennsylvania. Now Black and a team

of computer speech researchers have launched a competition to create a chatbot that can understand a news or Wikipedia article and then talk about it with a human.

"I'd like to have a system that reads the news in the morning, and I'd like to be able to talk about the news without having to go read it myself," Black says.

The winner of the Conversational Intelligence Challenge will be the team that the judges think has built the most engaging and convincing text-based chatbot. Evaluators will have to guess whether they're talking to a bot or a human, then rate the

quality and breadth of the discussion.

Black doesn't expect a convincing chatbot to emerge in the competition's first year. But Marilyn Walker at the University of California, Santa Cruz, thinks the stage is set for a big leap forward in the world of chatbots. "Things are really changing very, very rapidly," she says.

Researchers now have better access to data sets of conversations used to build chatbots. And better

"Chatbots designed for Amazon Echo devices must converse 'coherently and engagingly' with humans"

speech recognition systems are making it easier for us to chat to robots in a more natural way.

Walker and Black are both competing for the Alexa prize, a chatbot challenge run by Amazon. It tasks teams with building a speech-based chatbot for Amazon Echo devices that can converse with humans "coherently and engagingly" on a popular topic for 20 minutes.

The entries are now being put to the test by Echo customers in the US, with the best-performing team set to scoop a \$500,000 prize when the winners are announced in November. Matt Reynolds ■

Autoimmune diagnosis for Goya

Chelsea Whyte

DID Francisco de Goya develop a rare immune disorder before producing some of the darkest work of his career?

Often called the father of modern art, Goya fell ill with "colic" in 1792, aged 46. A year later, a mystery illness left him bed-ridden. It took him two years to recover, and he was deaf for the rest of his life.

Every year, the Historical Clinicopathological Conference challenges a different doctor to

investigate the ailments of a mystery patient. Ahead of this year's conference, Ronna Hertzano, a hearing specialist at the University of Maryland, was given details about Goya's condition without being told his identity, and asked to come up with a diagnosis.

Goya – then a renowned portraitist patronised by Spain's royal court – complained of buzzing in his ears before he went deaf. He also had severe headaches and difficulty seeing and maintaining his balance.

While bedridden, he experienced hallucinations and episodes of paralysis.

One possibility investigated by Hertzano is syphilis, but she says this doesn't fit. "You would expect syphilis over the course of many years to show some progressive neurological symptoms," she says, but none was reported.

Lead exposure can cause "colic" and deafness, and Goya used a lot of lead white paint. But Hertzano, who presented her diagnosis at the meeting in Maryland last week, has ruled this out, because, other than deafness, Goya's symptoms did not persist as they would have with lead poisoning.

Hertzano suspects Susac's syndrome, a rare autoimmune condition characterised by hallucinations, paralysis and hearing loss. It is caused by the immune system attacking the linings of small blood vessels and usually lasts three years or less.

Goya survived his illness and in 1799 published a collection of 80 etchings depicting ghosts, witches and nightmarish visions. But Janis Tomlinson, an art

"He complained of buzzing ears, severe headaches, and difficulty seeing and maintaining his balance"

historian at the University of Delaware, says that Goya's darker work wasn't likely to be a result of his ailments. "His contemporaries wouldn't have understood [this work] as dark," Tomlinson says. "They would have seen it as a satire of superstitions of the day."

Goya produced more than just nightmarish visions after his illness. He continued to paint portraits of Madrid society, and was given the rank of first court painter, the highest title he could achieve.

Had he lived today, Hertzano says Goya would have received immune modulation drugs for Susac's syndrome. If he went deaf, a cochlear implant could have restored much of his hearing. ■



Hallucinations or simply satire?

Electric shocks tweak you into running better

CHANGING your running style can be tricky. Perhaps a jolt of electricity might get you up to speed?

A device called FootStriker uses a blast of electrical muscle stimulation to move a runner's foot to the optimal angle just before landing.

More than half of all recreational runners pick up an injury each year, so having a good technique is important. Professional athletes tend to land on the front of their feet, but recreational runners normally land heel-first – something many coaches discourage (although the link to injury is disputed).

To check which part of an athlete's foot lands first, FootStriker uses a pressure sensor in a shoe's insole. Whenever a heel strike is recorded during a run, a pad on the back of the calf jumps into action. With a little burst of electricity, the muscles are stimulated to correct the position of the foot for the next landing.

Six runners used the device in a test. During an initial unassisted 1-kilometre run, the average percentage of heel landings was 95 per cent. Over the next 3 km, when FootStriker was switched on, the proportion of heel landings plummeted to 16 per cent. For a final kilometre, the device was switched off, but heel landings continued to decrease – to 8 per cent – suggesting the runners had learned the new technique. And although the device was worn only on one leg, the change in style happened in both.

In comparison, a control group coached on how to improve their running style, only managed to reduce their heel strike average from 97 per cent to 80 per cent.

"The same ideas could also be used for other sports with complex repeatable movements, like rowing," says Florian Daiber at the German Research Center for Artificial Intelligence in Saarbrücken, one of the makers of the device.

Timothy Revell ■

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Origins of first Americans up in air

Neanderthals first to reach America?

Colin Barras

RARELY have a few broken bones proved more controversial. Last week, an international team of archaeologists and geologists suggested that an ancient, broken mastodon skeleton found in California means early humans had reached the New World roughly 130,000 years ago.

If true, this revolutionises our understanding of the past, as the majority view is that the Americas remained unpeopled until about 15,000 years ago. It also means Neanderthals or Denisovans may well have been the first to reach America, not *Homo sapiens*.

"If this result stands up to scrutiny, it does indeed change everything we thought we knew about the earliest human occupation of the Americas," says Chris Stringer at the Natural History Museum in London.

But the initial reaction to the study was largely sceptical. Without any human bones at the site, critics say, evidence is circumstantial at best, though

this may be about to change (see "Finding ancient humans without bones" below). So how strong is the new paper – and its criticisms?

The archaeologists didn't find human bones, or any clear-cut evidence that humans interacted with the mastodon skeleton. What

they discovered were subtle, but tantalising, signs of a human presence. Some large bones were broken and were found alongside human-hand-sized cobbles with impact marks on their surface (*Nature*, doi.org/b6jh).

This leads to one immediate criticism: if the cobbles really are stone tools, they are exceptionally simple. They haven't been honed to produce a sharp edge. One stone tool researcher says even the simplest known ancient tools look like iPhones by comparison.

FINDING ANCIENT HUMANS WITHOUT BONES

The day after the controversial paper on the first Americans was published, another study revealed a new way to study early humans: looking only for their DNA in sediments.

The approach could be used to find out whether early humans were present even when there are no bones – and what kind of humans they were. It might help resolve the debate about when hominins first reached the Americas, for instance.

A team showed the approach could work by finding DNA from early humans at several caves where they are known to have lived. The DNA in the mud probably came from human excreta or rotting soft tissue. It had damage characteristic of ancient

DNA and contained variants unique to Neanderthals or Denisovans, so the team is sure it is the real thing, says Viviane Slon of the Max Planck Institute for Evolutionary Anthropology in Germany (*Science*, doi.org/b6jd).

The team now plans to look for DNA at some of the many hominin sites where no fossils have been found. "There are a lot of sites where there are stone tools, but it is unclear who made them," says Slon. If we can find enough ancient human DNA, it could give us a better picture of how our ancestors moved around but only back to about half a million years ago, as DNA doesn't survive much longer. Michael le Page

But others point out that humans are pragmatic. Why spend hours making a sophisticated stone tool if a simpler one has the same effect, says Gerrit van den Bergh at the University of Wollongong, Australia.

"The controversial study says the first early humans reached Americas 115,000 years earlier than thought"

One way to bolster the "tool" claim would be to check the stones for molecular traces of meat, which would strongly suggest they had indeed been used to pound the mastodon carcass. The team is performing such analyses now.

Another criticism is that the breaks in the bones could have been caused recently when heavy machinery trundled over the site during construction of a nearby road. But fresh bones fracture differently to ancient ones. The team says the bones show a breakage pattern often seen in fresh bones, suggesting they were broken in antiquity. It isn't obvious how modern machinery could have produced similar breaks.

A third criticism is based on the technique used to establish the age of the skeleton: uranium-thorium isotope dating. It is rarely used on skeletons because bone is so porous that uranium in surrounding sediment can seep in and fudge the results. But both Stringer and van den Bergh say uranium seepage usually makes bones seem younger, not older. Even so, sceptics would like to see the age confirmed using a different dating technique.

Finally, some critics point out that genetic evidence suggests all indigenous Americans trace their origin to waves of immigration within the past 15,000 years or so – not 130,000 years ago. But as the team points out, this doesn't preclude the possibility that some humans arrived earlier, were unsuccessful, and died out.

All in all, the jury is still out. ■



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Scotland floats on a hot starry plume

Colin Barras

THE plume of hot rock that sits beneath Iceland has long-reaching fingers – two of which stretch all the way to Scotland and Norway. This perhaps explains why the breathtaking scenery of areas such as the Scottish Highlands isn't submerged beneath the waves.

Mantle plumes are like chimneys that transport hot, buoyant rock from deep inside Earth. When they break through to the surface, the volcanic activity they generate can fuel the formation of new islands, such as the Hawaiian archipelago. Iceland also owes its existence to a mantle plume – and seismic maps of Earth's interior suggest that this plume doesn't have the typical circular outline. "It's far more irregular," says Nicky White at the University of Cambridge.

In fact, it looks a bit like flower petals or a star shape on top of a chimney of rising hot rock (see diagram, right). But why or how that irregularity arises has

remained a mystery until now.

When White saw one particular map of the plume's outline below Earth's surface, it suddenly dawned on him how it might have gained its irregular shape. He recalled experiments by some of his colleagues in Cambridge. They have looked at how fluids with different viscosities mix in the confined, almost two-dimensional gap between two

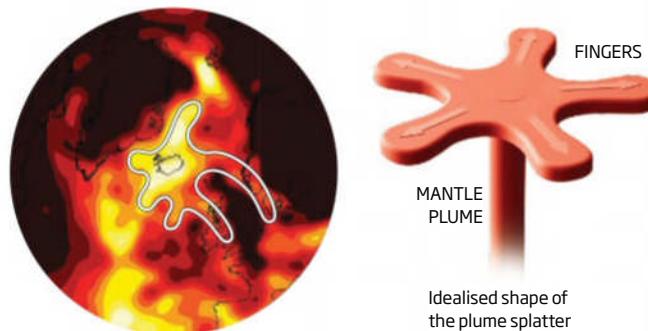
stacked sheets of rigid material such as glass.

These experiments show that when a runnier fluid is squirted into a more viscous one, it forms an intricate radial pattern of branches, or fingers. The work even inspired the logo of the BP Institute at the university. "I've walked past the logo every day for about 15 years," says White.

Now White and his student Charlotte Schoonman think the plume is behaving just like the fluids in the lab experiments, but on a much grander scale. About 100 kilometres below Earth's surface lies the asthenosphere, a zone of relatively free-flowing rock

Europe's splattering plume

When hot rock rising up below Iceland reaches the asthenosphere, 100 km below Earth's surface, it spreads out to form long, runny fingers, two of which reach Scotland and Norway



held between two horizontal layers of stiffer rock. Iceland's plume, they say, injects hot, runny rock into this layer that then spreads out horizontally into fingers. Other plumes don't form such tendrils, says White, because the rock within them is not sufficiently hot and runny, or injected with enough force (*Earth and Planetary Science Letters*, doi.org/b6hg).

The fingers on the Icelandic plume's eastern side seem to stretch surprisingly far, one reaching Scotland some 1000 kilometres away, and another one further still, to Norway. The hot fingers may even help to explain why Scotland and western Norway lie above sea level.

Earth's crust beneath these areas is unusually thin, meaning that both regions should in theory be below sea level. "Something else must be going on to explain why they're not under water," says White. "And that something else is the hot fingers." This is because the hot rock is relatively buoyant, which could compensate for the thinness of the crust, pushing it up.

Taras Gerya at the Swiss Federal Institute of Technology in Zurich thinks that the model makes sense. "It seems realistic to me," he says. ■

SOURCE: doi.org/b6hg (2017, 03, 05)

Most mammals take 12 seconds to defecate

EVERYONE poops, and we all take about the same amount of time to do it. A study of the hydrodynamics of defecation finds that all mammals producing faeces similar to ours take 12 seconds on average to relieve themselves.

"The smell of body waste attracts predators, which is dangerous for animals. If they stay longer doing their thing, they're exposing themselves and risking being discovered," says Patricia Yang, a mechanical engineer

at the Georgia Institute of Technology in Atlanta.

Yang and colleagues filmed elephants, pandas and warthogs at a local zoo, and one team member's dog in a park, as they defecated. These animals all excrete cylinder-shaped faeces like humans, and the duration of defecation remained constant (*Soft Matter*, doi.org/b6fg).

That consistency across animals is down to a few things. First, the length of faecal pieces was five times as long as the diameter of the rectum in each of the animals. Yang also found that the normal, low-level pressure animals apply to push through a bowel movement is constant, and unrelated to a creature's body mass. This means

that, whether it's a human or a mouse, the pressure on normal excrement is the same. This is similar to her previous finding that mammals take the same amount of time to empty their bladders.

The final piece of this puzzle is the crucial mucus layer in the colon. Cylindrical faeces aren't squeezed through a nozzle like a toothpaste tube. "It's more like a plug that just goes through a chute," says Yang. Larger animals have longer faeces and a longer rectum, but they have thicker

"Without a slick mucus layer, a human applying no pressure would take 500 days to void their bowels"

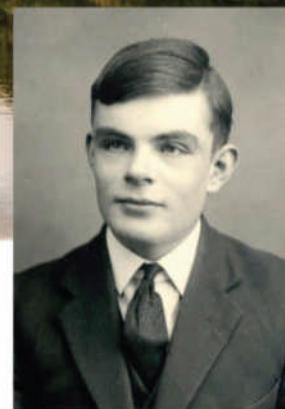
mucus, which makes the faeces accelerate faster – so they travel a longer distance in the same amount of time.

Constipation happens when that mucus is absorbed by the faeces. Without this slick layer, a human applying no pressure at all would take 500 days to void their bowels, Yang says. "It would be 6 hours if you apply maximum pressure," she says.

The team fed their observations into a mathematical model that can predict defecation times for digestive system problems. "If it's taking far longer than 12 seconds, I'd say you should go see someone about it," says Yang. "But you can't count the newspaper time." Chelsea Whyte ■

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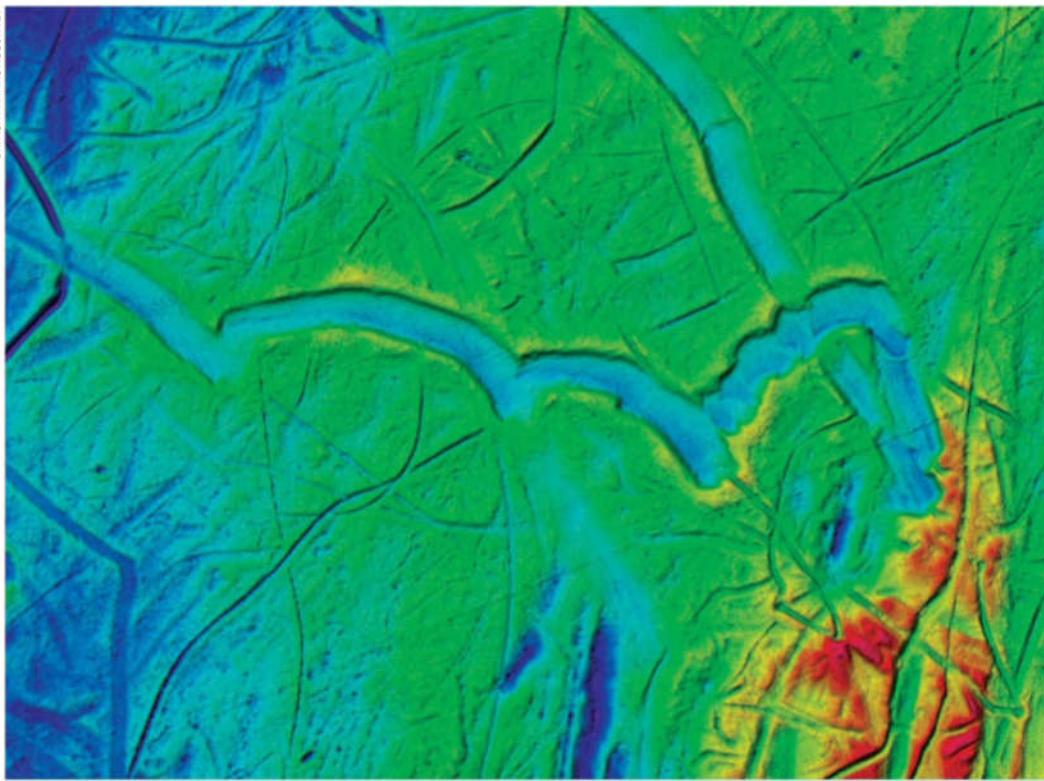
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Iceberg art: images reveal seabed scars in polar waters

IT MIGHT look like a weird road map, but the picture above shows scars gouged into the sea floor by the undersides of icebergs. The image is one of over 200 in a new atlas that shows in meticulous detail the tracks made by icebergs and glaciers on shallow seabeds in polar regions in the distant as well as the more recent past.

