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WEEKLY 11 November 2017

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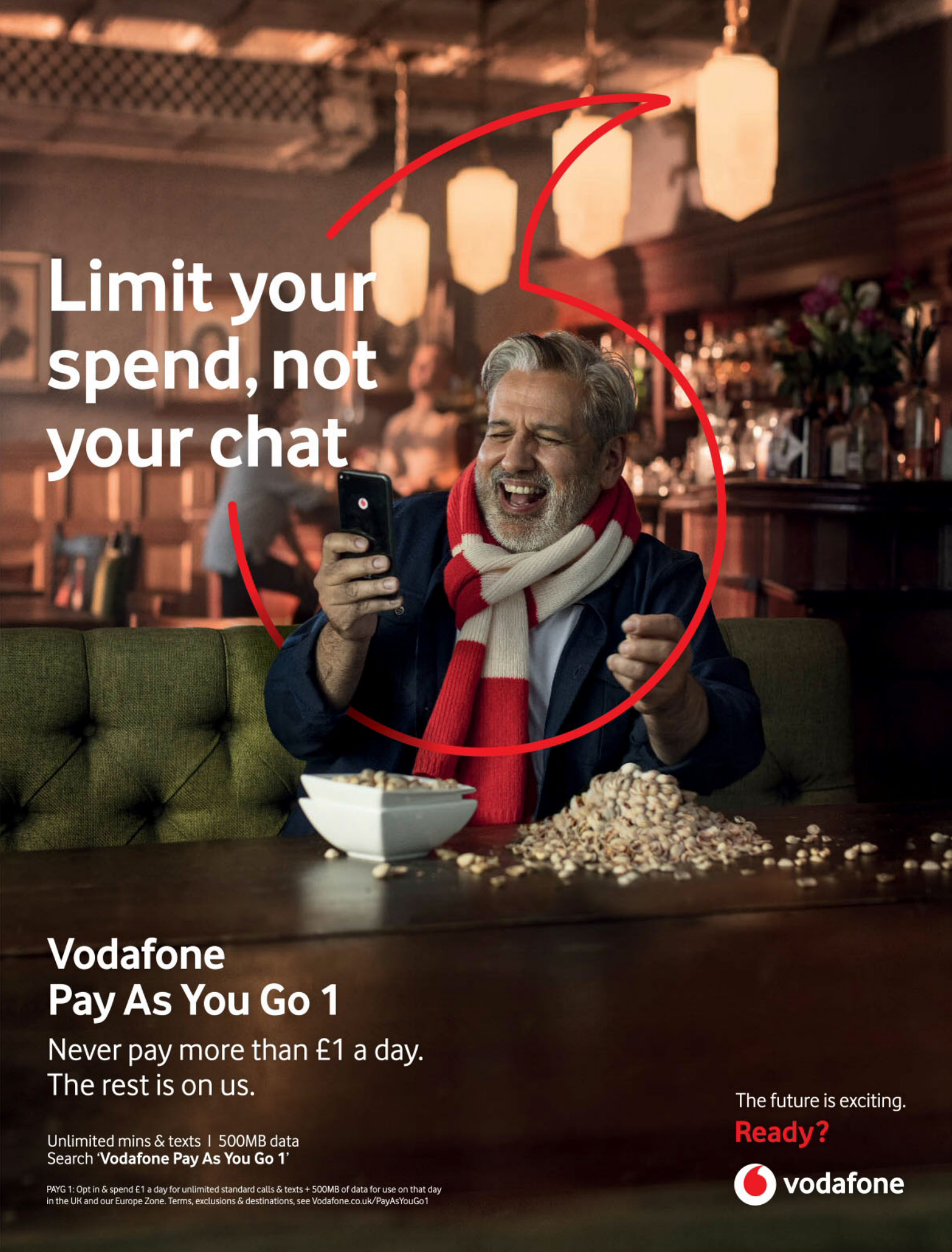
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Volume 236 No 3151

## On the cover

- 33 Fiddle factor**  
Why fidgeting is good for your brain
- 22 Fight for peace**  
Stop worrying and learn to love autonomous killer robots
- 9 Champagne supernova**  
The exploding star that keeps on popping its cork
- 8 Choke point**  
Ocean life faces an oxygen crisis
- 28 What if there are no laws of nature?**  
How nothingness can explain everything about reality
- Plus** Face blindness (16). New orangutan (14). Chronic fatigue (15). Digital detox (12). Language origins (42). Concussion cure (10). Abolish time zones! (25). Spider carnage (26)



**News** Oceans are set to choke **8**

## Leaders

- 5** New data laws will return power to who it belongs – you. We shouldn't distance ourselves from death

## News

- 6 UPFRONT** NASA's Deep Space Gateway. Cleaner air. Genetic test regulations eased
- 8 NEWS & TECHNOLOGY** Our oceans are set to suffocate. Gene therapy for fatal skin disease. Odd supernova dies again and again. Oxygen treatment for concussion. AI CSI. How human burials can save wildlife. Error-spotting quantum computers. Data detox. New orangutan discovered. Cake cutting trick could make US elections fairer. Virtual cocktails. Chronic fatigue syndrome cells lack energy. Face blindness. First mammals to live in daylight

- 19 IN BRIEF** Malarial mosquitoes eat more human blood. Enceladus has a hot, gritty core. Mites steal from spiders. Hidden pyramid chamber

## Analysis

- 22 Killer robots** Why armed machines could actually save lives
- 24 COMMENT** Releasing Stephen Hawking's PhD online is inspired. Let the dammed river sue
- 25 INSIGHT** It's time to end daylight saving time

## Features

- 28 Reality? It's what you make it**  
What if alternative facts are the laws of nature?
- 33 State of unrest** Why fidgeting can be good for you
- 36 Elements that rule the waves**  
The tiny forces that control ocean life
- 40 PEOPLE** Caitlin Doughty, the mortician who wants to fix our relationship with death

## Culture

- 42 The amazing conversation machine** The to and fro that happens when we talk is key to understanding language
- 44 Fetching figures** Mathematics, perception and beauty turn out to be close bedfellows

## Regulars

- 26 APERTURE**  
Spider dismembered in slo-mo
- 52 LETTERS**  
Focusing attention with eardrums
- 55 CROSSWORD**
- 56 FEEDBACK**  
Linguistic benefit of alcohol?
- 57 THE LAST WORD**  
Survival of the fittest

THE FORD MOTOR COMPANY PRESENTS

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PETER MACDIARMID/GETTY IMAGES FOR SOMERSET HOUSE

When 'agree' means agree

New data laws will hand power back to who it belongs - you

IF SOMEBODY from a shop you occasionally visited phoned and asked what you had been doing for the past month, would you tell them? Almost certainly not. Yet often without thinking we allow technology companies to track and collect such data. Everything from your movements to what you have been buying, watching, reading and listening to gets scooped up and filed, ostensibly to help tailor services to your needs and sell you things you want. But this data is so valuable that it is often sold to third parties.

None of this happens without your consent, but consent is often obtained by sleight-of-click, via

lengthy and impenetrable service agreements. The terms and conditions for an Amazon Kindle e-book reader, for example, are longer than many novels. Has any ordinary punter ever read them? Does Amazon actually expect us to? Both parties know it is easier to simply click "accept".

The cumulative result of this lackadaisical approach can be quite shocking. One of our journalists signed up for a "data detox", and was surprised at how much the tech giants knew about him (see page 12).

So should everyone detox? Probably. But in the real world, who can be bothered?

For citizens of the EU, the onus will soon change. From May, companies will have to be more transparent about their collection and use of data. Pre-ticked boxes will be banned; companies must seek specific consent to process and sell data. Those that break these rules will face hefty fines.

The change is long overdue. Even if EU citizens decide that they are happy to give their data away in return for useful services, at least that is a decision they have made themselves. The UK government has said it will keep the law after Brexit. That is a form of taking back control that we can all get behind. ■

Get closer to death

FEW people like to contemplate their own death, but knowledge of its inevitability has some surprising upsides. According to a school of thought called terror management theory, the desire to transcend death is the driving force of human civilisation. The "worm at the core of life" inspires people to create symphonies, build cathedrals, nurture their

children and seek knowledge. But if awareness of death is such a force for progress, we are not very good at harnessing it. In the West, we distance ourselves from death at every opportunity. Dying is medicalised and the aftermath stage-managed and sanitised (see page 40). The funeral industry must take much of the blame for this.

It could change its ways. Natural burials - which eschew embalming, expensive coffins and so on - are on the increase. There is also a growing movement to amalgamate burial plots into conservation areas, in which your own personal resting place is built into something bigger, lasting and environmentally beneficial (see page 11). Such burials promise to both demystify death and provide the lasting legacy that we so desire in life. Worms and all. ■



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Getting hotter

## Leaving heat behind

THIS year will be one of the three warmest on record, and the hottest ever without a temperature-boosting El Niño. However, a massive tree-planting programme could weaken the warming trend.

The temperature figures come from the latest state of the climate report from the World Meteorological Organization.

Climate negotiators are meeting in Bonn, Germany, this week to refine pledges to curb greenhouse gases that were made in Paris in 2015. They have much to ponder. The WMO says the first nine months of this year were 1.1°C warmer than pre-industrial levels. That means the world is more than two-thirds of the way to the limit of 1.5°C agreed in Paris.

In May, temperatures reached a

searing 54°C near the border of Pakistan and Iran, WMO secretary-general Petteri Taalas said in Bonn.

Climate scientists again said we must remove carbon dioxide from the air, as well as cutting our emissions.

Replanting forests could play a big role, the Woods Hole Research Center in Falmouth, Massachusetts, announced last week. Trees could store 100 billion tonnes of carbon – equivalent to roughly 10 years of fossil fuel emissions. To do so, we would need to end deforestation and encourage the regrowth of 500 million hectares of forests degraded by logging.

The plan “could help get the world at least a quarter of the way to limiting warming to 1.5°C”, according to Woods Hole director Philip Duffy.

## Mistaken identity

DIGITAL residents of Estonia have had their ID cards frozen due to a massive security flaw. The digital cards allowed both Estonian citizens and thousands of people from overseas who have

**“It was not a flaw of the Estonian ID card alone, but also included computer systems around the world”**

registered as e-residents to do things like access bank accounts or medical records, set up a company or vote online.

In September, security researchers discovered a bug in the system that might allow identify theft. Estonia hasn’t yet released full details of the flaw, but Kaspar Korjus, the managing director of the government’s e-residency programme, has said it is related to the cards’ chip.

“It was not a flaw of the Estonian ID card alone, but also included cards and computer systems around the world that use the chips by the same producer,” he wrote in a blog post.

“This brought the safety flaw to the attention of international cybercrime networks which had significant means to take advantage of the situation.”

As a result, Estonia has suspended nearly all ID cards issued in the past three years, until users update to a new security certificate. Adding to the problem, too many e-residents are trying to update their IDs at once, causing systems to crash. Despite the bug being known for two months, Estonian prime minister Jüri Ratas has said there have been no reported instances of ID theft.

## China’s cleaner air

CHINA is cleaning up its dire air, but there is a long way to go.

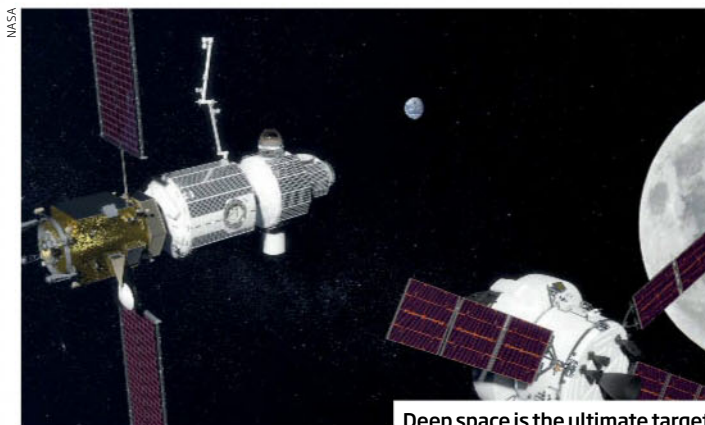
Beijing has awful smogs, driven by industrialisation. On Monday, levels of PM2.5 – particles 2.5 micrometres or less – hit 158 micrograms per cubic metre. The World Health Organization recommends no more than 10.

But despite this, an air pollution control plan China launched in 2013 seems to be working. A study using satellites to assess air pollution found annual average PM2.5 levels fell nationally by

21 per cent between 2013 and 2015, from 60.5 to 47.5 micrograms of PM2.5 per cubic metre (*Environmental Research Letters*, doi.org/cfxx). This may have cut associated deaths from heart attacks and strokes by 9 per cent.

“Our study marks the first estimate of the impact of this stringent action plan on pollution levels and mortality rates from 2013 to 2015,” says Yixuan Zheng of Tsinghua University in Beijing.

“It’s certainly an encouraging move in the right direction if correct,” says Frank Kelly of King’s College London.



Deep space is the ultimate target

## Space power play

NASA has given five companies contracts to find ways to power its proposed Deep Space Gateway – a crewed space station that is key to the agency’s plans for missions to Mars and beyond.

The contracts, totalling about \$2.4 million, went to Boeing, Lockheed Martin, Orbital ATK, Sierra Nevada Space Systems and Space Systems Loral. For the next four months, these companies will study how they



might develop a module to power and propel the Deep Space Gateway throughout its orbit around the moon.

The firms will attempt to design a system that uses solar electric propulsion – one that converts solar radiation to electricity and uses that to power space flight.

NASA plans to launch this bit of the gateway first. Other parts, such as the module in which astronauts will live, would join it later.

The idea is that the Deep Space Gateway may one day serve as a launch pad for missions much further afield.

## AI masters faces

THE results are in from the biggest computer face-recognition contest to date. The Face Recognition Prize Challenge tested two tasks: face verification and face search.

Face verification is what phone manufacturers such as Apple – whose iPhone X, out last week, can be unlocked with your face – are trying to master. The software must say whether a face matches that of a known person. Face search is the harder problem. It requires finding every image of a person in a database of maybe millions of images.

The winner of the contest's face-verification task was a company called Ntech whose FindFace product can match a person's face correctly 99.9 per cent of the time. The face-search task was won by Shanghai start-up Yitu Tech. Given one guess, its software can pick out the right face in a gallery of a million mugshots 80 per cent of the time – a big deal for police looking for suspects in hours of CCTV images.

The Intelligence Advanced Research Projects Activity and the National Institute of Standards and Technology, both in the US, have been running the challenge for the past six months. The results were announced last week.

## Gene tests ramp up

MANY more genetic tests could soon be on sale. The US Food and Drug Administration plans to loosen restrictions on selling direct-to-consumer genetic tests that predict health risks.

In April, the FDA approved the first direct-to-consumer genetic health risk product. Produced by 23andMe, it is designed to predict someone's risk of developing 10 diseases, including Alzheimer's.

The approval was criticised by some, given that people who have the main gene variant for Alzheimer's won't definitely

develop the condition, and that treatment options are limited.

Nevertheless, the FDA has decided more tests should follow. "In its consideration of genetic-health-risk tests, the FDA seeks to strike a balance that provides for an efficient pathway to bring these tests to consumers without sacrificing the assurances offered by FDA oversight," said Scott Gottlieb, FDA commissioner, in a statement on Monday.

From now on, some tests will be allowed straight on to the market, provided the company selling them has already been reviewed by the FDA for similar products.

## Screen less to cut cervical cancer

IT'S time to test less. Australia will soon become one of the first countries to introduce a cervical screening programme that will require fewer tests.