"This is a huge piece of work, combining images from 250 marine scientists from 20 countries, and took four years to put together," says Kelly Hogan of the British Antarctic Survey.

"It's the highest-resolution imagery from both poles in

one place, and it shows the way ice reshapes the sea floor." The pictures were taken by bouncing sound off the sea floor, using a method called multibeam bathymetry. "It's very similar to satellite imaging of Earth from space – except from ships instead," says Hogan, who unveiled the atlas last week at the annual meeting of the European Geosciences Union in Vienna, Austria.

The features range from 2 metres to hundreds of kilometres long, revealing where long-gone glaciers marked the seabed, and where and for how long they halted before moving on or melting. "It's like a fingerprint or tree ring of what went on in the past," says Hogan.

The historical behaviour of icebergs and glaciers can tell us how they might behave as global warming accelerates the melting of the ice caps.

There are two types of love addiction

EUPHORIA, dependence, relapse – can you really be addicted to love?

It's a contentious idea. "It gets complicated because people disagree on the correct theory of addiction, and people especially disagree about what we mean when we use the term 'love,'" says Brian Earp at the Oxford University Centre for Neuroethics.

But there may in fact be two types of love addiction, say Earp

and his team after reviewing 64 studies of love and addiction published between 1956 and 2016.

They found that people who feel desperately alone when not in a relationship and try to replace an ex-partner straight away could have what the team calls a "narrow" form of love addiction.

A broader form of love addiction includes love that is more like the usual experience,

but with stronger cravings. People who experience this struggle to ignore a strong desire to be near the object of their affections, but manage to control their urges.

Earp's team found evidence that both kinds of love addiction can have harmful effects on people's lives (*Philosophy, Psychiatry, & Psychology*, doi.org/b6gg). In some cases, being addicted to love seems to have contributed to people staying in abusive relationships or following a cult leader.

Spider courts mimic instead of eating it

A MOTH that looks and acts just like a predatory spider is so convincing that it receives elaborate courtship displays.

Many species mimic poisonous prey or blend into the background to escape predators. The metalmark moth of South-East Asia is one of the few that mimics its predator.

The impersonator's "furry legs" are contorted wings with a striped pattern, and its black, beady "eyes" are patterns on those wings. And instead of fluttering like other moths, the metalmark makes jerky leaps like the jumping spiders it mimics.

When Shen-Horn Yen at the National Sun Yat-sen University in Taiwan presented the moth to spiders in the lab, they responded by performing courtship displays, waving their legs at it (*Animal Behaviour*, doi.org/b6gv). They mistook the moth for another member of their species, says Yen.

Thawing exomoons may be life-friendly

ICY exomoons could hold on to life-giving atmospheres after being dragged towards their star.

Many of the exoplanets we see are Jupiter-like gas giants orbiting close to their star. They are too large to have formed where they are now, but could have done so further out – where there was more material available – then migrated inwards.

The temperature rise on such trips might vaporise the ice of any watery moons. Owen Lehmer at the University of Washington in Seattle simulated this happening in our solar system, and found that a moon the size of Jupiter's Ganymede could keep a water-rich atmosphere for hundreds of billions of years (*The Astrophysical Journal*, doi.org/b6hc).

Bears do the twist to leave a scent

FOR brown bears, doing the twist is about making a lasting impression – they dance to leave behind smelly footprints for others to sniff.

Wild brown bears are solitary and have huge ranges, so they could do with a long-distance messaging service. We know other mammals use chemical signals to communicate things such as identity, sex, social status and reproductive state. So Agnieszka Sergiel at the Institute of Nature Conservation in Poland and her team wondered whether the bears use a similar trick. “It appears a very important way to exchange information, which is still poorly understood,” says Sergiel.

Her team studied bears’ paws and their scent, and used camera traps to film wild bears in Spain’s Cantabrian mountains over three years. They found that the animals release scent from glands on their feet when they twist them into the ground. The scent contains at least 20 distinct compounds that probably act as sticky notes for other bears, communicating information such as sex.

They filmed 15 wild bears and found 81 examples of them scent-marking using their paws. Males were especially fond of doing the twist – they repeatedly retraced existing trails of footprints (*Scientific Reports*, doi.org/b6gp).



ALEX JEVON / BARCROFT IMAGES / BARCROFT MEDIA VIA GETTY IMAGES

Robots learn how to act around humans

ROBOTS are learning how to behave in social situations – which could help them work better with people.

Baxter the robot was trained on videos of humans shaking hands, waving, helping others up, passing a cup and high-fiving. Its learning algorithm generated rough skeletons of each person’s movement and used those outlines to infer human intentions and mimic their responses in social situations.

After watching 20 videos of each type of interaction, Baxter

was told to take the place of one human per situation and try to copy their movements.

Baxter used visual cues about the position of its partner to work out the most appropriate response in each situation. If it detected that its partner was reaching out with a cup, the robot responded with an open hand to take it.

Volunteers then rated how successful and human-like these interactions were compared with simulations involving an untrained robot. For each type of interaction, the volunteers rated

the trained robots as much more successful and human-like than the untrained ones.

The more the robot watches humans interact, the better it gets at responding appropriately in similar situations, says Song-Chun Zhu at the University of California, Los Angeles, whose team trained Baxter. He hopes his learning model, to be presented at an upcoming robotics conference in Singapore, will improve robot-human collaboration on production lines or in tasks such as building furniture.

Backspinning meal slows neutron star

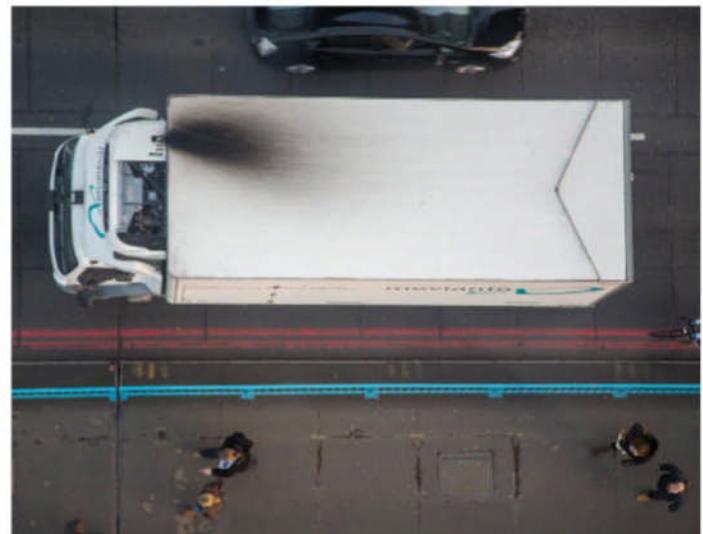
GOBBLING gas from a neighbour should make neutron stars spin faster, but sometimes the exact opposite happens. Now there might be an explanation: the gas arrives “backwards”.

Neutron stars are dense, fast-spinning stellar corpses that can pull material from a smaller orbiting star, spooling it into a disc before gobbling it up. This material carries momentum, which is why the neutron star should spin faster.

But when Demos Kazanas at the NASA Goddard Space Flight Center and his colleagues looked at 18 years’ worth of X-ray observations of neutron stars in binary systems in the Small Magellanic Cloud, they found that half were slowing down – at the same rate as the others were accelerating.

Kazanas and his team suggest that slowdowns happen when the swallowed gas is spooling around the neutron star in the opposite direction to the star’s spin (*arXiv.org/abs/1704.06364v1*).

If backed up by further observations, the idea could drastically change our view of the way neutron stars evolve, Kazanas says.



ARTUR DEBAT / GETTY

Nano-pollution gets into your blood

YOU may find it difficult to breathe easy after reading this. Airborne nanoparticle pollution may be able to enter the blood and build up in the diseased parts of arteries.

Numerous studies have shown that air pollution leads to millions of premature deaths worldwide each year (see page 35). Most of these are due to pollution raising our risk of cardiovascular disease, but the big question is why it has this effect.

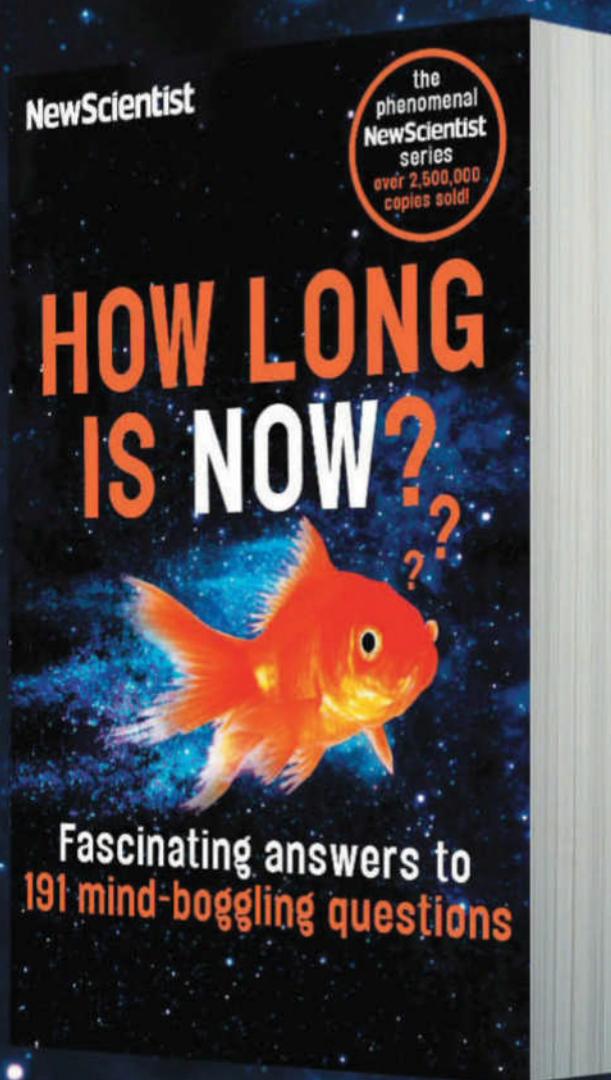
Mark Miller at the University of Edinburgh, UK, and his team got volunteers to breathe air filled with harmless gold nanoparticles. Within

15 minutes the gold began to show up in the volunteers’ blood – and could still be found in blood and urine three months later.

The researchers then repeated the experiment on people who were due to undergo surgery. They found that nanoparticles accumulated in the fatty plaques inside arteries that can cause heart attacks and strokes (*ACS Nano*, doi.org/b6gm).

Although gold nanoparticles are inert, the reactive compounds found in nano-pollutants in the air could have all sorts of harmful effects, Miller says.

WHY ARE DOGS' NOSES WET?



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JIM WEST/ALAMY STOCK PHOTO

DIY gun control

In the US, shootings are up and legislation is down. Can citizen science and technology keep people safe without laws, asks **Carrie Arnold**

SINCE the start of the year, there have been 105 mass shootings in the US, including a murder-suicide shooting at a school in San Bernardino, California, and the murder video recently posted on Facebook.

Legislators have always struggled to address this problem. But in the first 100 days of Donald Trump's administration, new gun legislation has only expanded, not restricted gun rights. In short order, lawmakers made it easier for certain people

with mental illness to buy guns, and pushed to expand the locations where people can carry firearms.

Over the past few years, however, gun owners and sellers have started taking matters into their own hands and have come up with creative solutions to reduce the threat from guns.

From working with public health organisations so gun sellers can recognise the signs of depression in a prospective buyer to developing biometric

gun locks, citizen scientists are cobbling together measures they hope will stave off the worst aspects of US gun culture.

The Federation of American Scientists estimates that 320 million firearms circulate in the US – about enough for every man, woman and child. According to the independent policy group

'In the absence of regulations against guns, individual gun sellers and owners are trying to help'

Gun Violence Archive, there were 385 mass shootings in 2016, and it looks as if the numbers for 2017 will not differ wildly.

Although the number of these incidents is alarming, it is dwarfed by the amount of suicides, which account for more than half of all firearms deaths (see graph, right). And last year, a report from the Associated Press and the USA Today Network showed that accidental shootings kill almost twice as many children as is shown in US government data.

In just one week in 2009, New Hampshire gun shop owner Ralph Demicco sold three guns that were ultimately used by their new owners to end their own lives. Demicco's horror and dismay that he had inadvertently contributed to their deaths led him to start what has become known as the Gun Shop Project.

The project uses insights from the study of suicide to teach gun sellers to recognise signs of suicidal intent in buyers, and know when to avoid selling a gun. To do this, Demicco teamed up with Catherine Barber, an epidemiologist at the Harvard T.H. Chan School of Public Health.

Part of what the project does is challenge myths. With suicide, the biggest is that people plan suicides over a long period. But empirical evidence shows that people usually act in a moment of brief but extreme emotion. One study has found that nearly half of people who attempted suicide contemplated their attempt for less than 10 minutes. In the time it takes to find another method, a suicidal crisis often passes, so even a small delay in obtaining a gun could make a difference.

Another myth that Demicco and Barber are seeking to dispel is that if you take away someone's gun, they'll just find another way to hurt themselves. While that's sometimes true, Barber says, alternatives are less likely to be fatal. Gun attempts result in death more than 80 per cent of the time; only 2 per cent of pill-

based suicide attempts are lethal. Within a year of its launch in 2009, half of all gun sellers in New Hampshire had hung posters about the warning signs of suicide by the cash registers in their stores. The programme has expanded to 21 states, and Barber is now analysing data to see how well it is working.

Another grass-roots project is trying to prevent children from accidentally shooting themselves. Kai Kloepfer, an undergraduate at Massachusetts Institute of Technology, has been working on a fingerprint lock to prevent anyone other than the owner using a gun. He has founded a start-up called Biofire Technologies to improve the lock's reliability and bring it into production.

Shot by a friend

To Kloepfer, the value of the lock is in preventing accidental shootings, especially by young children. Research has found a spike in accidental gun deaths among 3-year-olds, which typically happens when they find loaded guns in their homes and shoot themselves, and then another among 15- to 17-year-olds, who are more likely to shoot, or be shot by a friend.

These deaths aren't widely reported because their overall number is dwarfed by suicides and homicides, but "any deaths that smart guns prevent are significant, whether it's five or 5000", says Margot Hirsch, president of the Smart Tech Challenges Foundation. "We believe it should be a consumer choice, that people should have the option of smart guns if they want them."

Even mass shootings might be prevented with the right technology. Gun-free zones can be enforced with technology instead of laws. Geofenced Firearms in Philadelphia, Pennsylvania, uses satellite technology and other tools to make weapons that fire only

when in a location approved by their owner. Founder J.D. Ward built the specially designed gun with a GPS chip that allows, for example, a hunter to program her rifle to stay locked in and around the house. Similarly, someone who wants a handgun for home protection can dictate that the gun is usable only in that home.

If these guns become popular enough, Ward envisions a service in which restaurants, schools, cinemas and other public places can temporarily disable all firearms. "The goal is to limit opportunities for mass shootings," Ward says.

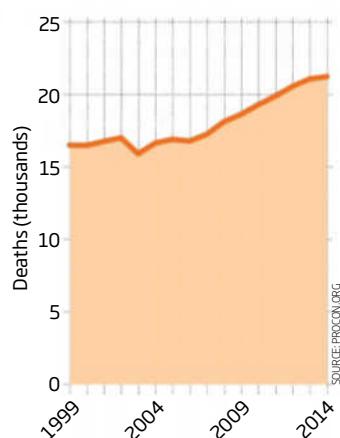
The Gun Shop Project and many smart lock schemes pride themselves in coming from within the gun community, not being imposed from the outside. But can they really make up for missing legislation?

Smart guns remain prototypes and still face several years of safety and reliability testing before they can be put on the market. There have never been laws against putting smart locks on guns; however, there aren't laws demanding them either.

Such laws could be needed if these technologies are ever to mature. "Today, the technology is not reliable enough for consumers

Lethal possession

In the US, suicides have jumped 24 per cent between 1999 and 2014. About half of the people used guns, often their own ones



Ward says.

Without laws, there's not much chance of manufacturers voluntarily adding extra safety features. And that's not necessarily just down to manufacturers. In 2000, gun maker Smith & Wesson tried

"When Smith & Wesson tried to make a gun lock, a boycott nearly drove the company to bankruptcy"

to work with the Clinton administration to improve gun safety by agreeing to add locks and restrict magazine size. When the US National Rifle Association got wind of this, it instituted a boycott that nearly drove the manufacturer out of business.

There can also be problems at the point of sale. A Maryland retailer who tried to offer a smart gun in 2014 received death threats and eventually decided not to stock them.

The NRA's stringent opposition stems from fears of restrictions on the US constitution's second amendment, which gives people the right to bear arms. The lobby even opposes mandates requiring gun owners to use locks or safes.

Grass-roots schemes like the Gun Shop Project have a better chance of being successful, because gun users are already buying in. But it may take years for the project to become big enough to have a significant effect on national statistics.

Regulatory changes might be needed to make any improvements stick in the long term. At the very least, new regulations shouldn't block the gun community's efforts at self-governance.

Change will not come quickly, regardless. Barber sees parallels between the Gun Shop Project and campaigns against drink driving in the 1980s and 90s.

"One commercial didn't change rates of drunk driving. It was an ad on TV, a scene in a movie, repeated over and over, that ultimately had an impact," she says. ■

WHY DO PEOPLE BUY GUNS?

You might think that after a mass shooting, gun sales would drop. But after the deaths of 26 women and children at Sandy Hook elementary school in 2012, gun shops sold in nine months what they would normally sell over two years.

And Barack Obama has been called "the greatest gun salesman in America", because of a surge in sales after his calls for greater gun control. Gun sales climbed 158 per cent during his presidency.

Donald Trump, by contrast, has been bad for gun sales. According to *The Washington Post*, in January and February, the number of FBI background checks – used to estimate gun sales – were 17 per cent lower

than in the same period in 2016.

We don't really know what such patterns mean. A 1996 law stops the US Centers for Disease Control and Prevention from using research funding to advocate gun control. This means there's little government-funded research on the subject.

The reduction of traffic fatalities and smoking in the US started with research into prevalence and causes, but it's not happening for gun violence.

"The continuation of this law for decades is astounding. If you're going to solve one of the leading causes of death in the country, you need data-driven decisions," says Michael Anestis, a clinical psychologist at the University of Southern Mississippi.

Cruel and unusual?

Regardless of your view on the death penalty, there's scant evidence that the use of lethal injection is humane, says **Anna Nowogrodzki**

ARKANSAS shocked the world when it said it planned to execute eight people in 11 days. It wanted to carry out the death sentences before its stockpile of one of three drugs used in lethal injection, called midazolam, reached its expiry date on 30 April.

Four of those executions took place. The others were halted by the courts. Arkansas should have let its midazolam expire. In fact, it shouldn't have used it at all.

Whatever you think of capital punishment, lethal injection in the US today doesn't offer the certainty of a swift end, because of a horrifying combination of a lack of data, historical quirks and uninformed decision-makers.

Compared with other methods of execution, lethal injection has a clinical air. In a 2015 US poll, it was the only method that the majority of people didn't think was a "cruel and unusual punishment".



In fact, it has a disturbingly high rate of going awry: 7 per cent, compared with 5 per cent for gas chambers, 2 per cent for electrocutions, and 0 per cent for firing squads, according to US legal scholar Austin Sarat.

A botched lethal injection can be terrible. When Clayton Lockett was killed in Oklahoma in 2014, he writhed, clenched his teeth and took 43 minutes to die.

The way it is supposed to work is that the condemned person gets three drugs. First, midazolam, a sedative related to Valium, to render them unconscious. Then vecuronium bromide to paralyse. And finally potassium chloride to stop the heart and kill.

But the second and third drugs feel agonising if the first fails to work fully, and there are claims it is not always effective. Then there are worries that a paralysing drug can mask partial consciousness.

In the loop

The consent of the people will be needed for a machine learning revolution, says **Paul Marks**

JACK Ma, head of Chinese internet retail giant Alibaba, is the latest tech visionary to suggest AI will harm society. He fears more pain than happiness as machine intelligence develops.

His warnings follow those of luminaries including Stephen Hawking, Bill Gates and Elon Musk, who have talked of the need

for research to focus on beneficial applications and ensuring AI is robust against runaway failures.

So you might think the British public, fed a diet of such views and worrying headlines, is feeling very negative about AI and machine learning, the computer method behind most AI. However, attitudes are relatively balanced

so far, according to an opinion poll for the Royal Society.

It found broad support for many potential uses of machine learning. For example, people expect AI's algorithms to be more honest brokers than their own species, quashing errors made by tired and emotional humans in deciding who gets a mortgage, insurance or a loan. And, if due regard is given to privacy and security of medical data, most felt healthcare driven by machine

"You might think the public, fed a diet of worrying headlines, is feeling very negative about AI"

learning would be a good thing

One broad streak of pessimism did emerge: people are concerned about keeping their jobs as intelligent machines inch ever closer to reality.

The poll has been used to inform a report from the Royal Society on what needs to be done to ensure this field thrives. One chief conclusion is that the AI industry needs public opinion on its side, so the society suggests developers spend at least some research cash on meaningful engagement. That's sound advice.

We can see the consequence of a lack of engagement where driverless vehicles are concerned:

When the US first used lethal injection in 1982, barbiturates were used instead of midazolam. They are far more effective at knocking someone out. But in the 2000s, barbiturates got harder to obtain for this, and states sought an alternative. With no particular evidence, they chose midazolam.

Makers of all three drugs now used and anti-capital-punishment campaigners have fought to stop the drugs being obtained to kill people. Arkansas's rush to carry out the death penalties shows that the drive to deny supply has been broadly successful. However, the result is that other execution methods are now being proposed.

Oklahoma recently made it legal to use nitrogen gas for this. Nitrogen gas suffocates, and is used in some doctor-assisted suicides. But there's little to no evidence on how it works with an unwilling participant, and it has never been used for an execution.

Regardless of the morality of the death penalty, it still exists in many states. As long as it does, and lethal injection is the method, the choice of drugs used should be based on data and medical advice – otherwise it's a cruel delusion to call them humane. ■

Anna Nowogrodzki is a science writer based in Massachusetts

here the poll found a lot of negative views. Research and testing on these cars presses ahead relentlessly, but no one really seems to be consulting those who drive for a living over what may happen to livelihoods. That is not good enough.

Developers of AI, and those who fund them, must be transparent about its aims, concerned not only with technical progress but also with the technology's potentially profound social impact. Only then can the power of machine intelligence benefit everybody. ■

Paul Marks is a science and technology writer based in London

INSIGHT Confirmation bias



Science shouldn't be partisan either

Reality is tough for both sides to swallow

Alex Berezow

TOUTING slogans such as "Facts have a well-known liberal bias", people on the Left have made clear they see themselves as the true heirs and defenders of the Enlightenment. New research, however, shows that they're just as deluded as everybody else.

One study, published in the *Journal of Experimental Social Psychology*, concluded that conservatives and liberals were equally averse to listening to opposing viewpoints on hot-button issues, such as same-sex marriage. In fact, they were willing to give up the chance to win money just to avoid the unpleasantness of hearing an opinion they disliked.

A meta-analysis of 41 studies recently published on the Social Science Research Network reached a similar conclusion: there was no difference in partisanship between liberals and conservatives. As it turns out, "open-minded" liberals are plagued by confirmation bias to the same extent as "closed-minded" conservatives.

Consider Seattle, a city that voted 87 per cent for Hillary Clinton and is proudly one of the most progressive –

and well educated – in the US. A warm embrace of scientific reality doesn't come with the territory: Seattle isn't terribly fond of biotechnology, rejecting GMOs and even vaccines. Rwanda's childhood polio vaccination rate is higher than Seattle's. As for other vaccines, including MMR, only five US states have higher exemption rates than Washington State. If liberalism translated into embracing science, we would expect places like Seattle to have vaccination rates of 100 per cent. Blame for "alternative facts" and "fake news" therefore, can't be pinned solely on the Left or Right. Both are culpable.

"Liberals also gave up the chance to win money just to avoid hearing an opinion they opposed"

This shouldn't come as a surprise to anyone who has followed politics in recent years. Society, fuelled by hyperpartisan news outlets and social media echo chambers, has created alternative realities for us to inhabit, full of self-reinforcing platitudes and free of any pesky information that might upset fragile world views.

That may explain the current US phenomenon of the "Regressive Left", as University of Chicago evolutionary biologist Jerry Coyne called them, believing that – as he put it – "some positions aren't just wrong, but [are] taboo to mention".

The resulting absence of intellectual diversity has contributed to a toxic and intolerant American university culture. Jonathan Haidt, a social psychologist at New York University, has documented how few conservatives there are in academia. In 1990, liberal academic psychologists outnumbered conservatives 4 to 1; today, the ratio is roughly 14 to 1.

Similar ideological exclusion was on display during the recent March for Science. Some protesters held signs that read, "Science is not a liberal conspiracy."

That's absolutely true. It is equally true, however, that science is for everybody – liberals and conservatives, atheists and believers. Twisting science into a bludgeon for political opponents is a gross perversion of humanity's best attempt at secular knowledge. Worse, it does grievous damage to the institution of science. Trust in science has been falling among conservatives for decades.

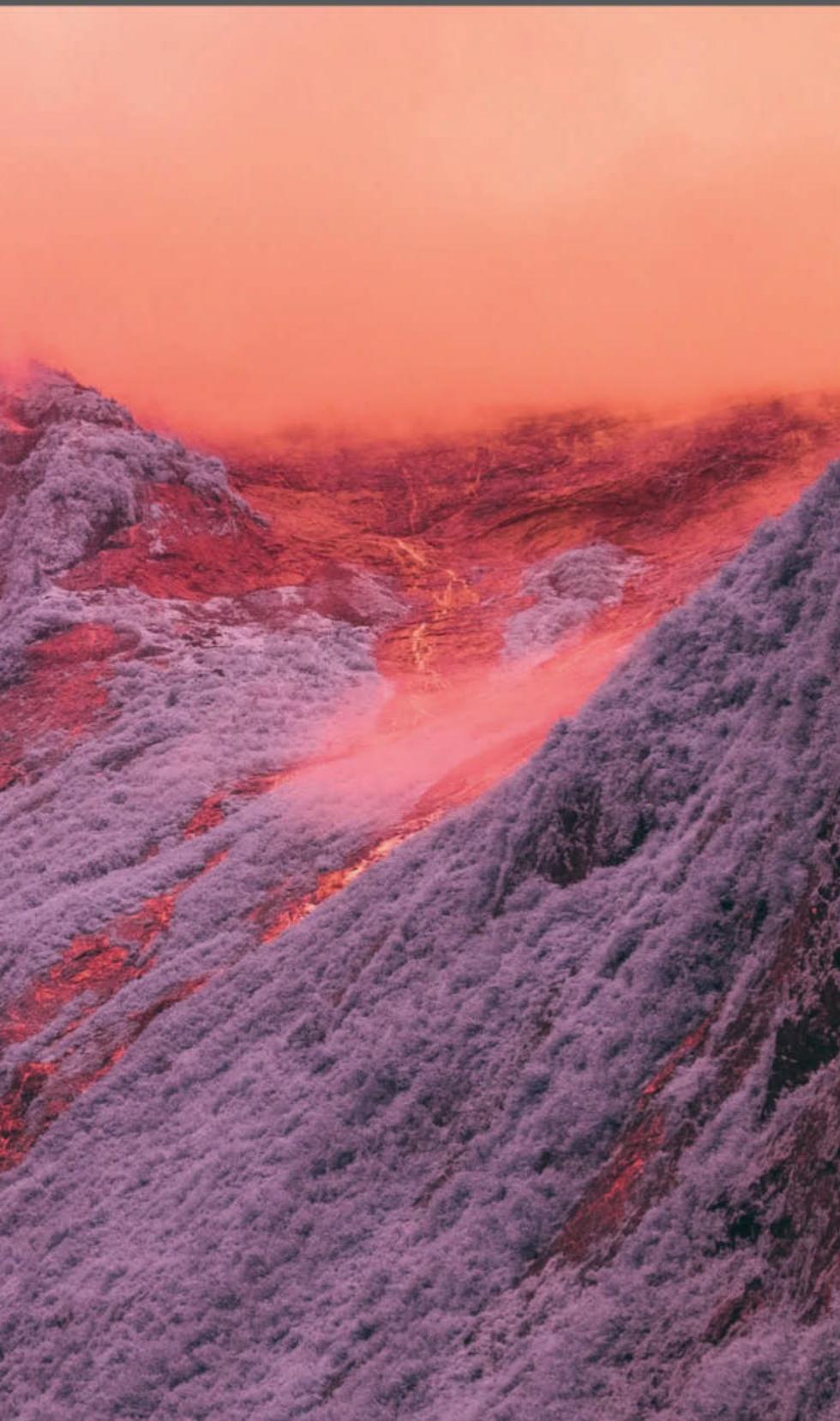
As it turns out, turning science into a political weapon has backfired spectacularly. The good news is that the first step toward solving any problem is to admit that we have one. These new studies are a good first step. ■

APERTURE



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Fjord of fire

THESE pink mountains bathed in an orange glow could easily be part of a Martian landscape. Instead, the peaks rise above the Tracy Arm – a 43 kilometre-long fjord near Juneau in Alaska. Photographer Bradley Munkowitz captured the scene during an excursion along the West Coast of the US last summer.

The fjord's steep cliffs were shot using a camera that catches infrared and ultraviolet, as well as visible light. This, along with filters, gives the scene its otherworldly palette.

The Tracy Arm fjord, named after a secretary of the navy who served in the 1890s, also features stunning waterfalls and floating glaciers. Two of the glaciers, known as the Twin Sawyer glaciers, are among the largest in Alaska.

The region is home to brown and black bears, as well as seals, whales and mountain goats.
Jessica Hamzelou

Photographer

Bradley G. Munkowitz

gmunk.com

Never-ending story

Can something be doomed to repeat forever? The laws of physics say no, but new materials are finding a way, says Shannon Palus

IT'S LIKE something out of a bad dream. You're stuck in a dance hall performing an interminable waltz. The hours go by and the dance continues. The hours melt into days, years, centuries, millennia. Eventually, billions of years have passed in which the universe has transformed into a featureless void populated only by you and your fellow indefatigable waltzers, dancing throughout eternity.

The vision is surreal, nightmarish – and entirely against the laws of physics. Anything that repeats on loop without an external energy source to power it seems to bend the cast-iron laws of thermodynamics, which govern how energy flows and can be exploited. So when five years ago, Nobel laureate Frank Wilczek speculated about a type of material that he called time crystals whose components could, in fact, do just that, he faced a wave of scepticism. "I took a lot of grief," he says.

In the time since, Wilczek's brainchildren have been championed, vilified, proved to be impossible, and now, apparently, made in the lab. If so, it's the birth of an entirely new phase of matter, one that is fundamentally bizarre, perhaps confounding – and possibly even useful.

Time crystals might still be waiting to be invented if Wilczek were not the sort of person

who gets bored easily. He won his Nobel prize in 2004 for theoretical insights into the nature of the strong force, which determines how fundamental particles interact within the atomic nucleus. He once described the experience of waiting for experimental verification of his theory as akin to watching grass grow. So when at some point his employer, the Massachusetts Institute of Technology, appointed him to teach a graduate course involving the structure of solid crystals, he was soon looking for ways to spice up the curriculum. "It's a beautiful subject, but kind of cut and dried by now," says Wilczek. "I wanted to hint at something different."

Wilczek ended up throwing around ideas about symmetry in crystals with a former student of his, Alfred Shapere, now at the University of Kentucky in Lexington. All crystals, from salt flakes to diamonds, are made up of some basic unit of atoms that repeats over and over again in space. The temptation is to think of such a pattern as symmetrical, but to a mathematician or physicist, this structure actually breaks a kind of symmetry.