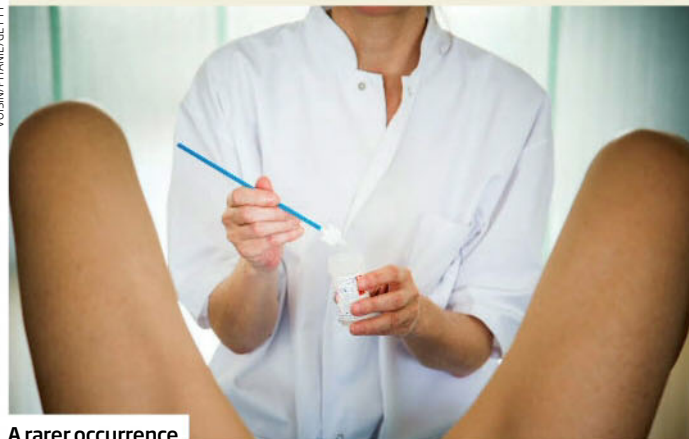
From next month, women will shift from a two-yearly Pap smear – also known as a Pap test – to a five-yearly human papillomavirus (HPV) test. The new test is expected to reduce cervical cancer risk by 22 per cent because it detects the disease at an earlier stage.

The Netherlands was the first country to switch to the HPV test, in January. The UK and New Zealand have said they will follow shortly and Italy and Sweden are considering the new test. Women in the US can pay to have an HPV test, but no organised

screening programme yet exists.

Unlike the Pap smear, which looks for abnormal changes in cervical cells that can lead to cancer, the HPV test detects the sexually transmitted papillomavirus that causes over 99 per cent of these abnormalities in the first place. This test can be done every five years because it takes many years – usually 10 or more – for HPV infections to cause cancer.

Some are worried that the switch in tests is a government cost-cutting measure, but Karen Canfell at the Cancer Council New South Wales charity in Australia says this isn't the case. "It's absolutely about introducing the latest technology and providing greater protection for women," she says.



A rarer occurrence

## 60 SECONDS

### Ozone rebound

The ozone hole above Antarctica has shrunk. Unstable clouds and warmer-than-average temperatures in the stratosphere helped reduce its size by 4 million square kilometres this year. The hole is now at its smallest since 1988, covering 19 million square kilometres or nearly twice the size of Europe.

### Strep B threat to infants

Infection with Group B *Streptococcus* may be responsible for 147,000 stillbirths and infant deaths annually. A global study of the bacteria – which usually causes no symptoms in infected adults – found that 21.7 million pregnant women carry it (*Clinical Infectious Diseases*, doi.org/cfxj).

### Truffle pushes north

Climate change had threatened supplies of one of the costliest foods, but there is some hope for foodies. Drought in southern Europe has cut yields of the Périgord black truffle, worth up to £1700 per kilogram. Now researchers have cultivated it for the first time in Wales, the farthest north ever.

### Blood loss lifesaver

A widely available drug massively reduces deaths from blood loss if given quickly. An analysis of 40,000 people with serious injuries or severe bleeding after childbirth found that immediate treatment with tranexamic acid reduces the risk of death by 70 per cent, but this benefit falls by 10 per cent for each 15-minute delay (*The Lancet*, DOI: 10.1016/S0140-6736(17)32455-8).

### Do ewe know who I am?

Sheep can learn to recognise mugshots of celebrities, even ones showing faces from unfamiliar angles. This suggests sheep can extrapolate 3D facial structure from a 2D picture, an ability only humans and monkeys had previously been shown to have (*Royal Society Open Science*, DOI: 10.1098/rsos.171228).

# Our oceans are set to suffocate

Climate change will devastate marine life by slashing oxygen in the sea

Chris Baraniuk

OUR actions today will change the world's oceans for thousands of years. That is the conclusion of a study simulating a little-discussed consequence of climate change: it could choke entire ecosystems by cutting oxygen levels in the ocean. In the most extreme scenarios, with the planet warming by almost 10°C, the oceans could be starved of oxygen for 8000 years.

Oxygen-poor waters have always existed in the sea, but in the last 50 years these "oxygen minimum zones" have grown. Climate change is one cause: the sea is warming, and warmer water can dissolve less of the gas.

Marine life is sensitive to these anoxic conditions, so a fall in oxygen of just a few per cent is enough to put enormous stress on ecosystems. The Late Devonian

extinction 360 million years ago, one of the biggest die-offs ever, unfolded largely in the oceans. It wiped out a fifth of all families in the tree of life, and anoxia was a key contributing factor.

Previous studies suggested the oceans will lose 7 per cent of their oxygen by 2100. But many effects of climate change, like rising seas, play out over millennia, and the same is true of deoxygenation.

Gianna Battaglia and Fortunat Joos at the University of Bern, Switzerland, simulated changes in ocean oxygen levels between now and the year 10,000. They looked at temperature stabilising at four different levels above pre-industrial conditions: 1.5°C (the key target set by the Paris Agreement), 1.9°C, 3.3°C and 9.2°C.

Average oxygen levels fell 6 per cent when warming met the Paris target, whereas 9°C of warming

led to a 40 per cent fall (*Earth System Dynamics*, doi.org/cfwq).

The study is awaiting peer review, but the implications are stark. "What is startling is the timescale over which they predict such dramatic reductions in oxygen," says John Spicer at the University of Plymouth, UK. "They are considerably shorter

**"The entire Bay of Bengal is on a knife-edge, and could flip over to a completely anoxic state"**

than anoxic events in the fossil record." The rapidity may make it even harder for animals to cope.

The findings agree with those of a 2009 simulation that concluded oxygen levels could fall 40 per cent (*Nature Geoscience*, doi.org/ngeo420). The new study uses a more detailed model, though,

allowing the team to look at different ecosystems. In the 1.5°C scenario, the biggest oxygen falls were in the depths, home to a profusion of life that we are only now discovering, from anglerfish to yeti crabs. This is now at risk.

Low oxygen is particularly hard on fast-swimming animals with correspondingly high metabolic rates, like tuna and sharks, says Alex Rogers at the University of Oxford. "We know that declining oxygen levels in the tropical Atlantic have already resulted in compression of habitat for fast-swimming large pelagic fish, such as marlin," he says.

The Bay of Bengal is particularly vulnerable, says Rogers. "That entire ocean basin is on a knife-edge, in terms of flipping over to a completely anoxic state," he says. "That's going to have a major impact on the marine fauna."

Ultimately, oxygen levels will recover – but not necessarily within the simulated time frame. In all the scenarios, Earth stopped warming in 2300, yet average oxygen fell for another 1000 years before bottoming out. Even then the dissolved gas still had to spread before things stabilised. "It takes several thousand years for the ocean to mix once through," says Battaglia.

With 1.5°C or 1.9°C of warming, oxygen levels eventually began to rise. But in the hotter scenarios, oceans remained depleted of oxygen by about 8 per cent.

This emphasises "the extreme sensitivity of oxygen levels to the climate emissions pathway we actually follow", says Rogers. While some impacts can't be avoided, the worst effects can. "I think that's a really critical message that has to go out to the people that have the power to change these things," he says. ■



The impact will be breathtaking

## In this section

- Oxygen treatment for concussion, page 10
- Data detox, page 12
- Why armed machines could actually save lives, page 22

# Gene therapy treats fatal skin condition

A BOY'S life has been saved by a gene therapy. The treatment replaced most of the 9-year-old's skin, correcting a mutation that causes a severe skin-blistering condition.

Epidermolysis bullosa is a rare disease in which the slightest touch - even dressing, for instance - can cause blisters and ulcers. Those with severe forms of the condition live in constant pain and tend to die young from infections or skin cancer.

The disease is caused by any one of several genetic mutations that lead to the outer layer of skin, the epidermis, lifting off from the layer beneath, sometimes in large patches. Now Michele De Luca at the University of Modena and Reggio Emilia in Italy has used gene therapy to help a boy with the condition who was close to death.

The then 7-year-old, from Syria, was admitted to a hospital in Germany in 2015 with widespread skin infections. Soon after, most of his skin came away. "The prognosis was very poor," says De Luca. "You simply can't live without your epidermis."

He and his team took a 4-centimetre-square patch of remaining skin and genetically altered the cells in a dish, correcting the mutation. They then grew the cells into sheets of skin, which were grafted onto the boy's body, covering around 80 per cent of him (*Nature*, DOI: 10.1038/nature24487).

Two years since treatment, the boy is now living a normal life, says De Luca. "I believe that the regenerated epidermis will last for a very long time, probably forever."

Marcel Jonkman of University Medical Center Groningen in the Netherlands says the biggest fear with this kind of gene therapy is that it might trigger cancer in the future.

Nevertheless, Jonkman has already referred his most severely affected patient to De Luca's team for the treatment. "It's the first hope for a partial cure for this terrible disease," he says. **Clare Wilson ■**



Slow-motion explosion

# Odd supernova keeps dying again and again

IT JUST keeps on banging. A dying star was caught mid-explosion in September 2014 and still isn't done. It has lasted 10 times longer than any other supernova of its type that we've seen.

Most supernovae brighten once as they explode and then fade into obscurity. But supernova iPTF14hls has had at least five peaks in brightness since Iair Arcavi at the University of California, Santa Barbara, and his colleagues began watching it (*Nature*, DOI: 10.1038/nature24030). It finally seems to be fading, he says.

"It refused to go gentle into that good night. It just kept on exploding and exploding," says Stan Woosley at the University of California, Santa Cruz. Evidence of one of the star's past explosions comes through in its light, which reveals a shell of material around the star.

The light from iPTF14hls has a signature identical to common type II-P supernovae, in which a massive star's core collapses and becomes a neutron star, with the resulting shock wave blowing away its hydrogen-rich outer

layers. Their bright flash lasts about 100 days before fading. This supernova seems to be acting a little like a type II-P in slow motion. After 600 days of exploding, it looks like a type II-P supernova after 60 days. It is also radiating several times more energy than any type II-P supernova we've ever seen.

Arcavi and his team are trying to find a mathematical model

**"It's too early to tell what it is, but it's definitely a weirdo. It's in the top five weirdest supernovae"**

that fits the star's behaviour, but none has matched up yet.

Woosley and Arcavi agree the most promising model is pulsational pair instability. The centres of very large stars - about 95 to 130 times the size of the sun - can reach over a billion degrees Celsius. At these temperatures, gamma rays in the core make pairs of electrons and their antimatter counterparts, positrons.

The radiation pressure from

gamma rays stops a star from collapsing under gravity. When the rays turn into particles, the star begins to fall in on itself, igniting an explosion that can blow off the star's outer layer but leave the rest intact to begin the process over again.

This could account for iPTF14hls's many explosions and for a possible pre-supernova eruption observed in the same spot in 1954. It would also result in multiple shells of expanding material like the one we've already seen.

But it's not an exact match. Pulsational pair instability supernovae don't produce the amount of energy or the mix of elements observed in iPTF14hls. "It's definitely in the top five weirdest supernovae," says Ashley Pagnotta at the College of Charleston in South Carolina. "It's too early to tell exactly what it is, but it's definitely a weirdo."

Because the star has exploded several times, it may not even fit the definition of a supernova. "You think of a supernova as a death of a star, and you think of death as something that only happens once. It's a very different kind of supernova that can die repeatedly," says Woosley. **Leah Crane ■**

# Pure oxygen can help concussion

Alice Klein

OXYGEN seems to repair brain damage years after concussion. The treatment may help the 5 per cent of people who experience long-term symptoms after sustaining a concussion.

Post-concussion syndrome can involve headaches, mood changes, sleep disturbances and cognitive problems. These symptoms arise because an impact to the head can damage tiny blood vessels in the brain, making it harder for oxygen to reach brain cells.

Shai Efrati at Tel Aviv University in Israel and his team have been investigating whether hyperbaric oxygen therapy can help. It involves sitting in a pressurised chamber and breathing 100 per cent oxygen to boost the amount in the blood and therefore the amount reaching the brain.

The team previously found that 40 1-hour hyperbaric oxygen sessions significantly improved the cognitive function and quality of life of 56 people with post-concussion syndrome following car accidents, falls, assaults or other non-military injuries that

occurred up to six years earlier.

Now, the researchers have used MRI before and after treatment to examine how it has this effect. In 15 people who sustained head injuries between six months and 27 years earlier, they found that

the treatment stimulated regrowth of blood vessels and nerve fibres in brain regions involved in information processing and memory by an average of about 5 and 7 per cent, respectively (*Frontiers in Human Neuroscience*, doi.org/cfwt). “Once the extra oxygen diffuses into damaged areas... the regenerative process can happen,” says Efrati.

However, the evidence is mixed. A large military trial in 2015 concluded hyperbaric

oxygen therapy is no better than a “sham” treatment for post-concussion syndrome. The study, by Lindell Weaver at the University of Utah and his colleagues, involved 72 military personnel with post-concussion. But the sham treatment also involved sitting in a pressurised chamber – albeit without extra oxygen – so could still have increased the amount of oxygen getting to the brain, says Efrati.

Weaver agrees this may have been the case. His team has just completed another study in 71 military personnel. This time, it found that hyperbaric oxygen therapy does work better than the same sham treatment. “I think the burden of evidence is starting to suggest there is a favourable effect, but there are still lots of unanswered questions,” he says.

It is estimated that one-quarter of military personnel who served in Afghanistan and Iraq sustained a head injury, and 244 concussions were recorded in American football players in the 2016 NFL season alone.

There is no FDA-approved treatment for post-concussion syndrome. Antidepressants and other medications can relieve symptoms but they don’t address the underlying causes, says Efrati. “We now have 20,000 people on our waiting list from all over the world,” he says. ■



Breathe deeply

# AI binges on TV crime shows to spot whodunnit

THE set-up in an episode of the TV show *CSI: Crime Scene Investigation* is nearly always the same. There is a body, some forensic evidence and one question: who did it? But the formula is gripping because the answer is rarely obvious. Cracking the case before the big reveal not only requires an ability to pay attention to the clues, but also to navigate plot twists and red herrings.

It is even harder for a computer to solve. But by binge watching *CSI* episodes, one artificial intelligence is learning how to be a sleuth.

Developed by Lea Frermann and her colleagues at the University of Edinburgh, UK, the AI watched 39 episodes of *CSI: Las Vegas*, involving 59 cases in all. Throughout each show, the AI had to say whenever it thought the perpetrator was on screen. The team tweaked the neural network’s output as it watched and guessed, then tested it on six previously unseen cases (arxiv.org/abs/1710.11601).

The AI didn’t beat human couch

detectives, but it was 60 per cent accurate in the last 10 minutes of each show. Humans were 85 per cent accurate. Bridging this gap would require the AI to reach another level of sophistication, however. “It doesn’t currently have a notion of people in the plot, it just predicts from each sentence,” says Frermann. “Learning a more structured representation of who is who would really help.”

Still, the hope is that such work will

**“The AI works more like humans. When we look for an answer in a document, we scan until we find it”**

make AIs better at understanding video or text. Existing systems can pass reading-comprehension tests, but only after processing an entire document. The *CSI*-trained AI constantly updates its answers as it receives more information. “This is more like humans,” says Frermann. “When we look for an answer to a question in a document, we don’t just blindly read the whole thing, we scan it until we find the answer.”

But AIs that can solve real crimes are some way off. “*CSI* episodes are 42 minutes long and normally only have a maximum of eight suspects,” says Frermann. Timothy Revell ■

## How burying loved ones can save wildlife

NEW “conservation burials” could help raise billions of dollars for wildlife.

Traditional burials contaminate soil with embalming chemicals and are also expensive. Natural burials instead use biodegradable coffins and maintain the surrounding landscape. Loved ones can find the site using GPS or natural landmarks.

The latest twist on natural burial is conservation burial. Tracts of land are turned into burial sites that double as refuges for endangered species.