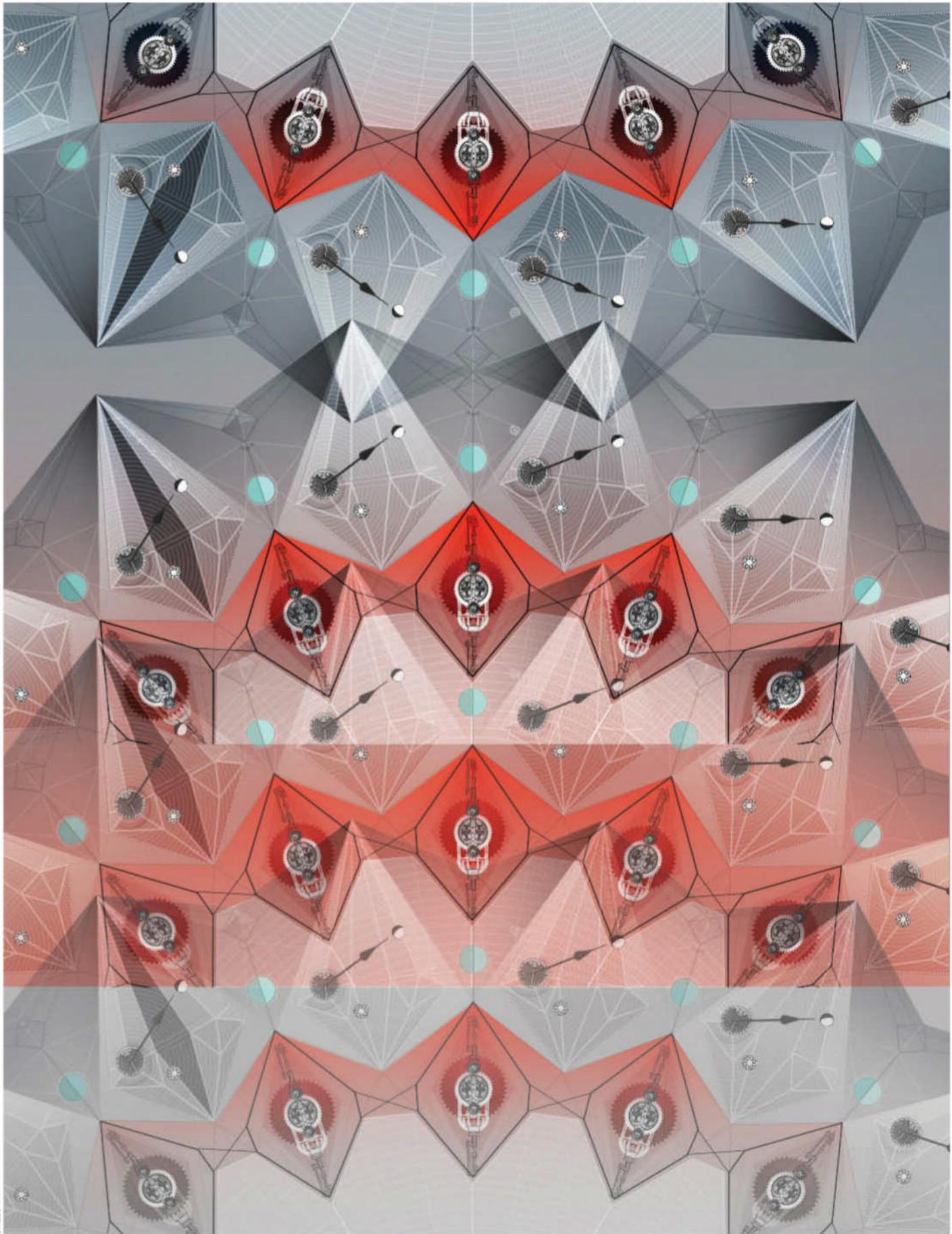
To see why, imagine asking for random samples of a carpet. If the carpet is plain, any pair of samples will be impossible to distinguish. But if the carpet is patterned,

it's likely no two are the same: if you overlay them, the patterns will not line up, just as they won't if you take two random chunks out of a repeated solid crystal. In physicists' speak, both the carpet and the crystals break translational symmetry in space.

So far, so ordinary. But Shapere challenged Wilczek to think of an object that would break translational symmetry in time: in other words, it would repeat naturally not in space, but in time.

Such things do not ordinarily exist on their own. A heart may constantly beat, and the hands on a clock may continuously move round the dial, but they need energy to power them – and hearts eventually run down and clocks cease to work. Claim to have built something that can run on a never-ending loop, with no power source, for as long as you please and you will get laughed out of the patent office. What you have designed is a perpetual motion machine: a long-discredited, thermodynamically impossible device for getting something out of nothing.

Wilczek's new form of matter, however, exploited a loophole. Time crystals would do no useful work: they wouldn't travel anywhere or power anything, and so technically would need no external energy source to run. For ➤



FORBIDDEN NO LONGER

Time crystals aren't the only seemingly impossible thing that physicists have created

TELEPORTATION

Quantum entanglement, the phenomenon that Albert Einstein called "spooky action at a distance", allows information and quantum states to be transmitted apparently instantaneously across space. Today, the world quantum teleportation distance record stands at over 100 kilometres.

INVISIBILITY CLOAKS

Metamaterials bend waves of light in unaccustomed ways, allowing them to pass around objects in your field of vision and potentially hide them from view. While human-sized objects can never be made totally invisible, similar principles might be used to divert seismic waves and shield entire cities from earthquakes.

NEGATIVE TEMPERATURES

According to the strict thermodynamic definition, temperature is a measure of order: the quieter and more ordered something is, the lower its temperature. So tidying up atoms already cooled to near absolute zero gives scientists a sneaky way of creating "impossible" negative temperatures.

MATTER MARRIED WITH ANTIMATTER

Matter and antimatter are supposed to violently annihilate when they come into contact. But so-called Majorana fermions would be their own antiparticles, capable of self-annihilating under the right conditions. Some researchers claim to have created ones in the lab, by tearing electrons out of superconductors and manipulating them alongside the holes they leave behind.

good measure, Wilczek imagined time crystals arising in a superconductor, a material that already exhibits unusual behaviour by allowing electrons to flow without resistance.

When Wilczek and Shapere published a paper outlining their thought experiment, the pick-up was immediate. "It generated a lot of excitement," recalls Vedika Khemani, a researcher at Harvard University.

At the time, Haruki Watanabe was a PhD student at the University of California, Berkeley. One of the questions during the oral examination for his degree was about what would happen if symmetry broke in the way that Wilczek proposed. Watanabe didn't know, and the question festered.

As is clear from the title of the paper he published two years later, "Absence of quantum time crystals", the answer he came up with was unambiguous. Time crystals as proposed by Wilczek were still thermodynamically impossible. The problem, Watanabe showed, lay in Wilczek's proposal that the dancers be in constant, seamless motion, entirely independent of the outside world. These dancers would be in thermal equilibrium, said Watanabe, a state he was able to painstakingly prove could never display periodic behaviour.

"That was that," says Khemani. "Everyone thought that time crystals were impossible." But the vagueness of Wilczek's thought experiment offered a lifeline: a time crystal might still exist, just not in thermal equilibrium.

Khemani ended up exploiting that get-out clause almost by chance. When Watanabe's paper came out, she was at Princeton, working on a problem called many-body localisation, which can be summed up as "a bunch of tiny particles get stuck". An example might be if all the air particles in a room, instead of filling the space evenly with gas, were hanging out in one corner. That's not a normal happening: thermodynamics says that, left to their own devices, things tend to evolve towards messy, featureless, randomly distributed states.

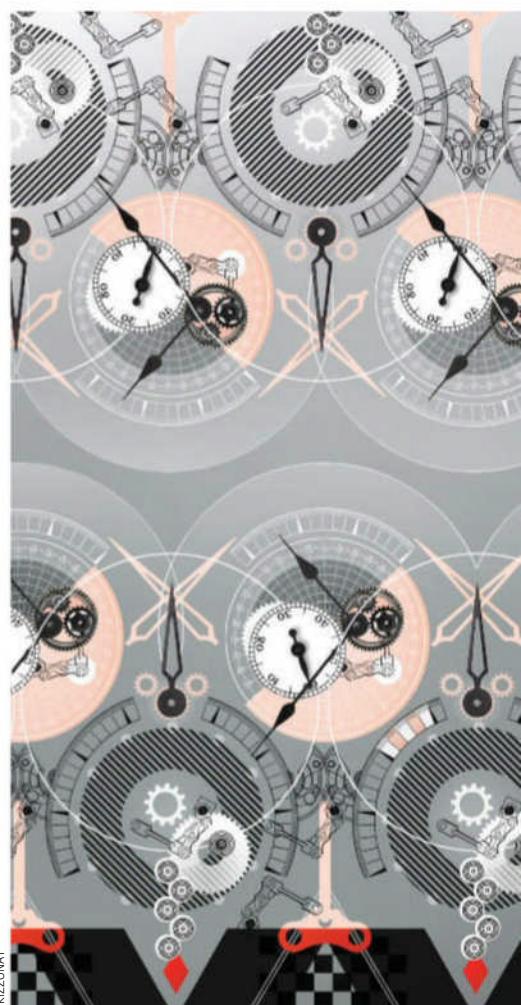
Loophole to hula hoop

But tickle a system in precisely the right way, Khemani found – gently, not imparting any energy to it – and keep on tickling it in a regular rhythm, and you could prevent that happening. In fact, you could get a bunch of particles to move in space at a rhythm different to the one you're poking it at. It's a bit like a sponge that you squeeze and release, says Khemani, except that the material doesn't follow the rhythm of your

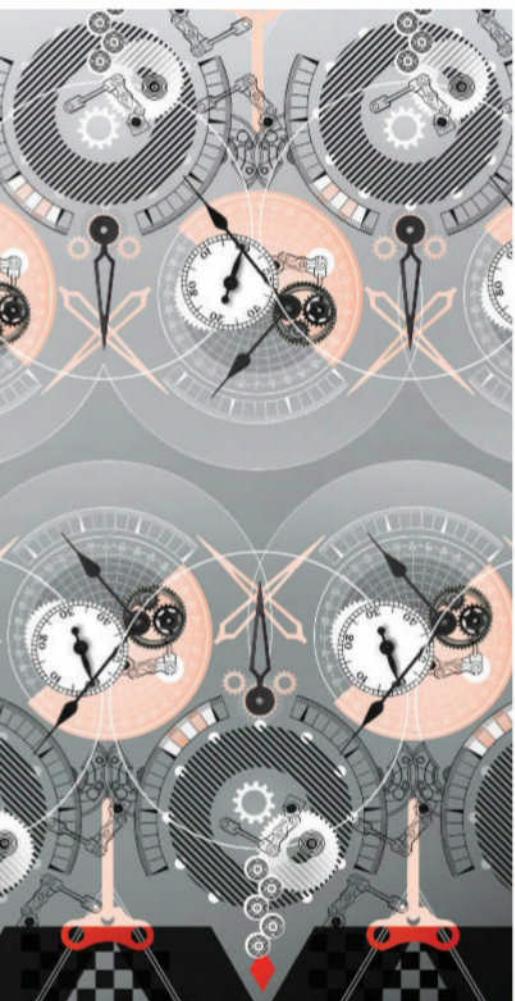
squeezing, but expands and contracts at only half the rate, say, as though you were squeezing it half as quickly.

It wasn't until Khemani's paper reached peer review that someone pointed out the connection with time crystals – although it was of a new sort, as her system was not in thermal equilibrium. With the loophole now expanded into a hula hoop, all time crystals needed was the right experimental home. And Soonwon Choi, a graduate student at Harvard, thought he could provide it. While listening to Khemani lecture about her idea in 2016, it occurred to him that the experiment his colleagues were using to observe strange quantum effects could be an ideal test bed for a time crystal.

Choi and his group were working with a black diamond, a close cousin of those clear rocks that adorn engagement rings, but with a few million carbon atoms swapped out



"It's as weird as a roomful of dancers leaving the party, going home, and continuing to dance in perfect lockstep"



for nitrogen atoms paired with little empty spaces. These impurities, meticulously inserted over months, give them their distinctive colour and extravagant price. More than that, however, they offer just the kind of disorder necessary to allow for the weird effects Khemani had envisioned.

Each nitrogen atom/empty space pair in the diamond has a property called spin, which can be made to flip between two values using a microwave signal. Choi and his colleagues found that they could send the microwave signal twice for every spin flip, just like the sponge moving half as fast as the rhythm of the hand squeezing it.

The Harvard experiment wasn't unique. Nearly 7 hours' drive south on I-95, in experimentalist Chris Monroe's lab at the University of Maryland, another group had built their own version of a time crystal. It was another possible rebel child of Wilczek's theory, based on a slightly different theoretical blueprint. It consisted of just a handful of atoms – ytterbium ions to be exact – flipping spins in unison inside a chamber the size of a softball. The atoms were responding to lasers pulsing at twice the frequency of the flips.

"My god," Wilczek recalls thinking when he read the papers this January. To him, this was a major justification of his idea. What's more, he'd had no idea that the experiments were under way. "It was a very delightful surprise."

Watanabe was unconvinced. To him, an object that needs an external signal to loop in time is no more a time crystal than a beating heart or a swinging pendulum. "In my opinion, the phenomenon should occur by itself," he says. The fact that time crystals were popping up in Massachusetts and Maryland represented little more than overenthusiastic branding.

Wilczek himself doesn't entirely disagree, and nor, for that matter, does Khemani. But she does see an important distinction between her work and the everyday phenomena Watanabe describes. "It is unfair to say that they are just pendulum-like," says Khemani. That's because the atoms in time crystals are separated in space, and yet are all still flipping together, cooperating at a distance. Pendulums and hearts don't do that. It would be as weird as a roomful of dancers leaving the party, going home, and then continuing to dance in perfect lockstep.

That feature makes the creations interesting in their own right, Watanabe admits. And now that they exist, says Wilczek, it's easier to see the implications of time crystals. Monroe's set-up, for example, is one

he typically uses to create elements for quantum computers. Time crystals could, one day, fit into that category. The fact that the spins align and appear to cooperate means that they could serve as a clock for a future machine or, because they have the capacity to maintain their state as time plods on, a way to store information.

They could also help perform MRI scans on tiny things, says Mikhail Lukin, the principal investigator at the Harvard lab. A time crystal could respond to a relatively weak signal coming from, say, a cell or even an individual protein, and flip millions of spins in unison as a result, amplifying the signal.

Happily ever after?

But for now, Monroe points out, the time crystal doesn't last long enough to do anything more than let us observe that it exists. Thanks to imperfect equipment, the processes used in the lab are "like deliberately throwing sodium and chlorine crystals together one at a time," he says, technically capable of creating salt crystals, but ones far too small to use as seasoning.

"Of course, naturally, salt crystals appear all the time," says Monroe. That means there could be larger time crystals out there in the wild.

Wilczek still believes that time crystals could hypothetically last forever. "There's no clear upper limit," he says. Experimentalists are more sceptical – and there are some practical aspects to consider, too. Phil Ricerme, who has been watching the emerging time crystal research from his post at Indiana University at Bloomington, drily notes that "in practical terms, the sun is going to explode and take out the lab."

In the immediate future, the hope is that the properties of this new phase of matter can be explored in more detail. "It's like we've stumbled on to some new territory," says Wilczek. "We don't know if it's an exotic island, or a continent."

For Khemani, the biggest consequences of the experiment are more subtle: it means that interesting things happen out of equilibrium. "Phases have been studied for so long," she says – the handful we knew about seemed to be all that were out there. Now, she says, "people are thinking about phases in this out-of-equilibrium setting." It opens up a whole new realm of matter, one sure to keep physicists dreaming for some time to come. ■

Shannon Palus is a science writer based in Brooklyn, New York



BLICKWINKEL/ALAMY STOCK PHOTO

Eaten to extinction

A growing taste for snacks made from orchids could spell the end for some of the world's most beautiful plants. What's to be done, wonders Stephanie Pain

WHAT links a warming drink once sold on the streets of London, Turkey's traditional ice cream and a wobbly brown cake that's fast becoming Zambia's favourite snack? Orchids. The main ingredient of all three is made by pulverising the tubers of some of the world's most exotic plants.

In England, tea and coffee ousted their orchid-based rival centuries ago. In Turkey and Zambia, though, demand for tubers is soaring, fuelled by an increasingly prosperous urban middle class with a taste for authentic foods. But there's a dark side to this growing appetite for traditional dishes: the tubers they are made from are taken illegally from the wild. "Collection is ruthless," says botanist Hugo de Boer of Uppsala University in Sweden. "It has reached a point where entire populations have gone and others are on the point of collapse."

For centuries, people in Turkey and its former empire have enjoyed a drink, sweets and a slow-melting, stretchy ice cream made from salep, a flour produced by grinding the tubers of bee and butterfly orchids and their kin. At the height of the Ottoman Empire, the warm, creamy drink made from salep became popular as far away as England and Germany. Street vendors still sell it in Greek cities in winter, but it is Turkey's consumption of the drink and dondurma – the revered traditional ice cream – that poses the greatest threat to the region's orchids. "Consumption has really taken off in the past decade," says de Boer.

In parts of East Africa, people ate orchid tubers during hard times rather than as a

delicacy. The Bemba people of north-east Zambia, however, turned this famine food into a more regular part of their diet in the shape of chikanda, a soft, savoury cake made by boiling orchid flour, peanut flour and ash, then baking the mixture until just set. Once a cheap and tasty substitute for meat, today chikanda is seen as part of Zambia's culinary heritage. "We thought consumption would fall as people grew more prosperous, but the opposite has happened," says de Boer. Chikanda is now available in towns and cities across the country, sold by the slice in markets and as a "taste of Africa" in big-city restaurants. It's even available from supermarkets.

The surge in demand for these products has seen the small-scale collection of tubers transformed into a flourishing commercial

It takes up to 4000 orchid tubers to make a kilo of flour



ABDOLBASSET GHORBANI

trade, with organised networks of middlemen offering cash for tubers. The results have been catastrophic for orchids. "Collectors dig up orchids with a spade or a hoe, take the fresh tuber and throw away the plant," says botanist Abdolbaset Ghorbani at Uppsala University.

The scale of the harvest is staggering. It can take between 1000 and 4000 tubers to produce a kilo of salep. In Turkey, an estimated 30 tonnes of tubers from 38 species are harvested each year. With many orchids becoming rare or locally extinct, traders have been forced to look to neighbouring Iran for supplies. Ghorbani estimated that between 7 and 11 million orchids belonging to 19 species and subspecies were collected in northern Iran in 2013, the majority exported to Turkey. In Greece, a revival of interest coupled with the economic crisis has also prompted an increase in the tuber harvest. "Across the whole region, collection is increasing, and it will continue to increase unless something is done to stop it or all the tubers are gone," says Ghorbani.

The picture is much the same in Zambia, where collectors target as many as 80 different orchids, mostly species of *Disa*, *Habenaria* and *Satyrium*, which have large, starch-packed tubers. "Landowners report that orchid-rich grasslands are now almost bare," says Ruth Bone, a conservationist at the Royal Botanic Gardens at Kew, London. Increasing demand has led to trade from Angola, the Democratic Republic of the Congo, Mozambique and Malawi. But the greatest traffic in tubers is from Tanzania; an estimated 3.5 million of them were brought illegally across the border in 2014. Harvesting from Tanzania's Southern Highlands threatens as many as 85 species, some found nowhere else. Collection is rife even inside Kitulo National Park, which was set up specifically to protect orchids.

How then to prevent these plants being eaten to extinction? There are already laws protecting orchids, and under the Convention on International Trade in Endangered Species (CITES), exports and imports of any orchid or orchid product is illegal without a permit. But with limited resources, enforcement is tough. And attempts to clamp down on illegal trade are hampered by difficulties in identification.

Tubers have few distinguishing features – fewer still once dried and sliced. So what are the chances of proving a sack of flour or a slice of chikanda contains orchids, let alone what species? The answer is that they are surprisingly good, de Boer and his

"In Turkey, some 30 tonnes of tubers from 38 species are harvested each year"



HEMIS / ALAMY STOCK PHOTO

colleagues at Uppsala are finding. "We are able to isolate orchid DNA from powdered tubers and we've even got it from samples of ice cream, hot drinks and chikanda," says Ghorbani. Using a technique known as DNA metabarcoding, the team can sequence all the DNA fragments in a sample and compare them against the DNA of known orchids until they find a match. "Barcode can show which species are most commonly collected, and help track those species in trade," says Ghorbani. "DNA sequencing also makes it possible to pick out small genetic differences that help to identify the region they came from, which can help to identify the places where we need to focus conservation efforts."

Alternative ingredients

Another strategy is to reduce demand. Some of the qualities attributed to orchids can be replicated with other ingredients. Glucomannan, the polysaccharide responsible for dondurma's stretchiness and high melting point, and chikanda's spongy texture, can be replaced by synthetic glucomannan or guar gum. Where orchid flour is used as a thickening agent, rice flour, cornstarch and flours made from other roots serve just as well. And although the distinctive earthy flavour of orchid tubers is harder to recreate, other flavours usually overwhelm it. Hot drinks made from salep are highly spiced with cinnamon and cardamom, while chikanda tastes more of peanuts and is generally served with chilli sauce.

In Turkey, ice cream manufacturers already use more of these substitutes than genuine salep. But the cachet attached to products made from the "real thing" continues to drive demand for wild tubers. In Zambia, enthusiasm for real chikanda may be even

more deep-rooted. "We don't know much about its cultural significance," says Bone. "There might be more to its popularity than its texture and flavour."

Commercial production would also ease the pressure on wild orchids. But it's not easy. There have been some attempts to cultivate salep orchids by tissue culture, although none has yet reached the market. In Zambia, a different approach is needed. In and around the country's orchid grasslands, as many as

FUNGAL PARTNERS

Orchids tend to be pernickety about the conditions they need, which is why many are rare and also why propagating them is such a challenge. But that's not all. In the wild, orchids need the services of fungi, which trigger germination and nourish seedlings until they are able to support themselves by photosynthesis.

During a project to conserve rare orchids from Madagascar, Kaz Yokoya of the Royal Botanic Gardens at Kew, London, discovered that some orchids form partnerships with a wide range of different fungi, while others team up with a single type. He also found that some orchids need different fungi at different stages of development.

Yokoya is now isolating and identifying fungi in the roots of various orchid species that are used in the traditional Zambian dish called chikanda. That done, he will test every combination of orchid and fungus to see which form mutually beneficial partnerships. This knowledge is essential for the future success of village orchid gardens (see main story). "You can propagate orchids without fungi and plant them out and they will grow," says Yokoya, "but they won't establish a population unless the fungus is present."

Interest in traditional foods, like dondurma ice cream in Turkey, is driving demand for orchid tubers

80 per cent of households supplement their income by collecting tubers, a job done mostly by women and children. Shrinking orchid populations mean they must travel farther and take greater risks, crossing national borders and trespassing into reserves. "These are some of the world's poorest people and we need to protect their livelihoods if we are to protect the orchids," says Bone.

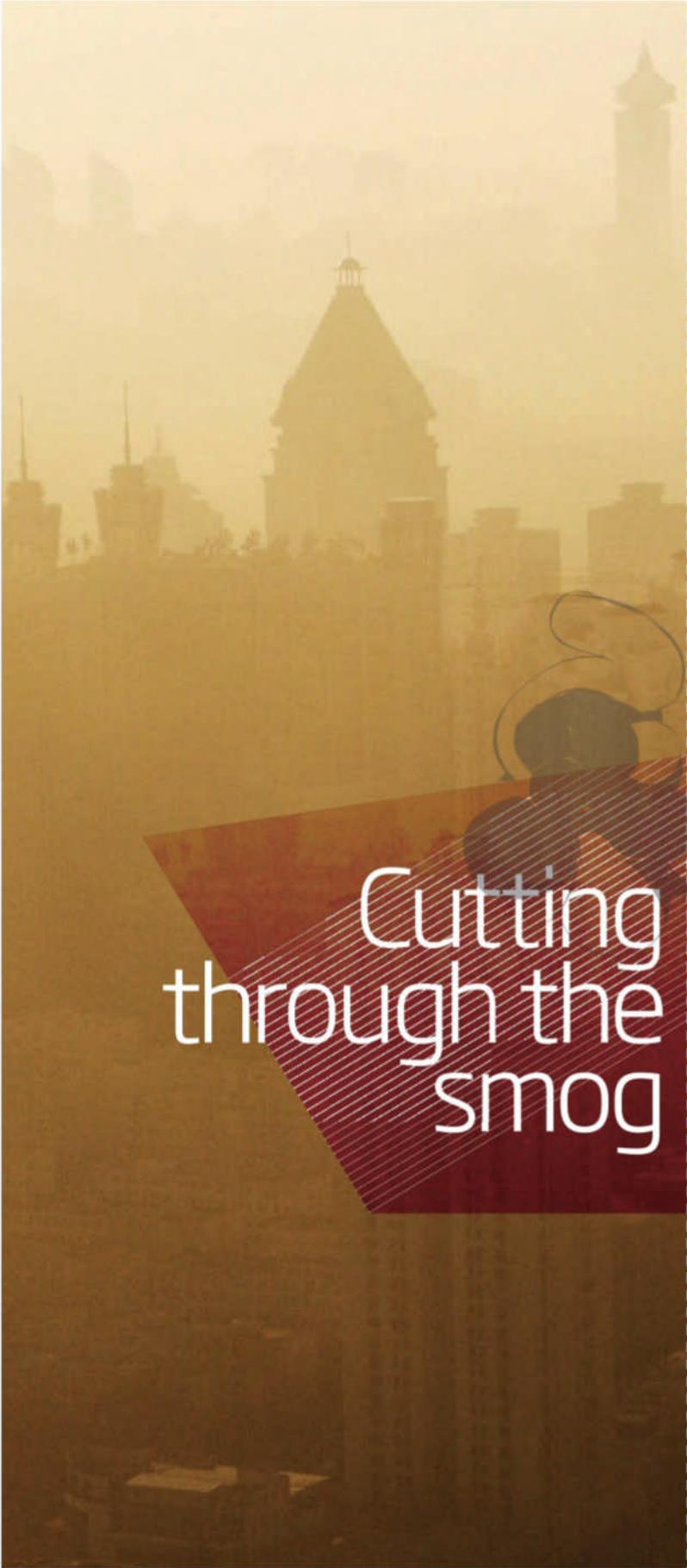
Last summer, Bone and a team from Zambia, Uppsala, South Africa and the UK began a pioneering project to conserve chikanda orchids. They are tracking the tuber trade with the help of DNA barcoding, alerting consumers to the origins of their favourite snack and the damage done by the harvest, and developing conservation programmes with local people. But the project's ultimate goal is to turn gatherers into gardeners. "By growing their own orchid crop, women would have a more reliable source of income without risking their safety or taking their children out of school," says Bone.

Raising orchids is not as simple as growing potatoes, however. Commercial growers mass-produce plantlets from tissue cultures spiked with the nutrients they need to grow. To culture chikanda orchids, you first have to find out what they need (see "Fungal partners", left). To make the task more difficult, every species has its own requirements.

Kew's Jonathan Kendon and colleagues at Copperbelt University in Kitwe, Zambia, are working on what it takes to persuade seeds from wild orchids to grow in culture and how to turn lab-raised seedlings into tough, healthy plants. If some species prove better suited to village gardens than others – because they are easy to grow or are quick to produce a crop – the university nurseries will grow them in bulk for distribution. Eventually, though, local communities will need to be self-sufficient, collecting their own seeds, propagating them in low-tech nurseries and rearing tubers in a wide range of much tougher conditions. "It's a big leap from university nursery to village garden," says Kendon. But the potential pay-off is huge.

The newly acquired expertise will be invaluable not just in Zambia but wherever orchids are being harvested from the wild. If local people grow local orchids, everyone wins: consumers get the real thing, and rural families can make extra money from the flowers as well as the tubers. The biggest winners, though, will be the orchids. ■

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Cutting through the smog



Is air pollution in the West really as bad as it seems?
Nic Fleming investigates

THE bad news on bad air seems to get worse by the day. Air pollution causes one in nine early deaths, according to the World Health Organization. It is a major health concern in both rich and poor countries. In the US, it is estimated to be behind 200,000 untimely deaths each year. The UK, where the annual death toll is reported to be in the tens of thousands, was one of five countries threatened with legal action for repeatedly breaching the European Union's nitrogen dioxide limits earlier this year.

But all is not as it seems. Quantifying the impacts of polluted air is a more complicated and uncertain business than many headlines would suggest. The growing pressure for politicians to take action raises important questions. Is air pollution really getting worse? How bad is it? And what should be done about it?

Q. IS AIR POLLUTION REALLY GETTING WORSE?

In rapidly growing economies, the amount of pollution in the air is undeniably rising, but it is a different story in most rich countries. Take, for instance, PM_{2.5} particulates – believed to account for most of the health burden of air pollution (see “What’s in the air”, page 37). Worldwide, average concentrations rose 11 per cent between 1990 and 2015, according to a report by the Health Effects Institute and the Institute for Health Metrics and Evaluation, both in the US. The trend reflects large increases in India, Bangladesh and China: concentrations in the US, the European Union, Canada and Australia fell over the same period (see graph, right).

Media reports on air pollution in the West frequently don’t mention the major improvements made since the 1950s. But the rate of progress has slowed and Europe, including the UK, is showing no signs of meeting WHO guidelines for clean air any time soon. “The data from monitoring sites across western Europe shows PM_{2.5} levels are going down,” says Gavin Shaddick of the University of Bath, UK, who develops air pollution models for the WHO. “But they are not falling quickly enough.”

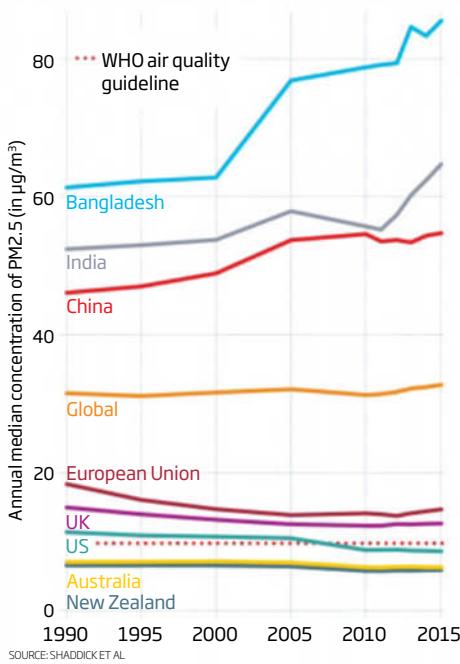
Q. IS IT KILLING ME?

Figuring out how many people die because of pollution is a tricky business. Widely quoted numbers vary enormously and mask a great deal of complexity, uncertainty and misunderstanding (see “How many deaths”, opposite).

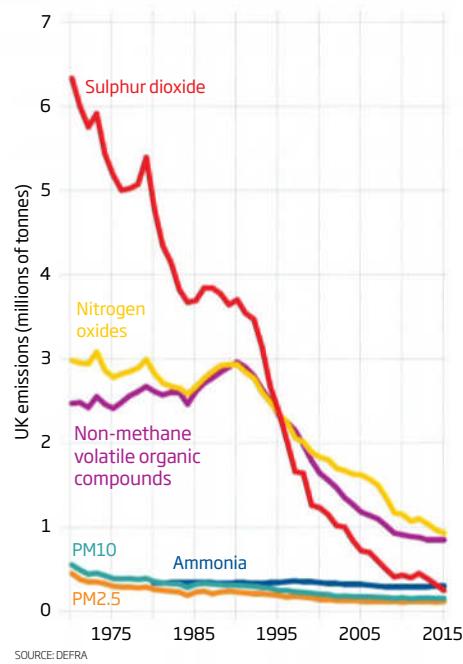
First, it’s important to realise that nobody drops dead from walking down a polluted street. Rather, air pollution aggravates other things that are likely to kill you, cutting months off your life. The UK Committee on the Medical Effects of Air Pollutants (COMEAP) estimates that anthropogenic PM_{2.5}, released at 2008 levels, would shorten the average person’s lifespan by six months. By totting up all this lost life, the group worked out that outdoor air pollution would cause the equivalent of almost 29,000 deaths. COMEAP stressed that PM_{2.5} was shortening the lives of many more people rather than causing that number of deaths. Yet the media often reports that air pollution kills 29,000 a year in the UK.

COMEAP’s calculations were based on a number of assumptions. One question is

Air pollution levels vary widely by country



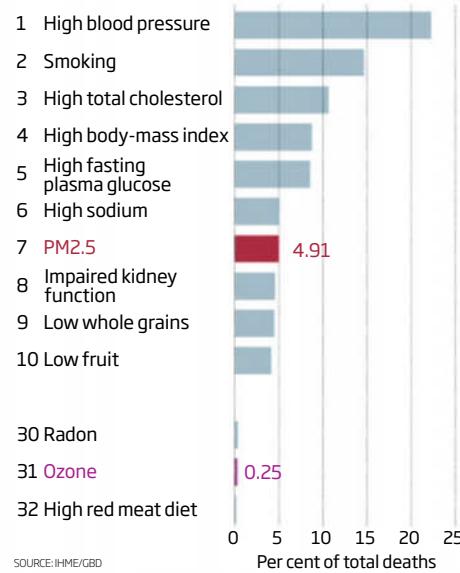
In the UK, emissions are dropping



Cycle or drive?

Cycle, and take the back streets. It’s win-win: less pollution and more exercise. The same goes for walking. (see “Leave the car at home”, page 39)

Air pollution ranks in the top 10 mortality risks in Europe



whether all PM_{2.5} has the same health effects regardless of its source. “I think everybody who studies this believes there are differences,” says Michael Brauer of the University of British Columbia. “But it’s been hard to consistently demonstrate what they are.”

A further complication comes from the probable overlap between the effects of PM_{2.5} and NO₂ – the two most harmful pollutants. “My personal belief is that the NO₂ epidemiology is largely a signal due to ultra-fine particles, which would already have been largely counted within PM_{2.5},” says Jon Ayres at the University of Birmingham, UK, who was chair of COMEAP until 2011.

International estimates of mortality due to air pollution have also varied dramatically, but for Brauer, quibbling over numbers misses the point. “The actual number makes for a nice headline, but it’s probably not that important,” he says. “What is important is that we can see how air pollution compares to other major risks such as smoking, and so can prioritise policy and funding.”



NICOLASASFOURI/AF/GETTY IMAGES



HOW MANY UK DEATHS?