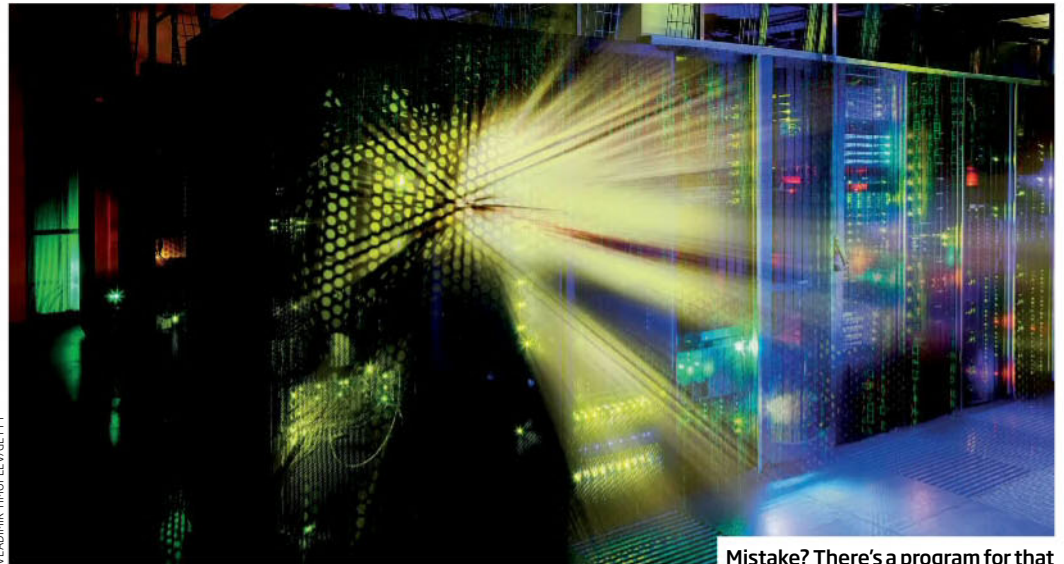
Ramsey Creek Preserve in South Carolina is one such site. Bodies are buried in a forest and planted over with endangered native species like crested coralroot orchids. The park also protects coyotes and black bears.

After the death of a close friend, mathematician Matthew Holden at the University of Queensland in Australia calculated that if the 1.2 million people buried traditionally in the US each year had natural burials instead, it would amount to spending \$3.8 billion on conservation (*Conservation Letters*, [doi.org/cfw6](https://doi.org/cfw6)). For comparison, reducing the risk to all threatened species on land would cost \$4 billion a year (*Science*, [doi.org/mg6](https://doi.org/mg6)).

Although there are now hundreds of natural burial sites in the US, UK and Australia, only a handful are dedicated conservation sites. There are currently seven in the US and two in the UK, with a handful due to open in Australia from 2018.

“People are looking to create some sort of tangible legacy, which is why we spend all this money on fancy coffins and tombstones,” says Holden. That money could instead provide a conservation legacy.

“The prime appeal of a natural burial is the return of the body to a living space that isn’t full of headstones and granite,” says Kevin Hartley at Earth Funerals, a not-for-profit in Australia. “Extending that - knowing it will lead to another acre of missing habitat being restored - it’s just lovely.” Alice Klein ■



VLADIMIR TIHOFEV/CGETTY

Mistake? There's a program for that

## The first step in trusting quantum computers

WHAT good is a fast computer if you can't trust it? Half a century of research on getting computers to work even when errors pop up makes our modern machines pretty reliable.

Unfortunately, the laws of quantum mechanics render all that research useless for quantum computers, the sheer complexity of which leaves them prone to errors. Now, we finally have the first quantum program that detects data corruption.

Two research groups – one from the University of Maryland and Georgia Tech and the other from IBM – have demonstrated the same quantum error-detecting program, albeit implemented with different hardware.

“Quantum computers can never be practical without error correction,” says Daniel Lidar at the University of Southern California. As we build bigger quantum computers, “errors add up to the point that they wash out the quantum effects... which obviates the need for the quantum computer,” says Lidar.

In classical computers, error detection and correction are done

with duplicated data – mistakes can be remedied by rebuilding the erroneous bits from uncorrupted parts of the machine.

But in quantum computers, it's impossible to duplicate quantum states without measuring them, and measurement causes loss of information. Without any means to back up intermediate results,

### “The more complex the computers, the more errors add up and wash out the quantum effects”

quantum computers cannot use classical error detection methods.

The solution the teams propose consists of five qubits, each of which can be in two states: one or zero. For every two qubits' worth of information, there are four possible combinations: zero-zero, zero-one, one-zero, and one-one.

The program uses four qubits to record these states, while the fifth qubit catches errors in the first four. For example, when four qubits represent a two-qubit state that should be zero-zero, it turns out that the four qubits

must either show four ones or four zeros, or an equal number of each digit. If there's an error in one qubit, the fifth qubit will note the uneven number of ones or zeros and change its state.

This verification system reduces the error rate to 0.1 per cent, compared with about 10 to 15 per cent potential error for quantum programs of about this size, says Norbert Linke of the University of Maryland (*Science Advances*, [doi.org/gcgjzb](https://doi.org/gcgjzb)). The IBM group shows similarly reduced error rates (*Physical Review Letters*, [doi.org/cfxq](https://doi.org/cfxq)).

However, there are limitations. For example, if one error changes the fifth qubit from zero to one, and a second changes it back to zero, then the program will not detect these two consecutive errors. Fortunately, experiments suggest such a scenario is rare.

Moreover, the program merely notes the existence of an error. Locating the error precisely requires more qubits. Linke says his group plans to scale up the experiment and implement an error-correction feature, which requires yet more qubits. Andrew Cross of IBM Watson Research Center says his group plans to first perfect the five-qubit program before moving on to error correction. Mark Kim ■

# My week-long digital data detox

Timothy Revell

EVEN as a technology journalist, it is hard not to switch off when someone starts preaching about personal data. I know, I know – we are telling our deepest secrets to mega-corporations for free, and they are using our innermost desires to sell us ads. But for most of us, much of the time, it is out of sight, out of mind.

Yet it shouldn't be – we should at least be on the ball about who we give data to. So to force myself to confront this head-on, I spent the last week doing a digital cleanse.

To help, I grabbed a data detox kit produced by the Tactical Technology Collective in Berlin and the Mozilla Foundation, a non-profit that promotes an open and free internet. The kit has been launched on the back of a London exhibition called The Glass Room that runs until 12 November.

The Glass Room looks like an Apple store, but is filled with exhibits designed to make abstract concerns about data more

tangible. One tracks my level of attention while I browse Facebook. Over 2 minutes, I give “1060 units of attention” and “50 units of scrolling”. I am told that on the minimum wage I could have earned £0.25 with the same effort. The average person spends nearly an hour on Facebook apps a day.

The data detox kit is meant to help you kick some of your worst phone habits. It consists of an instruction card for each of the eight days of the detox – and because it is made of paper, I can rest assured that it won't directly collect any of my personal data (you can also do this online).

“The data detox is about working out what is right for you,” says Jascha Kaykas-Wolff at Mozilla. “We need to choose what we share and what we don't.”

*Day 1 of the data detox: Escape the Google funhouse mirror*

The kit starts by asking me to identify the problem. Search for yourself online, it demands – not just with Google, but also a search

engine such as DuckDuckGo that doesn't use your data trail to tailor results to you. Why not switch to this permanently? And if you find any pictures of yourself, try a “reverse image” search using TinEye (tineye.com) to see where else that image turns up.

Luckily for me, I am as antisocial on social media as I am in real life, so there aren't that many pictures of me online. But if you do find something you are unhappy with, the kit has instructions on how to do something about it.

*Days 2 and 3: Who am I?*

I am tasked with finding out what Google and Facebook think they know about me. Using myactivity.google.com, I find out that Google is tracking where I am going, what I watch on YouTube and what I

**“The data detox is about what is right for you. We need to choose what we share and what we don't”**

have searched for, pumping it all back into operation data slurp. And because I have a phone that uses Google's operating system, Android, the company is also monitoring which apps I am using. I turn all the tracking off and perform a privacy check-up to

make sure everything is in order.

Using a neat tool called What Facebook Thinks You Like, I then find out what Facebook, um, thinks I like. The social media platform thinks I am into Science and New Scientist, which is fair enough. But it also thinks I am keen on Beer, Alcoholic Drinks, Beverages and Jägerbombs. I did do a lot of Facebooking in my student days, but come on Zuckerberg, everyone knows Jägerbombs are so 2008.

Surprisingly, there are also a lot of gambling-related categories, too. I don't gamble and am not interested in it either, so I find it odd that Facebook thinks I am a fan. I go through every page I have liked on Facebook and unlike it.

*Day 4: Watching my shrinking data footprint*

One of the slyer tactics harnessed by companies is using trackers. These sit all over the web and try to work out your surfing patterns by tracking your browser's digital footprint. The kit proposes installing a browser extension such as Privacy Badger, which blocks trackers. Another helpful tool called AdNauseam clicks on random ads as you browse to confuse firms that monitor you.

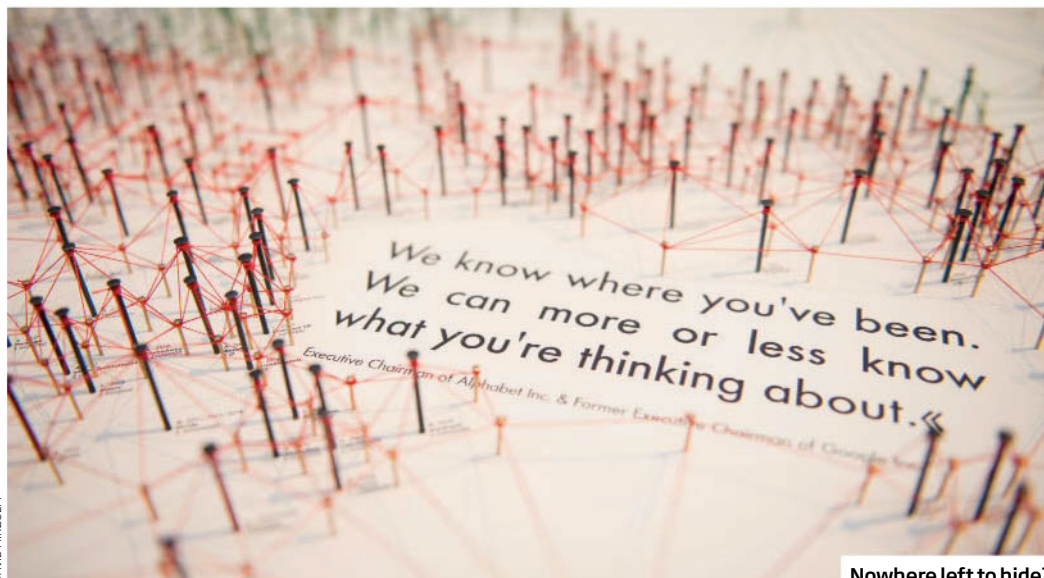
*Days 5 to 7: Changing my data metabolism*

Spurred on by a trip to The Glass Room, I am pleased to find that little fixes aplenty come in the next few days. How many apps do you have? I guessed 50, but I actually had 93. According to the kit, I have high exposure. So I delete some apps and revoke some permissions.

*Day 8: Cleansed*

After a week, I feel purged. We give away data all the time and there isn't much we can do about that, but this stage is about getting into some good habits. I am still giving the megacorps some data about me and it is handy to have some things sync across devices.

But that is now my choice. ■



Nowhere left to hide?

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# New species of orangutan found

Aylin Woodward

OUR family just got bigger. A new orangutan species has been found in the forests of Sumatra. The Tapanuli orangutan is only the third orangutan species, and the seventh non-human great ape. But they may not last long: there are only 800 and they live in an area smaller than London.

We already knew about two species of orangutan: the Bornean (*Pongo pygmaeus*) and Sumatran (*Pongo abelii*), both of which are critically endangered.

In the 1930s there were reports of orangutans in Tapanuli, in the Batang Toru area of Sumatra, but they were never investigated. The Tapanuli population was finally rediscovered in 1997 by Erik Meijaard at the Australian National University in Canberra.

In 2013, a Tapanuli orangutan called Raya died of his wounds after a conflict with locals. Finally, scientists had a Tapanuli ape that they could examine.

A team including Michael Krützen at the University of Zurich in Switzerland compared Raya's skull and teeth with those of 33 other orangutans. His skull

was smaller than the other two species', and his canines were wider than Sumatran orangutans'.

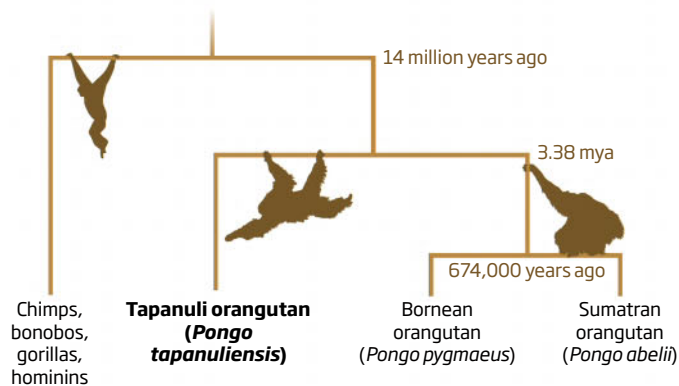
Plus Tapanuli males' long calls are 21 seconds longer than Bornean males', and they pitch their roars at a higher maximum frequency than Sumatran orangutans do.

Finally, the team analysed 37 genomes from various orangutan populations. Again, the Tapanuli orangutans differed from their Bornean and Sumatran cousins (*Current Biology*, doi.org/cfvk).

"It dawned on us that this is a new species," says Krützen. They

## Our new ginger cousin

How the recently discovered Tapanuli orangutan fits into the family tree



named it *Pongo tapanuliensis*.

The genetic results also offer a glimpse at orangutan history. Fossils and genetics had already revealed that orangutans split from other great apes about 14 million years ago. Now we know the orangutan lineage first split around 3.38 million years ago, when the Tapanuli orangutans hived off. The rest then split into Sumatran and Bornean species much later, 674,000 years ago.

Krützen says the Tapanuli species may be the descendants of orangutans that migrated from Asia to what is now Indonesia more than 3 million years ago.

But the Tapanuli orangutans' history may be coming to an end. They are confined to just 1000 square kilometres of land. If more than 1 per cent of the adult



MAXIME ALIAGA

We've only just met

population – that is, eight of the 800 animals remaining – is removed per year, the species will go extinct, Meijaard says.

Based on population numbers, Tapanuli orangutans may be the most endangered great apes, says Vincent Nijman at Oxford Brookes University, UK. Most other great apes have populations in the tens of thousands.

The species is threatened by hunting and poaching, and forest loss due to farming and mining exploration, says Matthew Nowak at the Sumatran Orangutan Conservation Programme. What's more, a proposed hydroelectric project threatens 8 per cent of the orangutans' habitat.

For now, the researchers hope to galvanise conservation efforts to protect what's left of the Tapanuli orangutans' habitat. ■

## Method to share cake may make US voting fairer

THE method to fairly split a cake between two people is tried, tested and mathematically proven. One person cuts the cake and the other chooses which slice they get. To get the biggest piece of cake possible, the cutter must split it fairly resulting in no hard feelings between the two eaters.

In US politics, however, cutting states into electoral districts doesn't

have a similarly fair method. The political party in charge often decides where the electoral lines are drawn and does so in such a way as to gain an advantage – a process called gerrymandering.

Now, Ariel Procaccia, Wesley Pegden and Dingli Yu at Carnegie Mellon University in Pennsylvania have devised a way to extend the cake cutting technique to redrawing electoral districts to make the system fairer ([arxiv.org/abs/1710.08781](https://arxiv.org/abs/1710.08781)). "It leverages the competition of the two parties. They can both act in their own self-interest and still result in an

outcome that is mathematically fair," says Procaccia.

With the approach, one political party draws an electoral map that divides the state into the agreed number of districts. The second party then chooses one district to freeze so that no more changes can be made to it by either side. It then redraws the rest of the map. Once the new map is complete, the first political party

**"Competing political parties can each act in their own self-interest and still make fairer voting districts"**

freezes one of the new districts, and redraws the rest of the map again. This continues until every district in the state is frozen. In Pennsylvania, for example, this would require 17 cycles as there are 18 districts.

To make this applicable to the real world, some mechanism would need to account for the Voting Rights Act, which protects voting rights for racial minorities, says Joshua Douglas at the University of Kentucky. Procaccia and Pegden say this could be checked after the process is finished, in the same way that new districts are checked now. Timothy Revell ■



## Trick your taste buds with virtual cocktails

DRINKS are so last century - but they're getting an upgrade. A device called the Vocktail is shaking up the traditional cocktail by mixing in a dash of electronics designed to fool your senses.

Made by Nimesha Ranasinghe and his team at the National University of Singapore, the Vocktail - short for virtual cocktail - is a glass that can be made to alter and augment flavours via an app. Once a liquid is poured into the glass, a drinker can change three aspects affecting its perceived taste.

First, you can alter its colour with an LED in the glass. Then you can make the drink seem sweeter, saltier or more bitter using tongue-stimulating electrodes placed around the rim. In previous experiments, the team showed that different electrical patterns can give the impression of various tastes. Finally, a tube in the side of the glass releases gases with different smells, such as lime, that change the perceived flavour even more.

Ranasinghe previously created digital lemonade using electrodes and coloured lights to trick people's taste buds. By adding smell to the mix, the Vocktail opens up many more flavour combinations. Virtual drinks can make you think you are drinking something sugary when you are in fact just swigging water, letting people satisfy their taste buds without any of the calories. The associated app also lets you share your favourite virtual cocktail recipes with others.

One day, devices like the Vocktail may become part of an ultimate virtual reality experience in which all sensations are simulated digitally. "A Vocktail could become a welcome addition to social experiences in virtual pubs or bars," says Adalberto Simeone at the Catholic University of Leuven (KUL) in Belgium. The Vocktail was presented at the Association for Computing Machinery Multimedia Conference in California last month. Timothy Revell ■



DAN ATKIN/ALAMY

Mitochondria not so mighty

## Lethargic cells in chronic fatigue syndrome

THIRTEEN years ago, Cara Tomas was rendered bedbound with chronic fatigue syndrome. It came on suddenly, she says, without warning. "A lot of people dismiss it as a psychological disease, which is a big frustration," she says.

Tomas knows more about CFS than most. A PhD student at Newcastle University in the UK, she has just published a paper demonstrating that white blood cells in people with the condition are as listless as the people themselves often feel. "It could explain the whole-body fatigue shown by patients," she says.

The finding adds to mounting evidence that the disorder has a biological explanation, and raises the prospects for new treatments and diagnostic tests.

For many years, arguments have raged over whether CFS - also known as myalgic encephalomyelitis, or ME - has a physiological or psychological basis. But the latest research comparing samples of cells called peripheral blood mononuclear cells from 52 people with the condition and 35 without has

reinforced the case for a biological explanation.

Across almost all measures of energy capacity, the cells from people with CFS were weaker compared with their healthy counterparts. If other cells are equally compromised, it could explain why people with the condition are often bed- or wheelchair-bound for months,

**"It implies that cells in people with CFS can't raise their output to meet the demands of routine tasks"**

and struggle with even modest physical exertion.

"The CFS cells couldn't produce as much energy as the control cells," says Tomas. "At baseline, they didn't perform as well, and the maximum they could reach under any conditions was so much lower than the controls."

Tomas and her colleagues measured the efficiency of mitochondria, the energy-generating powerhouses in cells. The team found that mitochondria in CFS cells can't produce energy properly. "We've

shown definitively that it's a fault in mitochondria," says Tomas. "It points directly to a physiological, not psychological disorder."

Tomas measured the oxygen consumption of cells in comfortable and stressed conditions, to see how well they could raise their game. Even at baseline, control cells consumed twice as much oxygen as the CFS cells. The disparity widened dramatically when the cells were stressed. In another test that artificially pushed cells to their maximum capacity, CFS cells could only increase their mitochondrial output by 47 per cent, roughly half the 98 per cent increase achieved by control cells. The implication is that cells from people with CFS can't raise their output to meet the energy demands of routine tasks (*PLoS One*, doi.org/gcgk4j).

"A major question now is whether the situation in these white blood cells reflects whole-body mitochondrial dysfunction in patients," says Karl Morten of the University of Oxford.

Tomas is currently taking samples of muscle cells and testing them in the same way as the blood cells. "Patients sometimes think no one cares, but we do have interest, and want to find out what's going on." **Andy Coghlan** ■

# Face-blind people miss a brain 'hub'

Helen Thomson

SOME find it difficult to spot a face in the crowd. Now we know why: people with face blindness seem to have a missing "hub" of brain connections. The discovery could help us to diagnose children with the condition and teach them new ways to identify faces.

People with prosopagnosia, which often runs in families, cannot easily tell faces apart. They rely heavily on voice recognition, clothes, hairstyle and gait to identify people, but can still fail to recognise family and friends. It can lead to social anxiety and depression, and can often go undiagnosed for many years.

Face processing isn't a function of a single brain region, but involves the coordinated activity of several areas. To investigate what is behind the problem, Galia Avidan at Ben-Gurion University of the Negev, Israel, and her colleagues scanned the brains of 10 adults who had reported lifelong problems with face processing. They also scanned 10 adults without the condition.

During the scan, participants were shown sets of images of

emotional, neutral, famous and unfamiliar faces. During the task, they were asked to press a button when two consecutive images were identical. Some of the images also included buildings, which people with face blindness don't have trouble identifying – these acted as a control.

The team was interested in the neural conversations happening in two sets of regions. The first, towards the back of the brain, we use to process basic visual information about a face. The second, at the front, processes higher level information, such as recognising emotion in faces, pulling up memories associated with a face or naming a face.

In people without prosopagnosia, the team found that regions towards the front of the brain form a "hub" that is highly connected with other regions, including those at the back that process more basic visual information – it is a bit like a busy airport, says Avidan.

But people with the condition were missing this hub-like behaviour. They also had a greater number of connections in the back portions of the



Hard to recognise

CAT THOMSON/MILLENNIUM IMAGES, UK

brain (*bioRxiv*, doi.org/cfvq). This hyper-connectivity at the rear of the brain might be a compensatory mechanism because they rely on more basic visual information, says Avidan.

A neural fingerprint of a prosopagnosic brain would be valuable, says Avidan. "It might lead us to the point where we can scan the brain of a child who has family with prosopagnosia, examine their connectivity and determine the chances that they too will develop the condition."

This would be useful, says Brad

Duchaine at Dartmouth College in New Hampshire. "But we still don't have neural measures that can be used to confidently categorise an adult as prosopagnosic, so I expect it'll be a long time before we can do it with kids," he says.

Early research suggests that some training techniques may help improve facial recognition in children with prosopagnosia. Studies indicate that the earlier you attempt to teach people new techniques, the more likely they are to be of use. ■

## Dino extinction let us come out in the day

HUNCH confirmed: mammals spent their first 100 million years in the dark, and only came out in the day when the dinosaurs disappeared. The first to truly embrace the daytime were simians – our direct ancestors.

Mammals evolved at least 160 million years ago, but most were small while dinosaurs ruled – and possibly nocturnal, only foraging at night.

Today, many mammals are active in the day – diurnal – yet most have eyes adapted to darkness. Most have a thin reflective layer at the back of the eye that helps them see in the dark. This may be held over from nocturnal ancestors. But this is hard to test, as eyes don't fossilise.

Roi Maor at Tel Aviv University in Israel and his colleagues compiled the lifestyles of 2415 living mammals. They aligned these with the mammal family tree to find the likely activity patterns of extinct mammals: if two related mammals are nocturnal, their common ancestor probably was too.

Maor found diurnality appeared 65.8 million years ago – a few hundred thousand years after the dinosaur extinction 66 million years ago (*Nature Ecology & Evolution*. DOI: 10.1038/s41559-017-0366-5). That supports the "nocturnal bottleneck hypothesis": the dinosaur extinction opened up new niches for mammals, particularly daytime foraging.

The large sample size meant Maor

**"I think it's very difficult to be social when you're nocturnal, because it's hard to communicate"**

could date diurnality in specific groups, says Chris Heesy at Midwestern University, Arizona.

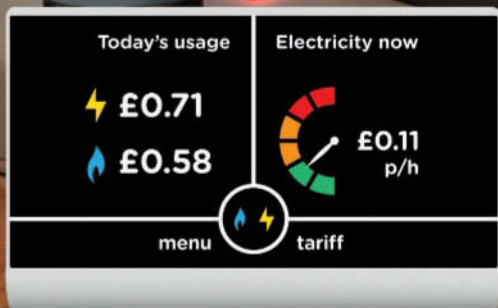
The first solely diurnal group was the simian primates, including monkeys and apes. They are the only mammals whose visual systems are specially adapted to daytime.

They can distinguish red and green, which may help them spot ripe fruit.

Simians' sunny lifestyle may have helped drive them to be social, says Maor. "I think it's very difficult to be social when you're nocturnal, because it's hard to communicate between the parts of the group." Claire Asher ■

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## Freeloading mites squat on spiderwebs and steal food

IN BRAZILIAN caves, mites live on spiders' webs and steal their food. They are the first mites known to do this.

Leopoldo Ferreira de Oliveira Bernardi at the Federal University of Lavras in Minas Gerais first saw live mites dotting a spiderweb by the entrance of Brazil's Lapa Nova cave in 2007. Intrigued, he and his colleagues placed live bait - a cave moth - on the web of a recluse spider.

The spider swiftly attacked the moth and began eating. But in the next 5 to 40 minutes, mites, previously scattered all over the web, gathered to feed on the moth.

The team has named the new-found mite *Callidosoma*

*cassiculophylla*: "cassiculus" means "spiderweb" and "phylla" means "friend" (*Zootaxa*, doi.org/cft9).

The mites only eat their host spider's freshly killed prey, and don't scavenge on dead insects. In turn, the spider is extremely tolerant of mites sharing its meals, with no signs of any aggression towards them. "I saw a mite walk under the spider's legs and nothing happened," says Bernardi.

"The mites are too small to be useful prey for the spiders and are not large enough to be a potential predator," says Robert Pape at the University of Arizona. "I suspect the spiders are not adversely affected by the small amount of nutrients consumed by the mites." The mites are only about 0.1 centimetres long, while the spider is about 5 centimetres.

## Visual trick has AI mistake turtle for gun

WHEN is a turtle not a turtle? This is a conundrum for an AI trained to identify objects. By subtly tweaking the pattern on the shell of a model turtle, Andrew Ilyas at the Massachusetts Institute of Technology and his colleagues tricked a neural network into misidentifying it as a rifle. The results raise concerns about the accuracy of face-recognition tech and the safety of driverless cars.

Previous studies have shown that changing just a few pixels in an image - alterations that are imperceptible to a human - can throw an AI off its game, making it identify a picture of a horse as a car, or a plane as a dog. The model turtle now shows that an AI can be made to misidentify an object even from multiple angles.

One concern is that such simple tricks could be used to sabotage

image recognition systems. "A hacker could make a hospital look like a target to a military drone or a person of interest look like an innocent stranger to a face-recognition security system," says Jeff Clune at the University of Wyoming. He warns governments and companies planning to use neural networks to be aware of this weakness and plan for a potential attack. "We do not currently know how to solve this problem," he says.

## Printable invisible ink is here

INVISIBLE ink is back, and it's better at hiding than ever.

Liang Li at Shanghai Jiao Tong University in China and his team accidentally made a new ink while trying to synthesise a kind of glowing nanomaterial (*Nature Communications*, doi.org/cftp). And they discovered that this invisible lead compound could be printed onto paper.

Apply a mixture of salts and the text becomes visible again. It's so much better than just using lemon juice. Most of the invisible inks we use now leave a residue behind as they become legible, so decrypting the message can be as easy as holding it up to a light.

This new ink leaves no residue, so it could be used in anti-counterfeiting measures. US currency, for example, uses a variation on invisible ink to hide text or pictures on large bills so that they're only visible in certain light.

## Europe and US caused heatwave

FOR the first time, the countries that are most responsible for a heatwave attributed to climate change have been named.

In 2015, Friederike Otto at the University of Oxford studied a heatwave that struck Argentina in 2013. She found climate change made it five times more likely.

Now, she has totted up how much carbon dioxide each country emitted between 1850 and 2013. She found the European Union contributed most to making the heatwave more likely, followed by the US and China (*Nature Climate Change*, doi.org/cfvc).

Many climate activists argue that developed countries, which have historically emitted most, should be held most responsible for stopping climate change.

## Icy moon may be boiling inside

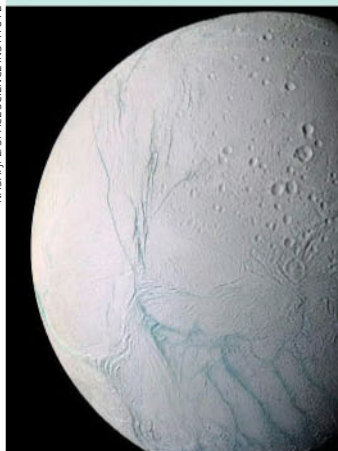
BENEATH Enceladus's icy shell, way under its global sea, seems to be a core made of wet sand, which could host life between its grains.

In 2005, NASA's Cassini probe saw signs that something within this icy moon of Saturn generates heat and fuels plumes of water that spew out of Enceladus's south pole. But we are unsure exactly how the heat is created.

Now, Gaël Choblet at the University of Nantes, France, and his colleagues have simulated conditions on Enceladus and say it is probably due to a porous, sandy core (*Nature Astronomy*, [doi.org/cfvd](https://doi.org/cfvd)). Ocean water from above can seep into the core and may make up 20 to 30 per cent of it, Choblet says.

The core is heated because the moon is always flexing due to tidal forces created by Saturn's gravity. It seems that as water flows through pores and cracks among the grains, it warms, possibly even boiling. It then shoots out into the ocean above in a thin, underwater geyser.

The geometry of Enceladus's orbit means this hot water moves more towards the moon's poles than elsewhere, thinning the underside of the ice in both spots. As a result, Choblet thinks we may see plumes at the north pole, as well. The tidal heating effect could persist for tens of millions to billions of years, giving any potential life time to evolve.



NASA/JPL/SPACE SCIENCE INSTITUTE

## Parasite makes mosquitoes hunt out humans

MOSQUITOES seem to fancy human blood more when they are carrying malaria, in an apparent case of parasites directing their hosts' behaviour.

The malaria parasite, the single-celled organism *Plasmodium falciparum*, relies on mosquitoes for transmission, but it can only reproduce and develop in humans, and to a lesser extent other great apes. If it ends up in a cow or sheep, it reaches a dead end.

So *P. falciparum* has tricks up its sleeve: infected humans become more attractive to mosquitoes, for

example. Amélie Vantaux at the Research Institute for Health Sciences in Bobo-Dioulasso, Burkina Faso, and colleagues wondered if the parasite might also drive mosquitoes to seek humans over other food sources.

They set up traps in three villages in Burkina Faso and analysed the blood in the guts of mosquitoes caught to find out what animals they had fed on. Out of the mosquitoes that were in the infectious stage of malaria, 77 per cent had fed on humans. For those in the uninfected

stage, the figure was 64 per cent. Uninfected insects were roughly the same, at 61 per cent (*bioRxiv*, [doi.org/cfth](https://doi.org/cfth)).

While all mosquitoes seemed to prefer human blood, those carrying malaria at its infectious stage were significantly more likely to have recently fed on humans. This might happen because the parasite changes the mosquitoes' behaviour or habitat choice, says Vantaux. "It could be that infected mosquitoes change their peak of activity to when humans are more available."

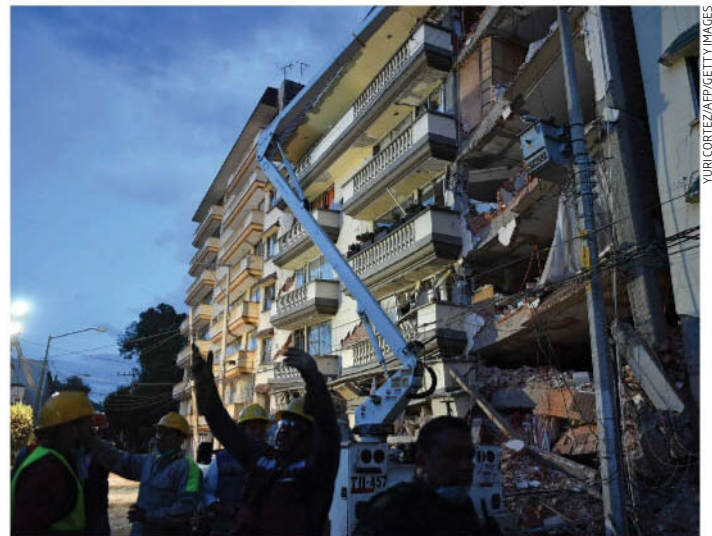
## Cosmic rays reveal pyramid's cavern

COSMIC rays may have unveiled a hidden chamber within Egypt's most famous pyramid.