Estimates of the annual deaths attributable to air pollution vary wildly

In 2010, the Committee on the Medical Effects of Air Pollutants estimated 29,000 annual UK deaths were attributable to particulates less than 2.5 µm across (PM2.5), assuming no safe limit

Uncertainties meant there was a 75 per cent chance the number could be anything between 5000 and 55,000 deaths

In 2012, the World Health Organization put the figure at 16,400, assuming a safe limit of 7 µg/m³

44,750-52,500 is the UK government estimate of deaths from PM2.5 and NO₂

40,000 is often quoted in the press as the number of deaths from air pollution. It comes from the UK Royal College of Physicians and Royal College of Paediatrics and Child Health, which estimate that PM2.5 and NO₂ cause between 30,000 and 50,000 deaths a year

Q. HOW DOES POLLUTION AFFECT MY HEALTH?

We still have a lot to learn about how outdoor air pollution causes ill health, not least because its effects on our bodies are likely to be multiple, complex and interdependent. Studies suggest PM2.5, NO₂ and ozone mess with oxidation reactions in the lungs and elsewhere in the body. This triggers inflammation and can cause tissue damage.

Most studies look for correlations between increased exposure to pollution and the prevalence of diseases. For instance, a 2014 study that followed some 100,000 people in five European countries for more than 11 years found that a 5µg/m³ increase in annual average PM2.5 exposure was associated with a 13 per cent increase in either heart attacks or unstable angina. Another study found the same increases in PM2.5 were associated with an 18 per cent increase in the risk of developing lung cancer.

There is also a well-established association between pollution and respiratory and pulmonary diseases, and stroke. A study published in January found that people living within 50 metres of a major road were 7 per cent more likely to develop dementia than those who lived 300 metres or more away. >

WHAT'S IN THE AIR

Particulate matter (PM)

Comes from: power plants, factories, gas cookers, industry, volcanoes, dust storms, forest fires, car exhaust.

Health effects: Any dust or droplet less than 10 micrometres (µm) across (called PM10) can penetrate deep into your lungs. Those smaller than 2.5 µm (PM2.5) are the most damaging air pollutants. They include ultra-fine particles, which are smaller than 0.1 µm. Long-term exposure to PM2.5 can impair lung and heart function and increase mortality, especially among those at higher risk of heart disease and stroke.

Nitrogen oxides (NO_x)

Comes from: road transport – especially diesel engines – as well as indoor heating and power stations.

Health effects: NO₂ is assumed to be the second most harmful pollutant after PM2.5. Exposure can trigger respiratory problems. In lab studies, volunteers given extra NO₂ exhibit inflammatory responses. However, long-term effects are unclear.

Ground-level ozone (O₃)

Comes from: reactions between other chemicals including NO_x and volatile organic compounds, especially on warm, sunny days.

Health effects: ozone can cause wheezing, shortness of breath, inflamed and damaged airways, a range of lung diseases, exacerbated asthma. Children, elderly people and those who are most active are at greatest risk. O₃ is a powerful oxidant, so damages cells and tissues.

Sulphur dioxide (SO₂)

Comes from: burning fossil fuels, especially coal. As a result, levels have dropped significantly in the West where natural gas has largely replaced coal.

Health effects: irritated airways and eyes, breathing problems, heart and circulation problems. Those with asthma and other respiratory conditions are at greatest risk. SO₂ can form sulphates that become PM2.5, and it causes acid rain.

Ammonia (NH₃)

Comes from: decomposing organic matter, livestock and fertilisers.

Health effects: At the concentrations that it is present in the air, NH₃ is unlikely to harm human health. Its main effect is to acidify the soil.

Other research has linked air pollution with diabetes, kidney diseases, Alzheimer's, premature births and mental illness.

There is also growing evidence of effects on child development. A 2004 study found that 18-year-old Californians who had been exposed to $28\mu\text{g}/\text{m}^3$ of PM_{2.5} per year for eight years, on average, were 4.9 times more likely to have reduced lung function than those exposed to an average of $5\mu\text{g}/\text{m}^3$. Researchers found delayed cognitive development in children in Barcelona who went to school in polluted areas.

A new US-UK-Chinese collaboration, led by Frank Kelly of King's College London, should offer a more precise understanding of the links between pollution and ill health. The study will give 120 Beijing residents and 120 people living in an outlying village portable pollutant monitors. It will then compare exposures with health data taken from urine and blood samples to help understand what pollution does to our bodies.

"Moving from just estimating people's exposure to actually measuring it and linking that to biological response markers is a major step forward," says Kelly.

Q. WHAT CAN WE DO ABOUT IT?

"Unlike finding a cure for cancer, we know how to tackle this problem because we've done it before," says Michael Brauer of the University of British Columbia. "The new laws introduced in the UK in the wake of 1952 [the pea-souper smog that killed 12,000 Londoners] and the way California has set standards to force industry to innovate and become cleaner point the way."

Still, solutions evade us. In the West, transport is the main cause for concern. Per capita car ownership roughly doubled between 1970 and 2012 in most of North America, western Europe, Australia and New Zealand. Cities have tried to keep cars off the road in several ways. Paris only allows vehicles with odd or even licence plate numbers on certain days. Freiberg in Germany has focused on providing cheap, efficient public transport. London and Stockholm have introduced congestion charges.

Evaluating these schemes is a challenge, because you would need to isolate their impact on pollution from other factors that might have also changed pollution levels. The best available evidence suggests many major efforts to reduce pollution from traffic have either failed or had little measurable effect.

SAM EDWARDS/PLAINPICTURE



Inside or outside of pavements?

That's a tricky one. Some studies show you get a lot less pollution just by moving a couple metres away from cars, but how the wind interacts with buildings can change everything.

Some road space rationing schemes have had perverse knock-on effects. According to some reports, people in Mexico and Beijing have started buying second vehicles with different licence plates to get around restrictions. Often the second car will be cheap and more polluting.

Charges or fines for taking larger, more polluting vehicles inside low-emission zones may be no better. There are more than 200 of these zones in Europe. But a 2015 evaluation of the London LEZ, the largest in the world, found it had no impact on levels of pollutants or related respiratory and allergy problems in children. The study authors speculated this was because of a delay in the introduction of tougher European standards for light goods vehicles and an increase in the proportion of diesel cars, encouraged by tax incentives. The results mirrored those in five Dutch cities,

where LEZs had little effect on traffic-related pollution levels. A 2011 assessment of London's congestion charge scheme also found no compelling evidence that pollution had fallen two years after it was introduced.

Copenhagen and Amsterdam lead the world in getting their inhabitants to ditch their cars by providing better cycling infrastructure, but other governments are failing to put their money where their mouths are. The UK government last year announced ambitious plans to double cycling journeys by 2025, reverse the decline in walking, reduce cycling fatalities and increase the proportion of children walking to school. The £316 million it has dedicated to achieving these goals over five years in England outside London is dwarfed by the £15 billion budget for major road improvements over the same period.

In the end, outside highly centralised,

Car or bus?

Bus. Studies suggest you inhale less pollution in a bus than inside a car (see "Leave the car at home", below).

authoritarian states, there is only so much governments can do. Individuals also need to realise the pollutants they breathe are produced when they drive short distances, fail to insulate their homes which would reduce heating bills, or buy intensively farmed meat, which produces a lot of NO_x.

Figuring out what you can do to make the most impact will depend on where you live. A European Union funded project, ClairCity is customising pollution models to help individuals in various cities to identify behaviours that will have the maximum impact in these locations. "Ultimately, we control our own behaviour," says Gavin Shaddick of the University of Bath, UK. "The tipping point will come when communities, societies and groups of people decide to do something about it."

Q. FIVE WAYS TO PROTECT YOURSELF AND YOUR FAMILY

1. Leave the car at home

Many drivers think windows protect them from the pollution they are generating. They are wrong, mostly. A 2012 study of commuters in Barcelona found that car passengers in busy traffic were exposed to 30 per cent more carbon dioxide than cyclists or pedestrians who can move faster along the same route, 25 times more carbon monoxide, and between two and three times more PM2.5 and ultra-fine particles. One reason may be that the air intake on most cars is at the front, right behind the exhaust pipe of the vehicle in front, says Shaddick.

There's a catch. Although they were exposed to less pollution, the active commuters inhaled more of it. Overall, bus commuters inhaled the least.

Some studies come to different conclusions. Outcomes vary with traffic speed, vehicle and fuel type, and the weather. "There is no one answer," says Ben Barratt of King's College London. "In slow-moving congested traffic, you will be more exposed than in free-flowing traffic. But the exercise benefits of walking and cycling generally outweigh any negatives."

2. Escape to the country, or a side street

Sometimes the simplest solutions are most effective. In this case, that means getting away from the source. Concentrations of NO_x and PM2.5 from car engines fall exponentially over the first few metres from the exhaust. "Moving from a congested road to a quieter street makes a big difference because you are much farther away and there are buildings in between you and the source," says Barratt.

Levels of NO₂, carbon monoxide and particulate matter are higher in towns and cities because of traffic. Country dwellers are less likely to suffer associated health risks, but ozone levels are on average higher in rural settings. Other pollutants can be just as elevated in the countryside as they are in urban environments. But overall, you are better off living in country lanes.

3. Wear a face mask

If you're shopping for a face mask, look for one with an N95 rating. It has been certified by the US National Institute for Occupational Safety and Health as filtering out 95 per cent of airborne particles larger than 0.3 µm. Many dust masks will fit this bill. Lab tests show that cotton handkerchiefs block just 28 per cent of particles from a diesel exhaust engine, and the simple cloth masks that tie behind the head won't help much more. Cycling masks vary from 55 to 85 per cent effectiveness. One study suggests that those with exhalation valves may work better. Surgical masks are surprisingly good: they can filter 80 per cent of particles in the lab. The results might not be replicated on the street though.

Masks won't keep out gases like NO₂ and SO₂ unless they have special components like charcoal filters. Some masks may help keep your blood pressure low. "If you have symptoms that worsen in polluted environments, a mask could be a sensible precaution," says Barratt. The key point in all cases is fit: all bets are off if a mask doesn't perfectly follow the contours of your face.

4. Give pushchairs the push

Children are at greater risk from pollution because their lungs and brains are still developing. Most vehicles release their

exhaust fumes somewhere between 30 and 60 centimetres from the ground.

"Being at exhaust level is bound to give you a higher exposure," says atmospheric scientist Rob MacKenzie at the University of Birmingham, UK. One 2009 study found that infants in prams were exposed to twice as much particulate matter from diesel exhaust as the adults accompanying them. Yet research published in February 2017, found no difference between PM2.5 concentrations for babies in buggies and for adults pushing them, but did identify busy intersections and bus stops as pollution hotspots. The lead author of that study, Prashant Kumar of the University of Surrey, UK, suggests parents use pram covers, especially near busy traffic and intersections.

5. Get some fresh air

Air filters in most modern vehicles are designed to block large particles like dust and pollen, but are unlikely to capture all fine soot. Gases such as NO_x and ultra-fine particles will get through. Tests have shown that switching to a vehicle's recirculation mode can reduce ultra-fine particles by around 90 per cent, but will push up carbon monoxide levels.

Although some of their claims have been questioned, car manufacturers are increasingly including higher performance filters. Tesla says its high efficiency particulate air filter can reduce exposure to PM2.5 from very high to negligible. Air purifiers for buildings are becoming commonplace in China. Such devices can work well on sealed commercial buildings and potentially flats, but are less effective in leaky houses. ■

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PLAINPICTURE/ALEKSANDAR ZAAR



Eye on the tiger

Two tantalising sightings have got **Bill Laurance** on the hunt for Australia's most famous extinct animal

THIS thing has taken on a life of its own," Bill Laurance tells me over a glitchy Skype connection from a fieldwork site in Borneo. I'm not surprised, but I don't say anything. What do you expect when you're one of the world's most respected conservation biologists, and you suddenly announce that you're going in search of thylacines?

Laurance is not averse to publicity, but he is not one for stunts. A professor at James Cook University in Queensland, Australia, his day job is to document the wanton destruction of the natural world by hunting, logging, climate change and the rest. "I'm repeatedly accused of being a depressing speaker because of the topics I talk about – habitat destruction, biodiversity loss and all that stuff," he says. But sometimes something falls into your lap that you just can't resist. For Laurance, an American living in Australia, it turns out to be the Tasmanian tiger.

Once the world's largest marsupial predator, thylacines have long exerted a strong tug on the imagination – and the conscience. They lived all over Australia until about 4000 years ago, when they were wiped off the mainland, probably as a result of competition from newly arrived dingoes. They persisted on Tasmania, but the last known animal died in a zoo in Hobart in 1936, just 59 days after the Tasmanian government passed legal

protection to halt an extinction for which it was largely responsible. For the previous 100 years, European settlers had subjected thylacines to remorseless persecution. With a government bounty on offer, sheep farmers shot, trapped and poisoned the animals in their thousands. The last wild thylacine was shot dead in 1930.

But sightings continued across Australia. Almost all have been dismissed as hoaxes or cases of mistaken identity: foxes, dingoes, feral pigs or even the rear ends of wallabies. But a few are less easy to discount.

One of those sightings was made by Brian Hobbs, a tourism operator and experienced bushman from Queensland. One night in 1983, while camping on the Cape York peninsula in the state's far north, he twice saw a group of four dog-like animals with thick tails, short hair and stripes on their sides. "I'd never seen anything like them before, ever," he later said.

Hobbs kept it to himself for 34 years. But earlier this year, prompted by a report on his local radio station about the possibility of de-extincting thylacines, he contacted the station. They recorded an interview in which he offered to reveal the location to anyone serious who wanted to investigate.

Which is where Laurance enters the story. As a frequent voice on the station, he was asked to comment on Hobbs's account. "After hearing it

PROFILE

Bill Laurance is distinguished research professor at James Cook University in Queensland, Australia

I thought, huh... and so I phoned him. I didn't lead him at all; I just tried to get him to tell me what he had seen. I kept asking open-ended questions – describe this, describe this. It's a very plausible observation. Of course, he could have seen pictures of thylacines and internalised them, and it was in the 1980s, which counts against him. But he said he sat on it because he didn't want to be seen as a kook."

One key detail was the eyes. If you shine a torch on an animal's face at night, the colour and shape of the reflected "eyeshine" is usually enough for an experienced zoologist to identify the species. Hobbs described the eyes as shining red. "That's not common," says Laurance. "On that basis, we're able to discount dingoes, dogs and feral pigs. Those were the things we really wanted to rule out. Foxes





don't occur up there because it's too warm."

A second witness soon came forward with a detailed description of a sighting in the same undisclosed – area, around the same time. "He said he saw it quite clearly, in bright moonlight and at close range, including the stripes. This guy is a really serious park ranger, a long-time employee of the Queensland national parks service. So we had two credible observers, with stuff you can't make up."

By coincidence, Laurance was organising a field survey in Cape York. The peninsula is biologically interesting but poorly documented, with many endangered and declining species, some shared with nearby New Guinea and found nowhere else in Australia.

"I asked, somewhat tongue in cheek, whether anybody wanted to incorporate a search for

the thylacine into their work." His colleague Sandra Abell put her hand up. The university issued a press release announcing the search, and after that, says Laurance, "it went batshit".

Not being all that familiar with thylacines, I decided to look one up. The Grant Museum of Zoology at University College London has three specimens, including the complete skeleton of an immature female. It is about the size and shape of a whippet. The museum also has a mature male skull that suggests a full-grown thylacine would be substantially bigger.

I asked museum manager and Australian mammals expert Jack Ashby whether it was credible for a predator that size to live undetected on Cape York. He weighed his answer carefully. "It's not impossible. It's not particularly well-explored and there aren't

many roads. Sightings are usually easy to dismiss, but the only ones I've ever thought sound slightly different are from Cape York. I'm not saying I think there are thylacines, but it's the only place where I'd say... maybe."

And for Laurance, maybe is enough. "We don't actually think there's a strong probability that thylacines still exist on Cape York, but it would be errant not to at least explore the possibility," he says.

And so Abell and her team are preparing to set 50 camera traps in the region of the sightings, 1 to 2 kilometres apart, baited with a scent known to be attractive to predators. Every couple of weeks they'll check the cameras, download the data – and hope. By the time the rainy season returns in November and makes the cape impassable, it is possible that the thylacine will be back from the dead.

"There are many cases where rare species persist in remote places"

Well, maybe. "We regard this as a remote possibility, 1 to 2 per cent. But there are many cases where rare species persist in remote places. Shy wildlife in small numbers can be very, very hard to see," Laurance says.

But is it really worth it? Most people who search for thylacines are regarded as cranks. I put it to Laurance that he's taking a huge risk. All that hard scientific work, all that effort arguing for conservation policies... could he end up being discredited as that guy who searches for Tassie tigers?

Laurance points out that he has been defending the mainstream end of cryptobiology for many years, not least because it pays off. Numerous "Lazarus" species have been rediscovered in recent years, including the Javan elephant, Cuban solenodon and terror skink.

But he nonetheless acknowledges the risk. "I've been trying to damp down some of the wilder speculation, and I'm hoping my scientific reputation will be intact by the time it has finished. I don't need an asterisk attached to my name saying 'partly unhinged'.