An international team led by Kunihiro Morishima of Nagoya University in Japan used muons, the high-energy particles made when cosmic rays collide with our atmosphere, to find a large void above the Grand Gallery that connects the King and Queen's chambers of the Great Pyramid.

Muons are absorbed at different rates depending on the density of the rock they pass through. By looking at the number of muons that arrived at different locations within the pyramid and the angle at which they were travelling, the team mapped out cavities within the ancient structure (*Nature*, [doi.org/cftw](https://doi.org/cftw)). This type of exploration – muon radiography – is perfect for sensitive historical sites as it uses naturally occurring radiation and doesn't damage the structure.

After several months in position, three types of muon detector all confirmed a void in the same location. It will take drilling and cameras to determine whether the cavity is a structural chamber, or a void created by a long-forgotten collapse.



YURI CORTEZ/AP/GETTY IMAGES

## Where are you calling from?

KNOWING the location of an emergency caller can be a matter of life and death. But sometimes those seeking help are too panicked to speak clearly or don't know where they are. Some callers don't feel it is safe to speak at all and simply call 999 or 911 in silence.

Detecting where a call is coming from automatically can make all the difference. Most emergency calls are now made by mobile phone and this gives emergency responders more data to work with. William Falcon and Henning Schulzrinne at Columbia University in New York have come up

with a way to use a smartphone's sensors to pinpoint which floor of a building a caller is on, as well as their location. By combining GPS, signal strength and atmospheric pressure – using the barometer that many smartphones now contain – the pair created an app called Sensory that identifies how high up a caller is.

The Metropolitan Police Service in London welcomes the idea. "Any development that assists emergency services in identifying the exact location of callers using mobile phones could be of assistance to us," says a spokesperson.

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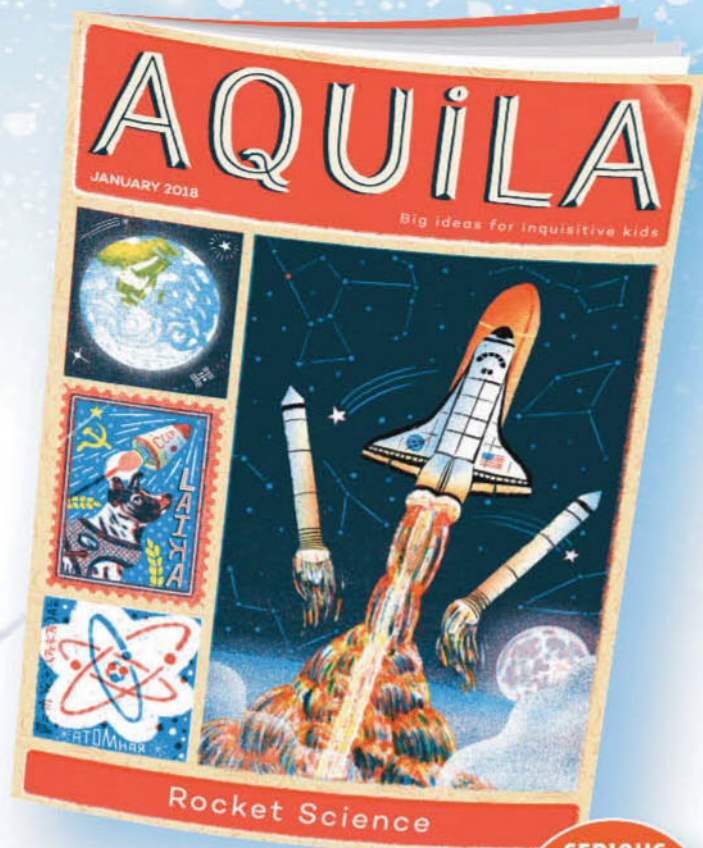


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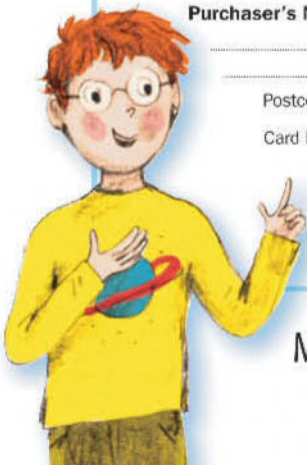
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# Lethal logic

Armed machines sound scary, but if driverless cars can save lives, so can robots with guns, says **David Hambling**

NEXT week, a meeting at UN headquarters in Geneva will discuss autonomous armed robots. Unlike existing military drones, which are controlled remotely, these new machines would identify and attack targets without human intervention. Groups including the Campaign to Stop Killer Robots hope the meeting will lead to an international ban.

But while fiction is littered with cautionary tales of what happens when you put guns in the cold, metallic hands of a machine, the situation may not be as simple as “human good, robots bad”.

To understand why, we should look at what people are saying about the ethics of driverless cars, which advocates see as a way of reducing accidents. If your life is safer in the hands of a robot car than a human driver, might the same apply for military hardware?

Clearly, replacing a human combatant with a robot one is safer for that individual, but armed robots could also reduce civilian casualties. For example, a squad that has to clear a building must make a split-second decision about whether the occupant of a room is an armed insurgent or an innocent civilian – any hesitation could get them killed. A robot can wait for confirmation, when the enemy starts firing.

The same principle applies to air strikes. An autonomous system can make several runs over a target to confirm it is really an enemy outpost, but a pilot can risk only one pass. In both cases the only downside is the loss of machines due to excessive caution, not casualties.

Human rights groups now see the use of precision-guided weapons as essential to avoiding

civilian casualties; crude unguided weapons are considered reckless and irresponsible. Is there a similar moral justification for developing armed robots?

“We cannot simply accept the current status quo with respect to non-combatant deaths,” says

**“Robots can’t understand the complexities of a situation or the nuances of human behaviour”**

Ronald Arkin, a roboticist at the Georgia Institute of Technology, who campaigns for regulating, not banning, armed robots. “We should aim to do better.”

Most weapon systems operate with a person in the loop, meaning the ultimate decision to kill is not made autonomously, but some weapons have more leeway, such as the Brimstone missile used by the Royal Air Force. The operator can define a box on the map, and fire a salvo

## RUSSIA’S ROBOT ARMY

While Russia has lagged in aerial drone technology compared with the US military, it is hoping to win the ground war. An initiative kicked off in 2013 has seen armed ground robots proliferate, from small bots that can operate indoors, up to full-sized tanks, some of which can operate autonomously.

For example, the Uran-9 is a mini-tank robot armed with cannon or anti-tank missiles; 22 have been delivered to the Russian army and they should enter service next year. Uran-9 can be controlled remotely, but also has a full autonomous mode to detect, identify and shoot targets on its own.

Vadim Kozyulin of the PIR Centre for Policy Studies, a Russian security

of missiles that search the area for tanks, striking when they spot one or detonating safely otherwise.

Human judgement in similar situations is all too fallible. In one lethal “friendly fire” incident in 2003, two US pilots incorrectly identified British armoured vehicles as Iraqi, despite orange panels marking them as friendly and the fact that they were in a “no engagement” zone.

Can robots therefore make better decisions than humans? Arkin argues that machines would not suffer from the cognitive error of “scenario fulfilment”, which was blamed for a tragedy involving a civilian Iranian airliner in 1988. As the plane flew towards a US warship, radar operators reported that it was descending for an attack run and shot it down, killing all 290 people on board. Later analysis of radar recordings showed the plane had been climbing. The radar operators had imagined

think tank, says the profusion of armed robots is slow, as many get no further than the proposal stage. The Russian military has not ordered autonomous killing machines as such, says Kozyulin, but semi-autonomous machines with the capacity to operate autonomously if they lose contact with human controllers as a result of radio jamming countermeasures by the enemy.

This need for autonomy may mean that, as with landmines and cluster bombs, Russia will not sign up for a ban that could reduce its military capability (see main story).

“At the moment Russia is reluctant to support the ban. They are evaluating the situation and this position might change,” says Kozyulin.

that they were under attack and unconsciously made the evidence fit that scenario, ignoring alternative interpretations.

But Bonnie Docherty, a lecturer at Harvard Law School and a researcher at Human Rights Watch, points out the limitations of artificial intelligence, particularly in complex war zones like Iraq. “Robots wouldn’t have the capacity to fully understand the complexities of a situation or interpret the nuances of human behaviour,” she says. “They would find it difficult to distinguish soldiers from civilians.”

## Send in the drones

But we may have to let robots off the leash sooner than we might like. New tactical jamming systems with names like DroneDefender and DroneShield, are designed to break the radio link between operator and drone, and are appearing more frequently on the battlefield. US drones donated to Ukraine proved useless because of Russian jammers. If remote control isn’t possible, uncrewed systems will need to be fully autonomous. (See “Russia’s robot army”, left)

Arkin has a better solution. Rather than simply leaving robots to follow orders as they see fit, armed bots could be equipped with “ethical governor” software that takes into account international law, he says.

For example, if a potential target cannot be confirmed as valid, the ethical governor may demand that the robot take further actions, such as moving in for a closer look. It could also veto an attack altogether, if say, civilians are in the area.

Arkin points to a video from





Armed and dangerous

MANDEL NGAN/AP/GETTY IMAGES

Iraq showing a helicopter crew complying with orders to shoot and kill a wounded insurgent. A robot with an ethical governor would decline that order, citing its legal reasons, he says. Unlike a human, a robot would not feel the need to react illegally out of a desire for vengeance, or from fear of authority. Killer robots might be less of a risk than killer humans, with their long history of committing war atrocities. As with driverless cars, machines may better uphold laws humans are inclined to break.

The ethical governor concept is in its early stages, though Arkin thinks future developments in AI will make it feasible. For some though, the issue is less a technical one than a fundamental question of ethics.

“Fully autonomous weapons raise a host of other concerns that do not relate to the ability to

distinguish between civilian and military objects,” says Docherty. “Delegating life-and-death decisions to machines crosses a moral threshold.”

But that threshold has already been crossed by cars on the market, such as Tesla vehicles that can change lanes without human intervention. Patrick Lin, a philosopher at California Polytechnic State University, says this exposes a double standard in those wanting to ban killer robots.

“I don’t think I’ve heard a single person call for meaningful human control in autonomous cars,” says Lin. “If it is a real ethical requirement for killer robots, then it would logically extend to other machines that can kill, such as robot cars.”

Clearly, killer robots are designed to be lethal, while a robot car might only kill by accident. But Lin argues this

distinction shouldn’t matter.

“Robot cars may accidentally kill more people per year than military robots, given that robot cars would be far more prevalent,” he says. If we allow driverless cars to make life-or-death decisions, then we should also accept killer robots – or reject both, he says.

Sydney Levine at the Massachusetts Institute of Technology studies the ethical

**“If we accept driverless cars making life-or-death decisions, then we should accept killer robots”**

issues associated with driverless cars, and also sees direct parallels. She suggests an ethical policy for autonomous weapons should follow the pattern set by her work on self-driving vehicles.

“We start with a psychological question,” says Levine. “How do

people perceive autonomous weapons and how do they attribute blame and causal and moral responsibility to them?”

The answers should inform our policy, she says. Her work on driverless cars highlighted inconsistent beliefs: we want cars in general to minimise harm, but we want our car to protect us rather than others. Public attitudes to killer robots may turn out to be just as paradoxical.

As such, we might want to rethink a ban on killer robots. “We should be in a hurry to regulate them, but a ban is premature,” says Arkin. Arming machines could mean less risk to soldiers, and less chance of killing innocent civilians, but only if we develop the technology for adequate safeguards. If an outright ban is implemented, that won’t happen – and civilian deaths will continue as before. ■

# An inspiring reboot

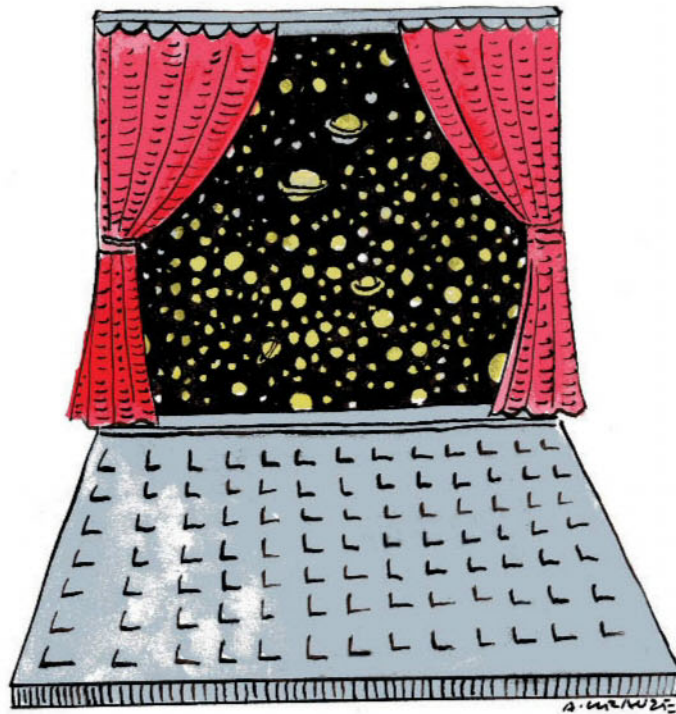
Millions lapped up Stephen Hawking's early ideas when they went online - a fine way to ignite minds everywhere, says **Geraint Lewis**

IT IS probably a first - the musings of a young physicist breaking the internet. This came after the PhD thesis of one of the world's most famous scientists was made freely available online. Dated 1966 and titled "Properties of expanding universes", it lays out the early thoughts of Stephen Hawking.

As one of the most requested documents from the University of Cambridge in paper form, this new electronic version was intended to make the insights within available to all. Predictably, the website crashed as millions rushed to access a copy.

What do those delving into it find? Firstly, it is a blast from the past - typed, with handwritten equations, and no figures or images. What about the science?

Hawking does not focus on a single topic, but chips away at several distinct questions, all under the overarching theme of



cosmology. Such an approach is not unusual when a young scientist explores potential avenues for ideas.

He opens with a salvo at a novel idea of gravity proposed by Fred Hoyle and Jayant Narlikar, showing it to be incompatible with an expanding universe. At the time, Hoyle was one of the UK's leading cosmologists and had already come into conflict with the more junior Hawking.

Hawking then turns his mind to the growth of clusters of matter and galaxies in the cosmos. He concludes that the universe cannot have been that smooth after its birth, because no structures would have formed, and the universe would have been eternally featureless. The source of this primordial lumpiness was a mystery, but foreshadowed the incorporation of quantum physics as an explanation

## Let the lawsuits flow

Allow a river to sue in court like a person? That isn't a bad idea, says **Richard Schiffman**

DOES a river have rights? A group of US environmentalists thinks so. They have filed a lawsuit that says the Colorado river's "right to exist, flourish, regenerate, be restored, and naturally evolve" has been violated by its namesake state.

Controversially, they want to represent it as a "person" in court, listing it as plaintiff.

The Colorado provides water to 36 million people in the US and Mexico. It irrigates a lot of land. But the river, overused for farming and left stagnant by huge dams, is shrivelling. Near its mouth in the Gulf of California, it is a toxic sludge of salts, agrochemicals and heavy metals. Most years, it dries up before it gets to the sea.

If we treated people with this level of abuse, we would be hauled into court. Yet there are few legal remedies when the same is dished out to a river, a wetland or an old growth forest. Ecosystems have no legal standing in the US.

A century ago in the US, women couldn't vote and child labour was a problem. Fortunately, the law evolves. If corporations, which benefit a few shareholders, can be legally recognised as "persons", as they can in the US and Europe,

**"Recognising the rights of nature affirms that the world is not dead matter to be limitlessly exploited"**

why not ecosystems whose life-support systems benefit us all? In fact, it makes a lot more sense.

Protection of natural systems is urgent given their overuse, threats from climate change and their role in mitigating the impact of extreme weather. There are precedents. In 2008, Ecuador enshrined the legal rights of nature in its constitution. Courts in India, Colombia and New Zealand have declared that rivers possess similar rights.

Still, some ask why we need new legislation as current laws are sufficient. But if they were powerful enough, we wouldn't be in crisis. In the half-century

that emerged in the 1980s.

Next, he considers gravitational waves, examining how these are emitted and absorbed. One has to wonder whether he thought, when he wrote “[h]owever this is slightly academic since gravitational radiation has not yet been detected”, that progress would take half a century.

The closing chapter is probably of most interest to physicists, examining the idea of cosmic singularities. This work, later explored with mathematician Roger Penrose, considered the idea that expanding universes such as our own must have been born in an infinite density state – with all the mass packed into a tiny space, known as a singularity.

It is important to remember that, unlike the recently released papers on the 1963 assassination of US president John F. Kennedy, Hawking’s thesis has not been kept secret for decades. It simply sat on a library shelf. Its electronic mass release is part of a move to make all science more accessible.

On that front, Hawking has taken an important step, hoping that his words will inspire the next generation. Many other scientists will surely follow. ■

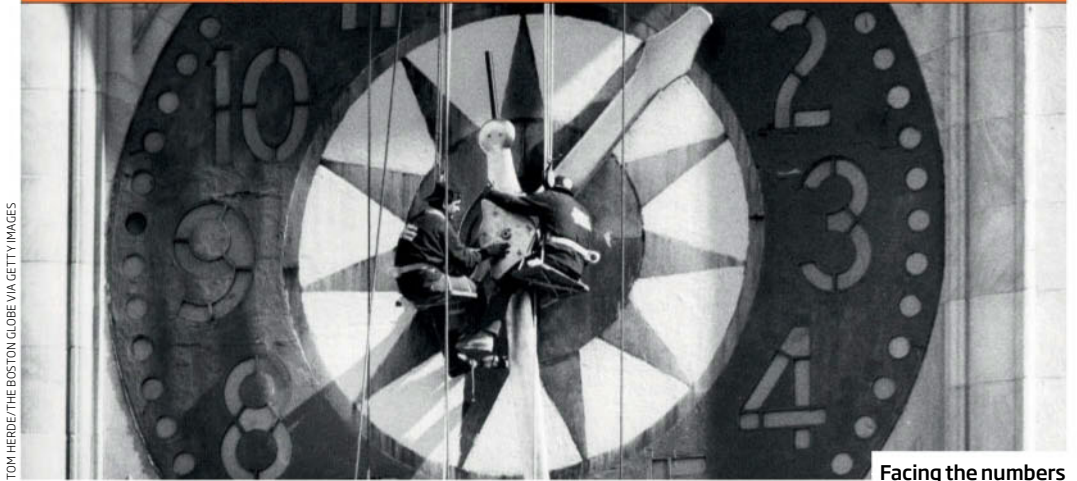
Geraint Lewis is an astrophysicist at the University of Sydney, Australia

since environmental laws were widely enacted, carbon dioxide levels have soared and key ecosystems have vanished, and now up to 200 species go extinct every day. The hitch is that these regulations are designed to marginally slow the rate of destruction, not preserve vital systems in perpetuity – which is what we need to do.

Recognising the rights of nature affirms that the world is not dead matter to be limitlessly exploited. It is a living being whose health is inextricably linked to our own. ■

Richard Schiffman is a US journalist who writes about the environment

## INSIGHT Daylight saving time



TOM HERDE/THE BOSTON GLOBE VIA GETTY IMAGES

Facing the numbers

# Time to stop messing around with clocks

## Chelsea Whyte

THAT time is upon us again: the twice yearly switching of the clocks, and the griping that comes with it. Both Europe and North America have now made the switch, a week apart. But in a world where people from far-flung places are more connected than ever, does daylight saving time (DST) do more harm than good?

A special commission on time zones in Massachusetts thinks so. Last week, the group recommended that the state move its official time zone from Eastern to Atlantic Time and do away entirely with the back and forth of daylight saving. The move would give Massachusetts more daylight in the evenings – currently, winter sunsets start as early as 4.11 pm.

The US first observed DST during the first world war, modelled on a German plan to move clocks forward in order to reduce energy use by providing more sunlight in the summer mornings. Savings in electricity costs and stress on the electric grid have been cited as reasons for changing clocks between summer and winter. But since energy demand actually peaks in the early

afternoon in winter, longer evenings would actually relieve the grid by reducing the need for artificial lighting. A 2008 report by the Department of Energy found that in 2005, when the US extended summer hours for a few more weeks into autumn, electricity use decreased by a small amount.

Ah, but what about those dark winter mornings caused by a permanent clock change? Supporters of DST say they could affect children waiting for a bus or walking to school. The commission recommends delaying school start times, which has been shown to better align with adolescent

**“China has one official time zone for the entire country, despite covering five time zones geographically”**

sleep patterns driven by hormones. Later school start times also result in higher test scores and fewer teen car accidents.

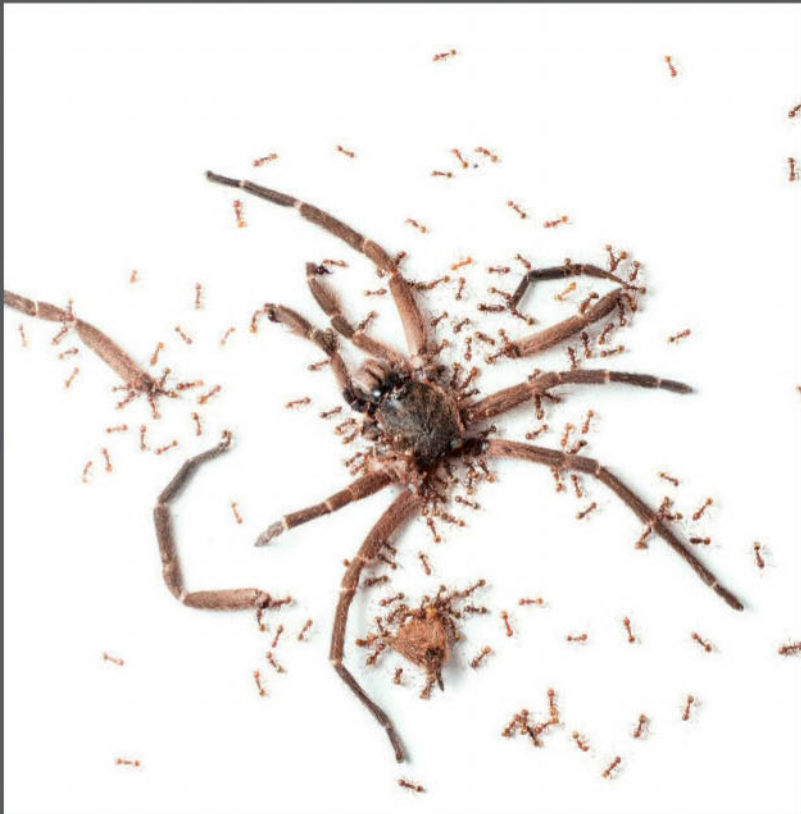
If Massachusetts acts alone on this, it could be disruptive to interstate travel and shipping, as well as national broadcasting schedules. Maine and New Hampshire have made similar

decisions to adopt Atlantic Time if other states in the region do as well, and the Massachusetts commission recommends that the state should only make this move if a majority of other north-east states join in.

But why stop there? It’s time we all gave up this arcane practice, and maybe time zones entirely. Steve Hanke, a professor of applied economics at Johns Hopkins University in Baltimore, has an idea for how we could do just that. He suggests we use one universal 24-hour clock, followed by everyone on the globe. Pilots and stock exchanges use it already.

It would mean that in some places, the sun would rise at, say, noon, instead of 7 am. It works in China, which has one official time zone for the entire country, despite covering five time zones geographically. Local custom dictates at which hour work begins and ends. Hanke thinks it’s only a matter of time before this practice is adopted globally, and our increasing reliance on technology may lead us there.

In the 19th century, the railroad connected people across distances so great that time zones needed to be implemented to align rail schedules. In the 20th century, the aeroplane eliminated all time zones, at least for pilots and airport personnel. Time is about coordination, and universal time is the ultimate expression of that. But let’s start with small steps: first, let’s get rid of daylight saving time. ■





## Dismembered in slo-mo

ON A recent visit to the island of Borneo, photographer Nick Garbutt found this dead spider just outside the field camp, its body seemingly in perfect condition. "I've no idea why the spider died," he says.

Having come across many other dead animals being dismembered by ants on the island, he saw an opportunity to record the process. Garbutt placed the spider, which including its legs was about the size of his palm, on a piece of paper. Then he took this series of photographs over 4 hours as ants broke it into pieces.

All the action took place in Danum valley, a protected area Garbutt regularly visits that is a haven for wildlife, including orangutans, pygmy elephants and maroon langurs. "It's one of my favourite places on the planet," he says.

Garbutt doesn't know to which species the spider or the ants belong. Michael Le Page

### Photographer

**Nick Garbutt**  
naturepl.com





# Reality? It's what you make it

An audacious new take on quantum theory suggests alternative facts are a fact of nature, says **Philip Ball**

**D**OES reality exist without us? Albert Einstein appeared to be in no doubt: surely the moon doesn't vanish when we aren't looking, he once asked incredulously. He had been provoked by the proposition, from quantum theory, that things only become real when we observe them. But it is not such a daft idea, and even Einstein kept an open mind. "It is basic for physics that one assumes a real world existing independently from any act of perception," he wrote in a 1955 letter. "But this we do not know."

In the decades since, physicists have found it maddeningly difficult to write the observer out of quantum theory. Now some are contemplating a mind-boggling alternative: that a coherent description of reality, with all its quantum quirks, can arise from nothing more than random subjective experiences. It looks like the "perspective of a madman", says the author of this bold new theory, because it compels us to abandon any notion of fundamental physical laws. But if it stands up, it would not only resolve some deep puzzles about quantum mechanics, it would turn our deepest preconceptions about reality itself inside out.

When it comes to forecasting how the world

will behave, quantum theory is unsurpassed: its every prediction, no matter how counter-intuitive, is borne out by experiment. Electrons, for instance, can sometimes display behaviour characteristic of waves, even though they seem in other circumstances to behave like particles.

## Wave of confusion

Before observation, such quantum objects are said to be in a superposition of all possible observable outcomes. This doesn't mean they exist in many states at once, rather that we can only say that all the allowed outcomes of measurement remain possible. This potential is represented in the quantum wave function, a mathematical expression that encodes all outcomes and their relative probabilities.

But it isn't at all obvious what, if anything, the wave function can tell you about the nature of a quantum system before we make a measurement. That act reduces all those possible outcomes to one, dubbed the collapse of the wave function – but no one really knows what that means either. Some researchers think it might be a real physical process, like radioactive decay. Those who subscribe to the

many-worlds interpretation think it is an illusion conjured by a splitting of the universe into each of the possible outcomes. Others still say that there is no point in trying to explain it – and besides, who cares? The maths works, so just shut up and calculate.

Whatever the case, wave function collapse seems to hinge on intervention or observation, throwing up some huge problems, not least about the role of consciousness in the whole process. This is the measurement problem, arguably the biggest headache in quantum theory. "It is very hard," says Kelvin McQueen, a philosopher at Chapman University in California. "More interpretations are being thrown up every day, but all of them have problems."

The most popular is known as the Copenhagen interpretation after the home city of one of quantum theory's pioneers, Niels Bohr. He argued that quantum mechanics tells us only what we should expect when we make a measurement, not what causes that outcome. The theory can't tell us what a quantum system is like before we observe it; all we can ever ask of it is the probabilities of different possible outcomes.

Such a perspective seems to back you into ►

## CONSCIOUS COLLAPSE?

The idea that consciousness induces wave function collapse, the process by which myriad possible outcomes of a measurement become a single definite one, is not inherently absurd. And yet physicists have long regarded it as a rather *louche* suggestion, because it seems to substitute one mystery for another: we have no idea how to describe consciousness, so how can we expect to know how it causes collapse?

Kelvin McQueen, a philosopher at Chapman University in California, and David Chalmers at the Australian National University in Canberra have recently started to make the case that we can now make things more precise.

The duo take their cue from integrated information theory, which posits that consciousness arises from interconnectivity in the brain. Its inventor, neuroscientist Giulio Tononi at the University of Wisconsin-Madison, has even proposed a mathematical measure of consciousness, known as Phi, based on how the components of a system share and combine information.

Integrated information theory challenges the view that consciousness is all or nothing. It leaves open the possibility that non-human creatures, and maybe even simpler (for example, artificial) systems, can have some level of consciousness. The idea has yet to be tested and no one has been able to formulate how Phi can be calculated for the human brain. But the prospect led McQueen and Chalmers to suggest a bold way of testing whether consciousness indeed causes wave function collapse.

In principle, McQueen says, you could do an ordinary quantum experiment with a twist: the particles would be themselves imbued with some kind of computing capacity, while still being small enough to show observable quantum behaviour. If such particles had a large enough Phi, they might then automatically induce collapse and could not show the quantum effects, such as wave-like interference, that same-sized but lower-Phi particles would display.

McQueen is under no illusions about how hard it would be to set up such an experiment. "I'm not wedded to the idea", he says, "but I do want to see it falsified or verified once it becomes clear how to construct the right kind of systems for testing."



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an uncomfortable conclusion: that the very act of our observation calls the outcome into being. Can that be true? It seems the antithesis of what science normally assumes, as Einstein intimated. Yet the idea has some pedigree. Hungarian physicist John von Neumann was the first to entertain it in the early 1930s, and

### **“What if reality can’t be described without invoking our active involvement?”**

his compatriot Eugene Wigner went deepest with a thought experiment in the 1950s now known as Wigner’s friend.

Suppose that Wigner is standing outside a windowless room where his friend is about to make some measurement on a particle. Once that’s done, she knows what the observed property of the particle is, but Wigner doesn’t.

He can’t meaningfully say that the particle’s wave function has collapsed until his friend tells him the result. Worse still, until she does, quantum theory offers no way for Wigner to think about all the unseen events inside the lab as having fixed outcomes. His friend, her measuring apparatus and the particle remain one big composite superposition.

It is as if we live in a solipsistic world where collapse only occurs when knowledge of the result impinges on a conscious mind. “It follows that the quantum description of objects is influenced by impressions entering my consciousness,” Wigner wrote. “Solipsism may be logically consistent with present quantum mechanics.”

John Wheeler at Princeton University put it differently: it’s not solipsism but a kind of interactive collaboration that brings things into being. We live, Wheeler said, in a “participatory universe” – one that can’t be



The reality we see may not be the reality that exists

primarily it is because if you take quantum mechanics seriously, some element of observer-dependent subjectivity seems impossible to avoid.

A couple of years ago, theorist Caslav Brukner at the University of Vienna revisited the Wigner's friend scenario in a slightly altered form proposed by David Deutsch at the University of Oxford. Here the friend makes the measurement – she has collapsed the particle's wave function, producing either outcome A or B – but tells Wigner only that she sees a definite result, not what it is. In Deutsch's scenario, Wigner is forced to conclude that his friend, her measuring apparatus and the particle are in a joint superposition, even though he knows a measurement has happened.

To Wigner's friend, she is definitely in, say, the state "I see A", but to Wigner she is in a superposition of "I see A" and "I see B". So who's right? They both are, says Brukner, depending on whose point of view you adopt. He has shown that if quantum mechanics is correct, there is no privileged perspective from which a third observer can reconcile both Wigner's and his friend's statements. "There is no reason to assume that the 'facts' of one of them are more fundamental than those of the other," Brukner says – and so we are forced to conclude that "there are no 'facts of the world per se'". Rather, there are only facts for each observer.