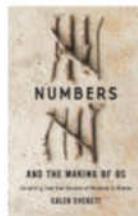
"But it's not the Loch Ness monster. It's not the yeti. Those are over on the other side. This is a creature that definitely occurred in this area and disappeared. If we get evidence – and that's a gigantic if – it would be a real sign of hope. And that's very important in the world we live in." ■

By Graham Lawton

From zeroes to heroes

Did culture give us our way with numbers, asks **Vyvyan Evans**

Numbers and the Making of Us: Counting and the course of human cultures by Caleb Everett, Harvard University Press



IMAGINE a world without numbers. Time and space would lose their meaning: telling time and counting the passing days, months and years would become impossible. Our ability to use numbers is essential for functioning in our quotidian here and now, from scheduling meetings to reading timetables and paying for groceries at the supermarket.

But in a fascinating new book, *Numbers and the Making of Us*, linguistic anthropologist Caleb Everett argues that number is a recent cultural invention, deeply tied to our linguistic smarts. Moreover, he likens it to a “flint stone that ignited the human timeline”. Not only does number make it possible to perceive quantities in the world, it has, he claims, “led to the advent of agriculture and writing, and indirectly to the technologies that flowed from the latter two”.

While on the face of it this is bold, heady stuff, the claim seems counterintuitive. After all, numbers are all around us. An octopus has eight legs, while you and I have two. Surely, that’s just an objective fact? And language reflects the reality of numbered quantities. We have a broad array of words for numbers: I can count from zero to 10, and beyond, using number words, and there are other quantifiers such as “few”, “several”, “many”, “a couple”, and so on. Moreover, the grammatical

system of English is numerical through and through, with plural words like “coats” denoting a distinction between one versus more than one.

English is by no means unusual, with other languages making more sophisticated grammatical distinctions. In the Austronesian language Moluccan, for example, there is a grammatical tier intermediate between one and more than one: a so-called “trial” category denoting exactly three items.

But there are enough languages that lack number. These range from unrelated spoken languages, such as Pirahā and Mundurukú – both indigenous to different remote parts of Amazonia – to non-spoken languages, such as Nicaraguan Sign Language.

Users of these languages, it turns out, cannot reliably count more than three items. According to Everett, quantity is not something that you or I can

“According to Everett, quantity is not something you can perceive without the help of language”

reliably perceive without the help of language: having number words makes it possible to see a world of number.

Moreover, this startling claim has been experimentally verified. For instance, when asked to show how many dots are printed on a card by counting the same number of fingers, Mundurukú speakers cannot go beyond three. This, Everett argues, has nothing to do with any cognitive deficit or the fact that they belong to a pre-industrial society. The decisive factor appears to be

the absence of number words.

Recent research reveals that the human brain has, broadly, two number systems. The first is an approximate sense: human infants are born able to distinguish between, for instance, 8 and 16. This enables only fuzzy maths, in which we can determine that one group is larger than the other, rather than the numbers of entities in each. The other system is an exact number sense, but one that only works up to 3. We can distinguish between 1, 2 and 3, precisely.

Unifying abilities

So how do we manage to identify larger quantities? Everett’s answer is: verbal number. Numerate cultures can count and perceive quantities precisely because number words – language – unite these two innate mathematical abilities. His evidence is indigenous such as the Pirahā: anumeric cultures lack “the means of unifying these two genetically endowed capacities”.

The invention of the linguistic means to convey number, a cultural tool, makes it possible to bootstrap our genetic endowment, enhancing and changing how we perceive our world. While anumeric peoples struggle to differentiate quantities greater than three, with the advent of verbal number, we can parcel up space and time in far greater detail.

The central claim of the book is that far from our being born with the ability to precisely identify quantities, number is a cultural achievement; it is facilitated by language rather than being innate. Here Everett raises the





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Do we think differently if our language has number words?

spectre of the classic distinction between nature and nurture, although the welter of evidence relating to anumeric peoples strongly supports the cultural-developmental, anti-nativist view.

Nevertheless, there are drawbacks to Everett's arguments. A nativist sceptic may still argue that correlation is not causation. Everett describes ingenious behavioural experiments with anumeric groups, but they only show that an anumeric language correlates with counting problems. Crucially, this doesn't establish that the absence of verbal number causes the counting deficit. To do that, we will have to go beyond clever field-based tasks to examine what's going on in the brain.

Second, the significance of number is perhaps over-egged in terms of human cultural and cognitive development – a tempting thing to do, perhaps, when this is the focus of an entire book. Everett's claim is that how we perceive time and space is, in part, made possible because of the existence of number.

Inevitably, things are more complex. Space and time are the foundational domains of human experience. And time, at the level of neurological processing, is arguably the cognitive glue that makes perception possible in the first place. For example, both being able to perceive a sequence of events and recognising iterations of events are fundamentally temporal abilities.

In short, temporal abilities underpin number sequences and the ability to add up, which are fundamental to number. This suggests that it may in fact be our temporal smarts that make number systems possible, rather than vice versa.

Finally, Everett invokes divergent quantification abilities across anumeric versus numerate cultures as evidence for linguistic

relativity: grammatical differences across languages cause their speakers to perceive the world differently.

This principle suggests that language can lead to cognitive restructuring in the minds of their speakers. To demonstrate this, however, we need to show that different number systems in different languages lead to divergent cognitive behaviour.

While Everett makes a powerful case for the cognitive restructuring of numerate versus anumeric minds, the jury is still out on the effects of number systems across all languages.

But these are minor quibbles. The breadth of research Everett covers is impressive, and allows him to develop a narrative that is

"Everett makes a powerful case for the cognitive restructuring of numerate versus anumeric minds"

both global and compelling. He is as much at home describing the niceties of experimental work in cognitive science as he is discussing arcane tribal rituals and the technical details of grammar.

The book is an exemplar of the best kind of academic writing: well researched, while written in a sufficiently engaging way to appeal to many educated lay readers. It is often poignant, and makes a virtue of the author's experiences with some of the indigenous peoples he describes, based on a childhood following his missionary parents – in particular his famous father, Daniel Everett – into the Amazon jungle.

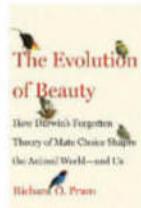
In many ways, *Numbers* is eye-opening, even eye-popping. And it makes a powerful case for language, as a cultural invention, being central to the making of us. ■

Vyvyan Evans is a language and communication consultant. His latest book is *The Emoji Code*

Useless beauty

Do we need to revisit one of Darwin's big ideas, asks **Adrian Barnett**

The Evolution of Beauty: How Darwin's forgotten theory of mate choice shapes the animal world – and us by Richard O. Prum, Doubleday



"THE sight of a feather in a peacock's tail... makes me sick," wrote Darwin, worrying about how structures we consider beautiful might come to exist in nature. The view nowadays is that ornaments such as the peacock's stunning train, the splendid plumes of birds of paradise, bowerbirds' love nests, deer antlers, fins on guppies and just about everything to do with the mandarin goby are indications of male quality.

In such species, females choose males with features that indicate resistance to parasites (shapes go wonky, colours go flat if a male isn't immunologically buff) or skill at foraging (antlers need lots of calcium, bows lots of time).

But in other cases, the evolutionary handicap principle applies, and the fact it's hard to stay alive while possessing a huge or brightly coloured attraction becomes the reason for the visual pizzazz. And when this process occasionally goes a bit mad, and ever bigger or brasher becomes synonymous with ever better, then the object of female fixation undergoes runaway selection until physiology or predation steps in to set limits.

What unites these explanations is that they are all generally credited to Darwin and his book

It is hard work sporting exuberant plumage like this bird of paradise

The Descent of Man, and Selection in Relation to Sex. Here, biologists say, having set out his adaptationist stall in *On the Origin of Species*, Darwin proposed female choice as the driving force behind much of the animal world's visual exuberance.

And then along comes Richard Prum to tell you there's more to it than that. Prum is an ornithology professor at Yale University and a world authority on manakins, a group of sparrow-sized birds whose dazzling males perform mate-attracting gymnastics on branches in the understories of Central and South American forests. Years of watching the males carry on until they nearly

collapsed convinced him that much of the selection is linked to nothing except a female love of beauty itself, that the only force pushing things forward is female appreciation. This, he says, has nothing to do with functionality: it is pure aesthetic evolution, with "the potential to evolve arbitrary and useless beauty".

As Prum recounts, this idea has not found the greatest favour in academic circles. But, as he makes plain, he's not alone. Once again, it seems Darwin got there first,

"Female love of beauty has got nothing to do with functionality: it is pure aesthetic evolution"



writing in *Descent* that "the most refined beauty may serve as a sexual charm, and for no other purpose". The problem is, it seems, that we all think we know Darwin. In fact, few of us go back to the original, instead taking for granted what other people say he said. In this case, it seems to have created a bit of validation by wish fulfilment: Darwin's views on sexual selection, Prum says, have been "laundered, re-tailored and cleaned-up for ideological purity".

Clearly Prum is, to put it mildly, bucking a trend, even if he is in good company. But his career has been diverse and full, so that reading this fascinating book, we learn about the patterning of dinosaur feathers, consider the evolutionary basis of the human female orgasm, the tyranny of academic patriarchy, and the corkscrewed enormity of a duck's penis. Combining this with in-depth study of how science selects the ideas it approves of and fine writing about fieldwork results in a rich, absorbing text.

Not all of Prum's analogies or counterexamples worked for me, and the attacks on the prevailing view often seemed strident. However, the book deserves to be read, just as the idea of pure beauty evolving unallied to selection and unalloyed by function deserves to be examined and considered. You may not end up agreeing with the reason for its existence, but the dance Prum performs to convince you to take him on as an intellectual partner is beautiful and deserves to be appreciated on its own terms. ■

NICK GARRETT/NATUREPL.COM

Adrian Barnett is a rainforest ecologist at Brazil's National Institute of Amazonian Research in Manaus



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EDITOR'S PICK**Let's investigate levels of brain structure**

*From Chris deSilva,
Dianella, Western Australia*

Caroline Williams reports work on the pattern of links in the brain – the “connectome” – that finds “holes” in the network (25 March, p 28). But I find the work interesting for other reasons.

First, I should say that the graph theory she describes doesn’t care

about the arrangement of things in normal space. Like topology, it treats space as stretchy. All that matters in graph theory is the pattern of connections between nodes. So if there are “holes” in the connectome in the everyday sense of physical space that connections skirt around, they’re not interesting to graph theory. It is no surprise that the graphs have loops. What is of interest is which neurons connect, or fail to connect, to which.

So I think the most significant implication of this research is that the connectome is organised in a hierarchical manner, with dense local clusters of neurons – “cliques” – connected to other clusters in different parts of the brain. It is possible that there are more than two levels of hierarchy. This should be the subject of further research.

**Morn came and went
and brought no day**

From Bryn Glover, Kirkby Malzeard, North Yorkshire, UK
Arguing that talk of a “localised” nuclear conflict is ignorant and dangerous, you refer to “nuclear winter” (22 April, p 5). During the cold war, some people used to carry around the 1816 poem *Darkness* by Lord Byron. It refers to the “year without a summer” that followed the eruption of the volcano Tambora. It tells us that any nuclear winter could have far worse consequences. Maybe we should resume the poem-carrying habit.

*From Bob Cory,
Altrincham, Cheshire, UK*
Clearly a nuclear exchange in North Korea or anywhere else is to be deplored, but I doubt that “millions of tonnes of smoke

would gush into the stratosphere, resulting in a nuclear winter”. There have been more than 500 atmospheric nuclear tests with a total yield in excess of 500,000 kilotons. North Korea’s stock is unlikely to exceed 50 kilotons.

The editor writes:

■ A model in which two states each use 50 small (15-kiloton) warheads predicts 5 billion tonnes of black carbon from firestorms entering the stratosphere (doi.org/b55g). Atmospheric tests don’t ignite cities. North Korea doesn’t have an arsenal that big, but both the US and China do.

**There is good reason
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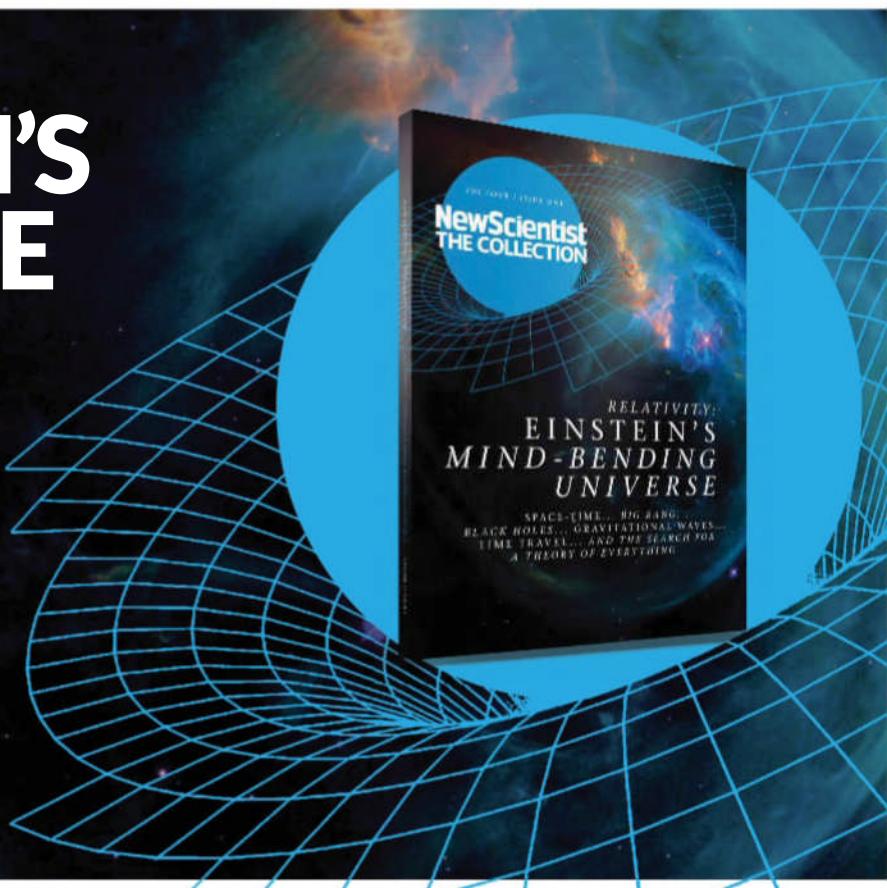
From Guy Inchbald, Upton-upon-Severn, Worcestershire, UK
Graham Lawton laudably aims the searchlight of reason impartially

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f "Can those who believe in 'alternative facts' on climate change find an alternative planet?"

Maggie McPherson responds to deniers who mocked the March for Science on social media (29 April, p 4)

at both atheism and religion (15 April, p 32). It is almost a dogma among certain atheists that the world's atrocities are largely due to religion. In reply, religious apologists single out vicious atheists – and atheists argue these weren't real atheists, but were heavily influenced by the religious beliefs around them.

Time and again, "to the glory of God" was merely the excuse of the politician seeking justification, just as "historical inevitability" became the excuse of many a 20th-century warmonger.

When one chimp group attacks another, it is rarely suggested that religion is involved.

*From Jan Willem Nienhuys,
Waalre, Netherlands*

Lawton mentions counterfactual beliefs being used to motivate behaviour. Anthropologists Pascal Boyer and Scott Atran have

studied not only the politically dominant religions, but also cults of ancestral spirits or sacred trees.

In their view, religions have, at their core, a counterintuitive and counterfactual idea that is taken seriously. Santa Claus, magic shows, Pythagoras' theorem, quantum physics and the telephone are counterintuitive ideas and thus fascinating, but those that are taken seriously are not counterfactual.

So the core of religion is worthless. How do shamans and priests stay in business? They dress it up with frills such as a ritual, a creation story or the pretence of being the fountain of goodness. If possible, they punish unbelievers.

*From Roger Redman,
Moorlinch, Somerset, UK*

I am sure that most rational unbelievers don't spend much

time agonising over their lack of interest in religion. They have better things to do than ask why a blasphemer has to be shot by a mere human. Surely an offended omnipotent being could turn them into a wastepaper bin or a pillar of salt – an effective deterrent, I should think.

*From Rod Munday,
Cardiff, UK*

Let us say that atheism is not a religion. Let us say it is a scientific theory. All atheists have to do is come up with some predictions. Then the theory can be tested by practical experiments.

*From Chrissy Philp,
Bath, UK*

I am an Everythingist. This is a religion I created for myself many years ago. It really stumps anyone who attempts to convert me, because my belief includes their

belief: I am already one of them.

Everythingism believes in "wonder". It values differences. It is scientific because it is open to learning, to discovering. It is in awe of this thing we are all part of, this "life living itself". It is not arrogant – there is so much we don't know. It is compassionate, as it includes everyone and everything. It is a religion because I believe in it. Everythingism is all-inclusive and non-exclusive. You can like it or not as you choose.