One interpretation of quantum mechanics takes such a conclusion in its stride. Devised in the 2000s by Fuchs and others, quantum Bayesianism (also known as QBism) is rooted in the view that quantum mechanics supplies only recommendations about what a rational observer should believe he or she will see on making a measurement – and that these beliefs can be updated as the observer takes fresh experiences into account. That's where the "Bayesianism" comes in: it refers to the classical theory of probability, initiated in the 18th century, that assigns probabilities on the basis of what the observer already knows to be the case.

QBism point-blank denies that there is any objective notion of a quantum state at all. This doesn't mean there can be nothing "real" beyond personal belief, only that quantum mechanics doesn't speak directly to that issue.

The existence of Brukner's "alternative facts" causes no pain in such a picture, because it has assumed them all along. Nor indeed does wave function collapse, which is then just a way of talking about how measurement updates our knowledge. But few physicists

are prepared to accept such stringent limits on their efforts to describe reality, which is why QBism remains a minority sport.

So what now? Enter Markus Müller, the self-described "madman" and a theorist at the University of Vienna. His answer is to take things up a notch. "QBism is not extreme enough," he says. "It assumes that there is this one external world out there which is ultimately responsible for our experiences. My approach starts without assuming such a world." That means imagining that there are no fundamental laws of nature – no general


**"It's deeply odd: you end up with a universe built directly from our experiences"**

relativity, no Maxwell's equations or Heisenberg's uncertainty principle – and asking what the world would then look like. The answer might surprise you.

For even if you throw out physics, the logic of mathematics remains – and this is where Müller begins to construct his hypothetical world. Let's say you have some experience X: you make an observation of the world and see the outcome X. Given that, what are the chances you will then experience another outcome Y? There is a field of maths that deals precisely with such questions. It's called algorithmic information theory and it shows how to make predictions based on inductive reasoning with a distinctly Bayesian flavour: given that X happened, there is an equation to figure out the probability that Y will follow.

Müller wanted to see where that reasoning leads in a world with nothing else to shape it. He represented each individual's experience at every instant as a string of bits of information – 1s and 0s, like binary computer code. Each observer's history then consisted of a walk through the various possible bit strings, and the probability of going from one to the next would be random but conditional: it must take the history of experiences into account. The idea, says theorist Giulio Chiribella at the University of Hong Kong, "is to think of our experience as a movie made of many frames and to ask the question, given the frames I have seen so far, what frame will I see next?"

You would think that such a picture could hardly be less likely to give rise to what we experience: a universe governed by laws and producing facts that are, as far as we can tell, the same for you as for me. But when Müller used the methods of algorithmic



meaningfully described without invoking our active involvement. "Nothing is more astonishing about quantum mechanics," he wrote, "than its allowing one to consider seriously... that the universe would be nothing without observership."

But Wheeler could not escape the thicket of irresolvable questions that the participatory universe raises. For one, Wigner and his friend seem locked in an infinite regress. Is Wigner himself in a superposition of states until he passes on the result to his other friends in the next building? Which observer "decides" when wave function collapse occurs? And what constitutes a conscious observation anyway?

Despite the persistence of such questions, some theorists have recently returned to a form of Wheeler's vision, what Chris Fuchs at the University of Massachusetts in Boston has called "participatory reality". That shift is partly for want of a better alternative, but

information theory to figure out what sequences of bit strings are likely, he found something remarkable.

As these random experiences stack up, the conditional probability of the next experience, as described by a string of bits, tends to be higher for simpler bit sequences than for complex ones. This makes it look as if there is a fairly simple algorithm generating the bit strings. So the observer deduces a simple “model” of reality, characterised by regular and comprehensible laws that smoothly connect one experience to the next.

This seems deeply odd: how can randomness give rise to this apparently law-bound behaviour? It’s a little like the way we understand a gas. Although in principle all possible configurations of its molecules are allowed, the probability distribution of particle speeds we see has a simple bell-shaped curve, and the particles are distributed in space with bland uniformity. Out of that come simple laws relating to things we can easily measure: pressure, temperature and volume. Those laws aren’t written into the gas particles themselves; they are an emergent property of the probabilities of different configurations.

“The remarkable thing is that a notion of an objective external world emerges automatically in the long run,” says Müller. What’s more, “different observers will tend to agree on properties of that external world”. That’s because according to algorithmic information theory, the probabilities of bit

Every fragment of your experience makes reality what it is



SUHAIMI/ABDULLAH/GETTY

strings for different observers will tend to converge on the same distribution – so they will agree on what the “laws of the world” are. “Overall, the ‘movie’ is likely to be simple and different observers can generally agree on some aspects of the plot,” says Chiribella.

The surprises don’t stop there. This emergent reality should have just the qualities we see in quantum physics, where objects can show wave-like properties and behave in “non-local” ways, when a measurement on one particle can seem instantaneously to influence

the state of another separated in space.

The upshot is that from the most minimal assumptions about the probabilities of what our personal experiences will contain, you can recover a world like the one we know. “The world could still look something like how we experience it, even though in truth it would be mind-bogglingly different,” says Müller.

It’s not easy to see how Müller’s ideas can be tested. But circumstantial evidence that he could be on the right track comes with the way they solve the problem of Boltzmann brains, an almost metaphysical conundrum that suggests we are not the kind of beings we think we are (see “Spontaneous brains”, left).

All the same, this image of the universe built directly from observer experiences is so “out there” that other researchers barely know what to make of it. It’s “a very interesting starting point, which prompts new questions”, says Chiribella. Meanwhile, Brukner is keeping an open mind. “Markus’s conceptual grasp and mathematical background is strong, and enables him to step outside the comfort zone and come up with true conceptual changes and modifications of our theories,” he says.

Müller himself is deeply aware that he has not chosen an easy path, but argues that it is one worth treading. “It is not as crazy as it first seems,” he says. “But it will be a major challenge to convince people, since the world view that it suggests is so unusual and different from what we are used to.” ■

## COSMIC BRAINS

In the late 19th century, Austrian physicist Ludwig Boltzmann described the world as space filled with particles in random motion, adopting all manner of different configurations.

Experiments have long confirmed that our reality matches this vision, but there’s a problem. If you examine the probabilities of each configuration, it turns out we are much less likely to be sentient beings who evolved on a planet over billions of years than ephemeral lone “brains”, condensed out of chaos by sheer chance and floating freely, complete with imagined memories and experiences. How can we know we aren’t these “Boltzmann brains”, apt to dissolve back into the fluctuating cosmos at any moment?

Physicists and philosophers have

fretted over this for decades. But a radical new perspective can make the problem disappear. If objective reality emerges from the mathematically predictable way our past experiences determine future observations (see main story), then sudden discontinuities in experience of the sort Boltzmann brains would encounter will be vanishingly improbable. Experience should be smooth, connected and, at our scale, rather predictable.

Similar arguments make it unlikely that, as some researchers suggest, we are nothing more than “intelligent agents” in some super-intelligence’s cosmic computer simulation. That too would be vulnerable to abrupt events like shutdowns, whereas we have a persistent perception of reality.

Philip Ball is a science writer. His next book, *Beyond Weird*, is about the meanings of quantum mechanics

# State of unrest

Can fidgeting really help concentration? And do fidget spinners help ADHD? **Christian Jarrett** tries to pin down the science of restlessness



VLADIMIR GODNIK/PLANPICTURE/PFS TOP

**WONDER** whether you will stay completely still until you reach the end of this article. If you do, then perhaps I have done a good job – fidgeting, as you might expect, is a pretty reliable indicator of waning attention.

But is there more to it? For those incessant pen-clickers, hair-twirlers and foot-tappers among us, the urge to fidget is irresistible. The popularity of the fidget spinner is a case in point: earlier this year, variants of it made up every one of the top 10 bestselling toys on Amazon. Many of these gadgets come with claims they can help children with ADHD (attention deficit hyperactivity disorder), anxiety or autism. Some people say fidgeting aids focus, or could even boost efforts to lose weight. So should we all harness the powers of restlessness?

Our interest in the subject has a long history. In 1885, the polymath Francis Galton – a cousin of Darwin – found himself in such a tedious meeting that he measured the amount of fidgeting in the audience, publishing his findings in *Nature*. Freud ascribed deeper meaning to fidgeting, interpreting it as a manifestation of sexual problems. And then in the 1950s, when “hyperkinetic disorder” – later ADHD – came to prominence, fidgeting began to



be seen as a pathological symptom.

Underlying the claim that fidget spinners can help boost attention in those with ADHD, especially children, is the idea that the disorder is associated with chronic under-arousal at a neural level. This hampers mental performance, but the thinking is that movement can compensate by stimulating the neurotransmitters associated with arousal. "When I watched [children with ADHD] working, I could see that they were concentrating, or at least attempting to concentrate, but also that their legs might be moving back and forth," says Julie Schweitzer of the MIND Institute at the University of California, Davis. "They might be tapping their fingers, humming to themselves or somehow producing some other movements. I thought that these might be serving a purpose."

## Positive spin

Schweitzer and her colleagues put this idea to the test in a paper published last year. They asked children to wear an ankle gadget that measured movement during a tricky mental task. For those with ADHD, but not a control group, their movement was more intense in those trials where they got the correct answer.

The finding is consistent with the idea that fidgeting helps kids with ADHD compensate for low arousal levels and pay more attention, although the results need to be replicated. Even so, Schweitzer warns that fidget spinners are unlikely to be beneficial. "The fidgeting I recorded was naturally produced by the children and not external or a toy. The fidget spinners that I have seen are likely more distracting than helpful."

Pouring more cold water on claims of fidget spinners' therapeutic benefits, a recent review in a paediatric journal concluded that these "fad" gadgets simply haven't been subjected to rigorous tests. "Thus, their alleged benefits remain scientifically unfounded."

But what about the rest of us fidgets? While modern psychology has been relatively quiet on the subject, we know fidgeting is a clear sign of a restless mind. One recent study found a correlation between how often people's thoughts wandered and how often they fidgeted – you could say that those prone to mental fidgeting also tend to be prone to bodily fidgets. "When the mind is spontaneously released from the burden of attending to the task at hand, the body is likely to follow suit," concluded the researchers at the University of Waterloo in Canada.

But even if the mind is wandering, fidgeting



could, paradoxically, be a way to help us concentrate on that task. "I see fidgeting as a natural strategy that develops for getting tactile stimulation that may help us to stay focused mentally," says Katherine Isbister at the University of California, Santa Cruz.

This would fit with what is known in cognitive psychology as perceptual load theory, the notion that additional sensory stimulation can actually help us focus. The idea is that the sensory stimulation fidgeting provides uses up "spare" attention that might otherwise get grabbed by distractions. The same principle underlies

## "Fidgeting can help weight loss, apparently burning 800 calories a day"

the finding that doodling appears to help people stay more focused.

James Farley at the University of Alberta in Canada is one of the few researchers to have studied the impact of fidgeting on our powers of concentration. "The missing piece here," he says, "is whether fidgeting is demanding enough to 'soak up' those free resources that could otherwise process distractions." Conversely, he warns that fidget spinners or other forms of "complicated fidgeting" might

## Telling students to stop fidgeting could backfire

boost our cognitive load, which would make it harder to focus on the main task at hand.

To test some of these ideas, Farley and his colleagues recently filmed 21 students as they watched a 40-minute video of a lecture, and later measured how much they fidgeted throughout. Every 5 minutes, the students also noted whether they had been paying attention or daydreaming. Afterwards, the researchers quizzed them about the different sections of the lecture.

Many of the results were unsurprising: attention tended to stray more the longer the lecture went on, and the students' memory of what was presented was poorer during the bouts of distraction. Crucially, fidgeting also increased through the lecture and, unfortunately for the fidgets among us, it correlated with poorer retention of the lecture material, even after factoring out the influence of daydreaming.

However, for Farley, "fidgeting is probably a symptom, but not a cause" of waning attention. He says his results are consistent with the idea that fidgeting is a strategy people use to cope with increased boredom as a demanding task – like paying attention to a lecture – wears on. Unfortunately, it also

happens to be an ineffective strategy, as the experimental findings suggest, although it is still plausible that fidgeting helped the students deal with the physical discomfort of sitting down to watch the lecture.

Of course, it is also possible the students' memory of the material would have been even worse had they been made to sit completely still. Indeed, from a practical point of view, Farley says, it is unlikely to be helpful for teachers to tell students to stop fidgeting. "If you're trying to inhibit something that your body has a tendency to do, that is likely to be taxing in and of itself and may have a further detrimental impact on your ability to direct focused attention elsewhere," he says.

But even if fidgeting isn't great at keeping us focused, it may serve another function – to help beat stress. Early evidence comes from work done in the 1970s by psychologist David Barash at the University of Washington. He spent several hours observing people in a Seattle dentist's waiting room and found that those about to get their teeth seen to were much more likely to fidget than those accompanying them.

Much more recently, researchers at the University of Roehampton, UK, set volunteers a stressful task – doing arithmetic in front of an audience – and found that the more the male volunteers fidgeted, the less stress they experienced – measured both subjectively and according to their heart rate. The same benefit wasn't found for female volunteers, who fidgeted about half as much as the men and who found the challenge more stressful. The researchers speculated that perhaps women try harder to avoid fidgeting and as a result get more stressed.

So it seems there might be two types of fidgeting: one to help calm us down in times of pressure, the other to help keep us alert when boredom strikes. The two may even be connected, as the students in Farley's experiments discovered – because trying to pay attention to something tedious can be uncomfortable and stressful. Either way, this difference may explain the results of a new study that found that how much we fidget seems linked to our personality.

Paul Morris and Amy Warne at the University of Portsmouth, UK, asked volunteers to sit doing nothing for 10 minutes on a specially designed chair fitted with a secret pressure mat that recorded how much they shifted around. Afterwards, the participants completed personality questionnaires. What emerged was that those with high neuroticism or extroversion scores

**Fun for tricks, but not yet proven to help with ADHD**



HOUINBSP/SUPERSTOCK

## WHEN FIDGETING IS NO JOKE

**In extreme cases, the urge to fidget can lead to huge distress. People with a disorder known as restless leg syndrome, or Willis-Ekbom disease, often describe unpleasant sensations such as crawling or aching in the legs or other parts of the body, including the mouth or genitals. They can only relieve these by moving the affected body part. The sensations usually worsen during rest and especially at night. More than 10 million adults in the US are thought to be affected by the condition.**

**The triggers vary from iron deficiency to pregnancy, and there is a clear genetic component. Lifestyle changes, such as taking more exercise and avoiding caffeine, can help. In more extreme cases, people may have to take drugs that alter levels of dopamine, the neurotransmitter involved in movement control. For some, though, a simple technique may also boost dopamine levels and have the same effect on the brain – masturbation has been found to relieve the symptoms.**

tended to fidget the most. This makes sense because neuroticism is associated with greater anxiety, and extroverts are thought to have a lower baseline level of physical arousal when resting, which makes them want to seek out stimulation. Presumably, the neurotic folk fidgeted in the chair as a way to keep calm, while the extroverts simply struggled to cope with the boredom of the situation.

The underlying reason why you fidget could help determine what best to fidget with. Isbister has been researching the different things that people use to fidget, and asked them to submit pictures of their favourites via a blog. If you want to up your focus, "clickable, bendable, twistable things – items that may have mechanical parts and more defined edges – may help you to bring up your arousal level", she says. For stress relief, on the other hand, a smooth, soft object like a worry stone or stress ball may be just the ticket.

I hope you got to the end of this article without too much fidgeting. However, if you did resort to swinging your legs or thumb-fiddling, take heart – it could have an unexpected upside.