Distribute carbon tax as a citizens' dividend

From John Hindley,

Marlborough, Wiltshire, UK

Michael Le Page's article on carbon pricing and tariffs was very welcome (8 April, p 22). But an aspect it doesn't cover is the negative effects that carbon pricing could have on poverty ➤

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and economic growth. One way to counteract, and probably even outweigh, these is to redistribute revenues equally to citizens as a dividend.

This idea has been gaining ground in the US, even among Republican politicians and in spite of Trump's denialist rhetoric. It is promoted by the Citizens' Climate Lobby, an organisation started in the US, but also growing internationally.

Spare not of your free speech to spare my ears

*From Ben Haller,
Ithaca, New York, US*

Sally Adey observes that bot accounts sometimes drown out the voices of actual humans on Twitter, "effectively censoring speech without suppressing it" (1 April, p 25). Puzzlingly, she then jumps to a wholehearted defence of government-mandated censorship of "hate speech".

Wouldn't it make more sense to simply come up with solutions to the bot problem? There are many: introducing time-consuming procedures to certify that the

submitter of a post is human; charging a few pennies per post to discourage bots since the expected pay-off per post would be less than the charge; using human moderation; or crowdsourcing the elimination of bots through a "down-vote" mechanism.

The modern problem of "fake news" wouldn't fall into the category of "hate speech" to begin with and so wouldn't be solved by the censorship Adey proposes.

Those who oppose censorship don't "hide behind the old defence of free speech", as she puts it. They are committed to protecting free speech as one of the freedoms that is core to democracy, is a basic human right and is a freedom that authoritarians everywhere have always worked to undermine.

Are degrees of belief enough knowledge?

*From Gareth Williams,
Ross-on-Wye, Herefordshire, UK*
You discuss the problems of epistemology (1 April, p 32). Many can be avoided if we take the statement that we know

something and replace it with a degree of belief based upon all the available evidence. Degrees of belief can be modelled using probability theory and can be updated as we acquire new evidence using Bayes' theorem. Since your available evidence can be different from mine, our probabilities can be different too.

If I think it is about lunchtime and glance at a clock that says 12, then I will adopt a probability distribution function narrowly peaked around 12 o'clock. If I glance again a short while later and see the clock hasn't moved, I will revert to a much wider distribution of possible times, and infer a high probability that the clock is broken.

Quantum socks are a misplaced analogy

*From Chris Skillern,
San Diego, California, US*
Neither Stuart Clark (4 March, p 28) nor Brian Horton (Letters, 1 April) has demonstrated an understanding of the "weirdness" of quantum entanglement. The essence of some ultimately

observable attribute of a quantum particle, such as the "spin" of an electron, is that before it is "measured" or "observed", it is totally undefined.

It doesn't have a definite value, but exists in a superposition state of every value possible. So the analogy of two differently coloured socks is inapt.

The "sock" representing a particle before "measurement" can't only be any colour, it can be any of the infinite hues of any colour. The weirdness arises because no one understands how the second "unmeasured" entangled particle somehow "knows" the "measured" value of the first particle when there was insufficient time for any signal to pass between them.

The attribute of the second particle is also undefined, supposedly without a definite value, until it is "measured". Yet somehow when "measured", it always adopts a value that preserves conservation laws. That is quantum weirdness.

I breathe not thy name

*From Geoff Badley,
Hedge End, Hampshire, UK*
Leah Crane mentions the black hole Sagittarius A* (8 April, p 8). Can we ever say that aloud?

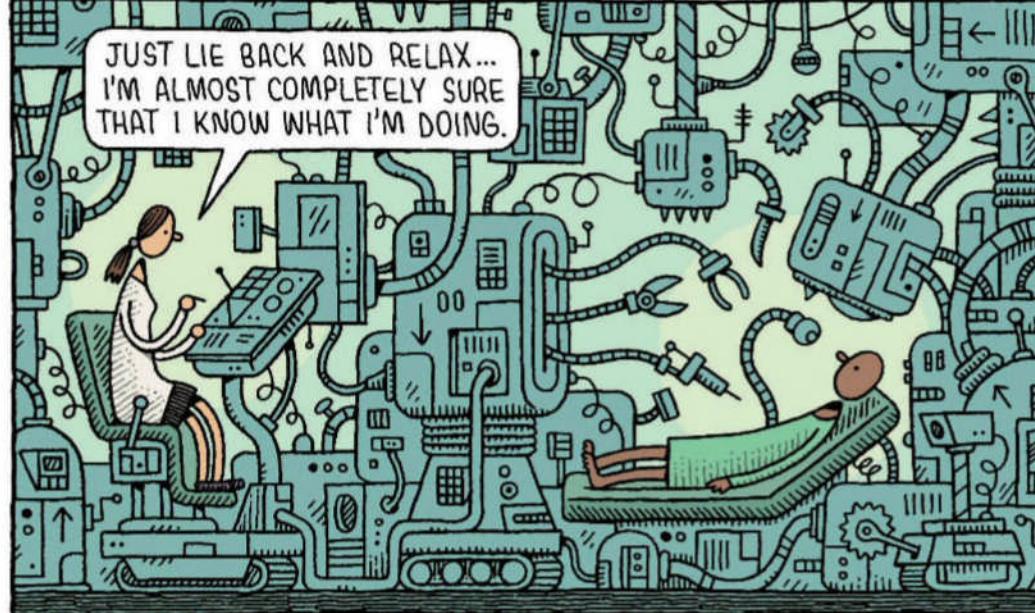
There was no footnote to the article, so, clearly, it's not "A asterisk". However, "A star" sounds equally wrong. This black hole at the centre of our galaxy swallows many stars, but it's not really a star itself.

There used to be gods, once, so mighty their names could never be mentioned. Perhaps A* is where they retired.

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TOM GAULD

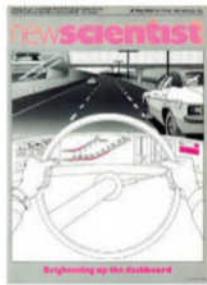


OLD SCIENTIST

What was *New Scientist* talking about in May's past?



KEN TOWER/ANU/REX/SHUTTERSTOCK



Was teletext the forerunner of the internet? Back in the day it seemed quite futuristic. For those who don't know, teletext allowed you to see pages of information on your TV. Even if it was just a couple of paragraphs of news or sports results, which it mostly was, you were plugged into what was to become cyberspace. In 1976 this new era had just dawned. Our

27 May issue announced that although the system was available on only 300 television sets in the UK, decoders to convert older sets would soon be on sale. We seemed rather pleased that they would come in at "no more than £200". That's closer to £1000 today, so you would have been better off waiting for somebody to invent smartphones.

Another socio-technological revolution was afoot in 1988. The 26 May issue of *New Scientist* reported on a spat between Philips and Discovision Associates over who was due the 3c royalty payable on the sale of every music CD. For those who don't know, people used to listen to music on a CD player. Tucked away in a paragraph near the end of the story came news of a major cultural shift. The stakes were high, we reported. The 3c on each disc represented a potential windfall because "in Japan and the US some shops no longer stock vinyl LPs and conventional gramophones". Those who don't know what a vinyl LP is – probably most readers who aren't DJs, audiophiles, retro aficionados or of a certain age – can Google it.

Then again, perhaps you won't find what you're looking for. In 2006 we noticed a new cyber-twist: some people didn't want to be found anywhere on the internet. In our 6 May issue we quoted an anonymous technocrat saying: "The thing now is to be untraceable. Make yourself ungoogleable." The growing trend even had a name – Myspacecide – named after the social networking site. Considering the declining fortunes of Myspace since 2006, it seems more than one person heeded the advice. And for those who don't know what Myspace is... **Mick O'Hare** ■

To delve more into the *New Scientist* archives, go to newscientist.com/article-type/old-scientist/

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LIQUID water, as you may recall from your school days, takes on the shape of the container in which it is placed. But that's not all it takes on, reports Anneliese O'Callaghan. She discovered TC Energy Design carafes, glass vases that, according to the Mesa Creative Arts website, use the "structural physics of Sacred Geometry" to restructure liquids placed within, enhancing the taste and improving their biological value.

Disguised as regular glass carafes, the containers are necessary because, we are told, "sending water through straight pipes and sharp, right angle bends at high pressure, filtering, distilling... robs water of its natural life force." These carafes restore the primordial memory of the water, which can then be transferred to your own body.

To borrow a phrase from luxury watchmaker Patek Philippe, you never actually consume a bellyful of water, you merely look after it for the next generation. We would prefer our

water stripped of any memories of where it has been. And ideally cleansed of *Cryptosporidium* and any other natural life force.

FURTHER to the Flat Earther's challenge to prove them wrong (15 April), Paul Rendell writes "I was on honeymoon in Kenya, near the equator, and saw the moon close to the horizon." Here, says Paul, it appeared at a totally new angle from the one he was used to.

Travelling from one pole to the other, anyone can see the moon turn through 180 degrees – almost as if they had traversed one side of a sphere, keeping their feet pointed to the centre at all times.

Flat Earthers, we're sure, have an esoteric explanation for this phenomenon: perhaps the moon rolls around the curved heavens like a coin in a fishbowl. Which makes us wonder, do Flat Earthers think all planets are flat, or just our own?

O2 tells Martin Dehnel-Wild: "Tariffs include unlimited texts. Text messages are charged at 15p per message thereafter." So they charge only for aleph-one texts beyond the infinite, he asks

PAUL MCDEVITT

A COMPANY run by British politician Andrew Haigh sells a health supplement that resembles industrial bleach, reports BuzzFeed. Haigh was made national organiser for Wales for the right-wing populist UK Independence Party in 2015. His company Vitalox sells "Aerobic Oxygen", an element that is said to be the key to treating everything from low energy levels to "bowl cancer".

The liquid appears to be similar to the infamous Miracle Mineral Solution, a sodium chlorite cure-all that the Food Standards Agency has issued more than one warning about.

While some might accuse UKIP of having a preoccupation with whiteness, it would be an unusual strategy for any party to encourage constituents to drink bleach.

RESPONDING to US senator Scott Wagner's theory that human body heat might be behind global warming (15 April), Ian Napier writes: "Someone once claimed that most body heat is lost through the head. Global warming has escalated as hats have gone out of fashion. Coincidence?" If only there were some way to arrest this situation – perhaps some heat-reflecting headgear made of a metallic foil-like material?

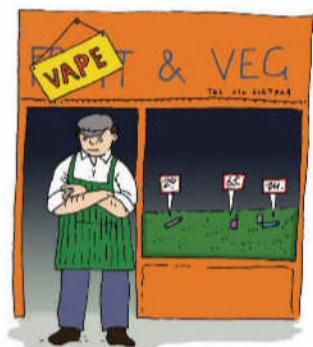
COME again? Tracy Kiss splashes into our collective consciousness again to exhort the medical benefits of human semen. The personal trainer told *The Sun* newspaper that she mixes a regular donation in with her breakfast smoothie, a daily practice she claims boosts her immune system, if somewhat challenging her dietary status as a vegan.

Previously, Kiss made headlines using the unusual ingredient in a face mask to treat rosacea, demonstrating that widespread media coverage is one of the few guaranteed effects of consuming sperm. Medics warn that ingesting semen poses a risk of contracting STIs, and has little nutritional value. Feedback notes that sperm has also been shown to cause dramatic weight gain, the effects of which can take 18 years to shake off.

PERHAPS wishing to revisit some late 90s mixtapes, Tony Lang found himself digging out an old Sony MiniDisc player and set about transferring the music to his hard drive. "The manual had an interesting section about connecting it to a computer," he says, "in which they recommend using a resistance-free cable."

"I'd love to comply," says Tony, "but even if I could afford the superconducting cables, the rest of my hi-fi is at room temperature, so keeping the cables at cryogenic temperatures could be a bit tricky."

A CASE of the vapours: a company set up in Beverly Hills introduces Californians to "the inhalable multivitamin". VitaminVapor is a sort of e-cigarette that claims to deliver essential B vitamins directly to the bloodstream.



Inhale Health says this is more efficient than oral supplements. We presume it also poses much less risk of scuffing the expensive dental work of any celebrity clients.

As California has already reduced meals into the pallid nutrient goop known as Soylent, Feedback wonders if the next stage will be to cram this in turn into an inhaler, a sort of Campbell's condensed soup for your vape stick.

You can send stories to Feedback by email at feedback@newscientist.com. Please include your home address. This week's and past Feedbacks can be seen on our website.

Whither weather?

Why don't we ever notice the weather in our dreams? A straw poll of about 20 friends suggests others have the same weather-free dream experience as me. So why is it such a rare feature?

■ Dreams tend to deal with matters of intimate and immediate personal concern. I suspect that people who regularly experience hazards presented by snow, flood and drought, and for whom they are relevant to survival, income or food, notice a great deal of unfavourable weather in their nightly programme.

So might anyone who is involved with events or professions that depend on weather, such as sporting fixtures, outdoor weddings or deep-sea fishing. For everyone else, however, weather is of little interest beyond small talk, so it rarely figures prominently in our nightly dreams.

*Jon Richfield
Somerset West, South Africa*

Morning compost

I routinely add coffee grounds and teabags to the compost that I put in my wormery. What effect, if any, would residual caffeine have on earthworms and other invertebrates?

■ We live in the country and have an aerobic sewage treatment system that depends on worms. Our suppliers advised us not to

put coffee grounds in because the worms don't like it. Since these animals are such a mission-critical component, we have scrupulously followed this advice.

A relative with a simple compost system – like that of your correspondent – reports that by gradually increasing the dose, he has got his worms to tolerate caffeine, but we still won't risk it with our sewage.

*Guy Cox
St Albans, New South Wales,
Australia*

Hot source

If nuclear waste is still so radioactive, why can't we continue to use it as an energy source?

■ Scientists and engineers have designed nuclear reactors that can burn waste. Of these, a molten salt reactor (MSR) is arguably the most promising option. These were first developed in the US after the second world war, with the aim of keeping strategic bombers airborne for weeks on end, but the project was mothballed.

The front runner among MSRs appears to be the liquid fluoride thorium reactor (LFTR), also known as a "lifter". After 300 years, the waste from a lifter is about 10,000 times less toxic than that from a conventional reactor. The relatively small amount of waste produced by LFTRs also requires a few hundred years of isolated storage, as opposed to the few hundred

thousand years for the waste generated by the uranium-plutonium fuel cycle of pressurised water reactors.

Lifters offer other significant advantages. Only 0.7 per cent of natural uranium is in the form of the fissile isotope uranium-235, so enrichment is required, whereas thorium is plentiful in Earth's crust and doesn't need enriching.

A lifter would operate at atmospheric pressure, doing away with the expensive containment buildings and pressure vessels typical of a conventional nuclear reactor. And in contrast to such reactors, meltdown is impossible in a lifter, partly because the fuel is already molten.

A crucial safety feature is a plug of salt at the bottom of the core, cooled by a fan to keep the salt below its freezing point. If there were a power cut or the temperature exceeded a critical value, this "freeze plug" would melt, allowing the molten liquid to fall into a "catch basin" built to safely contain it. Finally, lifters pose virtually zero risk of nuclear weapons proliferation.

There would be challenges in making lifters a commercial reality, but the investment would surely be worthwhile.

In common with all nuclear power stations, a lifter's greenhouse footprint would be virtually zero during the operational part of its life. But the technology trumps conventional nuclear because it is safer, produces little waste and poses no proliferation risk. In addition,

lifters can burn the waste from conventional reactors.

*Mike Follows
Sutton Coldfield, West Midlands, UK*

Time and tide

We know the moon used to be much closer to Earth. What kind of tides might there have been back then?

■ The force causing lunar tides is inversely proportional to the cube of the distance to the moon. So if the moon were twice as close, tides would be eight times higher. If it had once been only a tenth the distance, tides would have been 1000 times higher than those today, if there were seas back then.

Such giant tides would have a proportionally stronger effect on the moon in return, causing it to move away, and so eventually reducing the size of the tides.

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

This week's question

SPIN A YARN

All astronomical bodies, from moons and planets up to galaxies, spin and have orbits. Spin is also a key characteristic of subatomic particles. Yet in our human world, we are relatively static. Why is spin unimportant for us, but at other levels it is all-pervasive? How do the laws of physics make our biosphere so special?

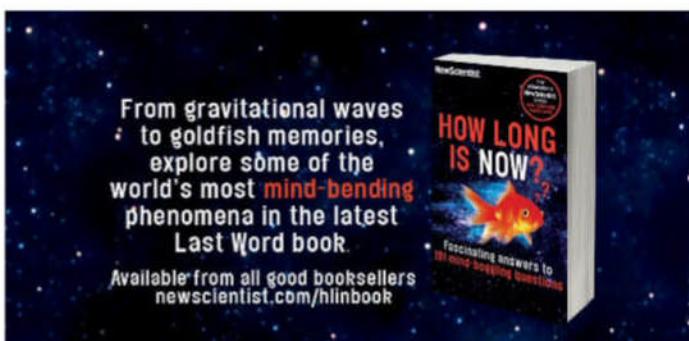
*Rob Francis
Bishop's Stortford, Herts, UK*

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