In 1999, researchers at the Mayo Clinic and Mayo Foundation in Minnesota instructed volunteers to eat an extra 1000 calories per day for eight weeks while their weight and exercise were monitored. For those who kept the weight off, the key turned out to be increased fidgeting and other subtle movements, even as small as posture control. Fidgeting, it seemed, worked as a kind of automatic weight maintenance strategy. Other, similar research backs this up – all the jiggles and wriggles that the most fidgety among us do apparently burns 800 calories a day. No fidget spinner required. ■

Christian Jarrett is a UK-based psychologist and writer

# Seven elements that rule the waves

**S**EAWATER is a cocktail of elements. Some – like the sodium and chloride that make it salty – are abundant. Others exist in vanishingly small quantities but pack a powerful punch. Iron controls where life can thrive; mercury has the power to snuff it out; and a delicate balance in selenium levels can drive bursts in biodiversity and mass extinctions.

*Like unseen puppet masters, these trace elements control all the living things in the oceans, yet stubbornly resist our best efforts to detect them. Now, for the first time, elaborate studies are revealing where they come from and the grip they exert on ocean ecosystems.*

**Andy Ridgway** investigates

## Iron

Even in iron-rich regions of the oceans there is just 30 nanograms of it per kilogram of seawater. It is so critical that it is the main factor limiting life in one-third of the ocean – all living things need iron to survive, and it is essential to photosynthesis. This has led to suggestions that we should fertilise the oceans with iron to promote plankton growth and stem climate change.

Since the industrial era, oceans have sucked up roughly 40 per cent of the carbon dioxide we have emitted, and are absorbing more and more each year. Some CO<sub>2</sub> simply dissolves into the water, but the rest is taken up by phytoplankton during photosynthesis.

To figure out whether sprinkling the waves with iron would boost CO<sub>2</sub> uptake, we need to know how iron cycles through the oceans. The basics have been known for decades, but recent studies have thrown up a few surprises. For instance, we used to think iron was primarily eroded from rocks on land and carried to the oceans by winds or, to a lesser extent, rivers. We now know that is only part of the story.

GEOTRACES is a global collaboration of oceanographers aiming to map the movement of trace elements in the oceans. In August, it released the results of the first 10 years of its efforts. That data includes nearly 2000 samples from below 2000 metres – a massive improvement on the eight readings that had previously been collected in 10 years of deep ocean iron measurements.

Cruises in the Atlantic, Pacific, Southern and Arctic oceans revealed that deep-sea hydrothermal vents pump huge amounts of

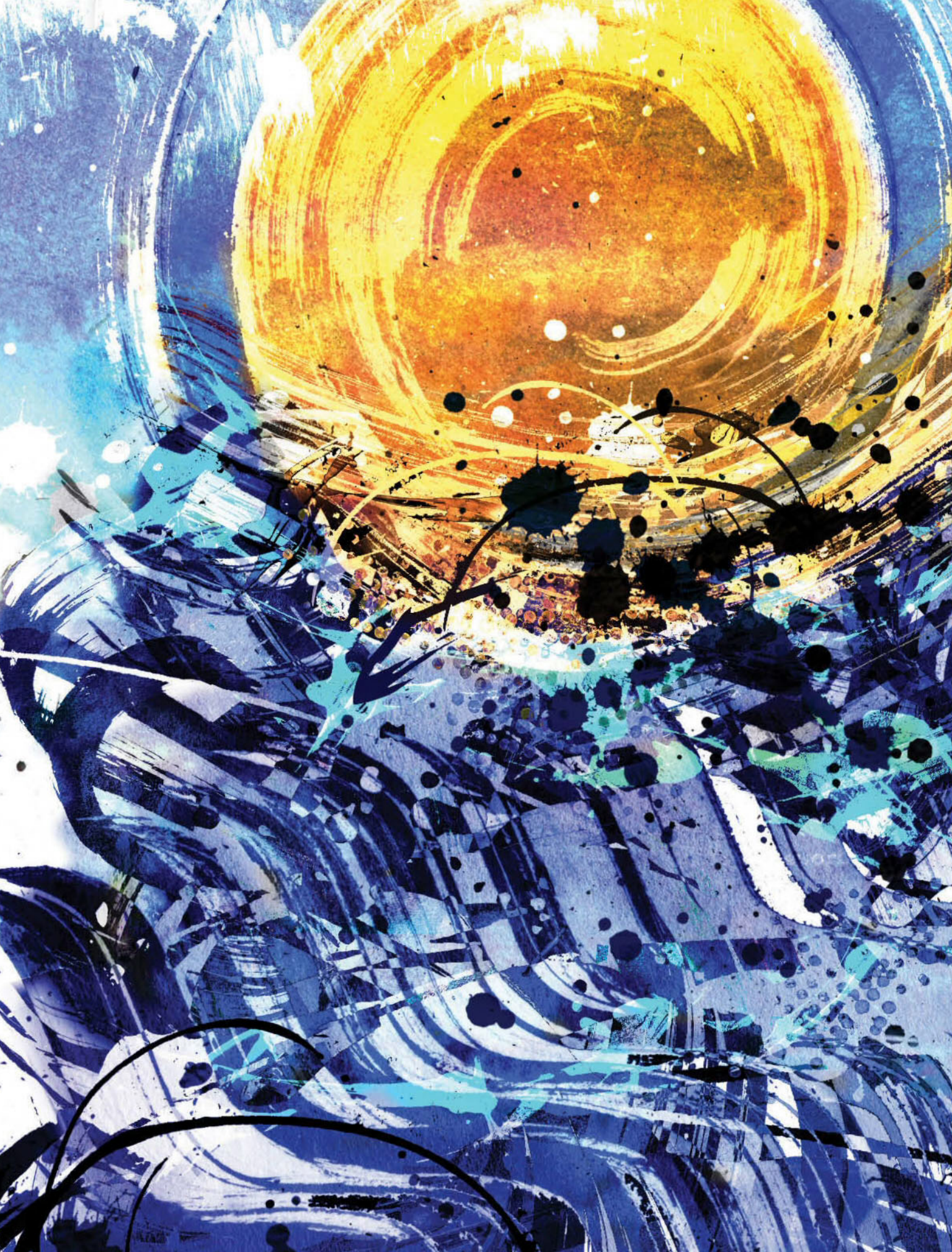
iron into the water. Iron doesn't hang around in the water for a long time – no more than a few years – before sinking to the sea floor. This makes its distribution patchy, which suggests iron fertilisation would be more effective in some regions than others.

## Nitrogen

The importance of nitrogen wasn't lost on the architects of the 20th century's green revolution, which saw a huge rise in the use of nitrogen fertilisers and the dawn of intensive farming. Without it, organisms can't build proteins, and in many land-based ecosystems, the amount of nitrogen available to plants is the primary factor setting a limit to how much life can thrive. Agriculturalists of the 20th century realised this meant that by adding more nitrogen to the soil, they could boost crop yields.

The price we pay is that large quantities run off farmland and into rivers and the oceans. Yet despite the extent to which we are supercharging the nitrogen cycle, we know surprisingly little about what happens once the element enters our oceans. One recent study suggests it is influenced by the Coriolis effect, where ocean currents are deflected by Earth's rotation. Beyond that, how it moves around the seas is a bit of a mystery.

What we do know is that too much nitrogen in the oceans is a problem. Excesses trigger explosions in algal growth that are large enough to suffocate everything else, creating what's known as a dead zone. These are set ➤



to worsen: a study published in July shows that predicted increases in rainfall due to climate change will push more nitrogen into the oceans.

It's a vicious cycle, too. As well as being influenced by climate, ocean nitrogen levels affect the climate. Waters that are rich in

**“We need selenium to make DNA but in high levels it can be toxic”**

nitrogen, for example due to agricultural run off, help the formation of nitrous oxide. Some of that ends up being emitted into the air above, which is a problem because nitrous oxide is a greenhouse gas and it depletes ozone. A third of atmospheric nitrous oxide comes from the oceans – which just goes to show how the hidden trace elements of the oceans can impact life across the globe.

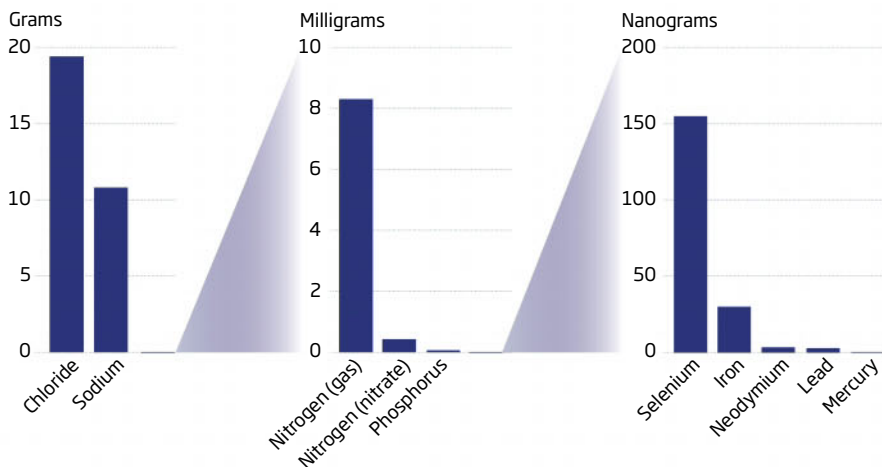
**Phosphorus**

Phosphorus is part of the structure of DNA, cell membranes and the energy molecule ATP. As a result, its availability sets a limit to how much life there can be in the oceans, together with nitrogen and iron.

Nitrogen has historically been the big one, setting a cap on life in 60 to 70 per cent of the oceans. But phosphorus is creeping up in the stakes, as intensive fertiliser use on land releases more nitrogen into the oceans. As a result, some oceans, like the tropical North Pacific, now have plenty of nitrogen.

**Needles in a wet haystack**

On average, there are 3 grams of salt in a litre of seawater, in the shape of sodium chloride. Trace elements are far more rare but have a powerful impact on life in the oceans



SOURCE: MBARI

Elsewhere, things are a bit more complicated. In some ecosystems, two nutrients put an upper bound on how much life can exist in one location at the same time, perhaps because two or more organisms in that environment have different requirements. Current estimates suggest that 5 to 10 per cent of the surface of the ocean is co-limited by nitrogen and phosphorus.

Increasingly, researchers are finding that these interactions between two trace nutrients are in control. “The more experiments we do, the more systems we find that are co-limited, so it’s clearly more prevalent than many of us thought it was,” says Mark Moore at the University of Southampton. His team is investigating co-limitation by lifting tanks of phytoplankton out of the sea and adding nutrients to see what happens. “It’s kind of bucket biology, it’s just that you need a very clean bucket because a lot of the work we do is with trace metals.”

**Selenium**

There is a narrow window where levels of this micronutrient are just right for life – call it the selenium Goldilocks zone. Selenium is essential for most organisms, including us. We get it from various foods – fish, chief among them – and build it into the proteins we need for making DNA, for reproduction and to regulate our hormone levels, among other things. It even helped drive the Cambrian explosion some 500 million years ago, when most animal groups first appeared on Earth.

But in higher concentrations it can be toxic.



**Gold smelting is toxic to the oceans; black smokers are a surprise source of iron; measuring trace elements can be chilly business**



“This is the case in the San Francisco Bay and some lakes and reservoirs in the US and elsewhere,” says Greg Cutter at Old Dominion University in Virginia. In the mountains upstream of San Francisco Bay, selenium is eroded off the rocks and carried into the bay – a journey that has been amplified by irrigation for agriculture. Nearby oil refineries also discharge effluents rich in selenium into the ecosystem.

Federal limits were put in place to stem the arrival of selenium after deformed ducks and other animals were found in wildlife refuges downstream in the 1980s. Recent studies suggest that these limits are still too high, triggering calls for more stringent regulations.

The delicate balance of selenium has caused havoc at the other end of the scale, too. Low selenium levels have been linked to no fewer than three mass extinctions. At the end of the Ordovician, Devonian and Triassic periods – when three unexplained mass extinctions occurred – selenium levels in the ocean dropped two orders of magnitude lower than their current levels, well below what’s needed to support animal life.





ELENA CHERNYSHOVA/PANOS



CORY MENDENHALL U.S. COAST GUARD ACADEMY

So all that mercury from the industrial revolution still has the potential to affect us today.

It's not just the overall volume of mercury from human activities that has been a surprise. The latest data also sheds light on where it comes from. According to the 1850-2010 inventory, coal burning has accounted for 38,000 tonnes of the stuff. This was previously thought to be the largest human source, but it turns out there's a far bigger culprit: gold production has chucked out 221,000 tonnes and silver production 365,000 tonnes.

"Most people think human activity has dramatically perturbed the carbon cycle," says Sunderland. "That same realisation has not taken place for many of the other cycles of the elements that we have been using in human activities. I wouldn't say there's too much of a focus on carbon, but our focus needs to be on more than just that."

## Lead

Like mercury, lead accumulates in the food chain. It is absorbed by plankton, and moves into herbivores and the animals that eat them. It can be toxic to all of these, and ultimately to the animal right at the top of the seafood chain: us. Because levels get higher as it moves up the chain, tiny amounts in seawater can have large consequences for big predators. It meddles with enzymes and how our cells function, is harmful to our hearts and kidneys, and can cause irreversible brain damage.

Almost all the lead in the oceans has come from human activities. At the same time, it is tricky to measure. For a long time, ships were coated in lead paint; water sampling devices were made of plastic that contained lead; there is even lead in the air around a ship, from the

***"Mercury from the industrial revolution still has the potential to affect us today"***

fumes it belches. "It's basically everywhere in the human environment," says Ed Boyle at the Massachusetts Institute of Technology.

To get accurate measurements of lead in seawater, researchers have had to come up with complicated protocols. "We generally don't sample in the upper 20 metres or so of the water, as that's basically bathing in ship juices," says Phoebe Lam at the University of California, Santa Cruz. Sampling tubes

are stored in containers filled with filtered, pressurised air. The container doors, made of metal, have to be opened by someone who won't touch the tubes. Metal frames that hold the tubes are powder coated and steel cables that hold the frames are wrapped in Kevlar. Later, there is the challenge of detecting trace atoms in seawater samples. "You've got 3 per cent salt in the water," says Boyle. Compare that with the tiny amount of lead (see graph, below left), and "you are looking for a needle in a haystack if you want to see a lead atom in all that sodium chloride", he says.

Attempts are finally bearing fruit. They have revealed that since the US, Europe, Canada and Mexico banned lead in petrol in the 1990s and 2000s, there has been a 10-fold reduction in lead levels in the North Atlantic. Elsewhere, it's not such good news. In the North Pacific, initial reductions have been overwhelmed by recent Chinese emissions, mainly from burning coal.

## Neodymium

Some trace elements are neither a nutrient or a toxin. Our interest lies in what they tell us about other trace elements. The rare earth element neodymium, for instance, helps us follow the journey of other elements.

That's all down to how neodymium ages in rocks. The younger the rock, the higher the ratio of two isotopes, neodymium-143 to neodymium-144. When a rock is eroded, the dust that is blown into the ocean carries a neodymium fingerprint with it, like a time stamp.

"The age of the rock has been mapped around the world," says Bob Anderson at Columbia University's Lamont-Doherty Earth Observatory. This means that when researchers find neodymium in the ocean, they can look at its time signature and match it to places on land that have the same age to figure out where it is most likely to have come from. And because trace elements often travel together, it helps them identify probable sources of other elements like iron.

Pinning down key sources on land could help us protect the oceans. For instance, farming new areas or building new roads and houses can hold dust down. If we know which regions produce dust that is a particularly important source of iron to the oceans, then we can avoid starving oceans that are thousands of kilometres away. ■

## Mercury

Mercury isn't a force for good. It has no function within cells and is toxic to nervous systems. It has been found in concentrations approaching toxicity levels in oceans and lakes, accumulates as methyl mercury in aquatic organisms, and causes brain damage, birth deformities and reduces reproduction rates. Yet how much there is, and where it all ends up, has been unclear.

Because of mercury's hazardous nature, 128 countries have signed up to the Minamata Convention in order to curb its release. In April, a global inventory of cumulative mercury discharges between 1850 and 2010 was published, showing that 1.5 million tonnes were released due to human activities alone. That means 78 times more mercury has been released by things like burning fossil fuels than by natural sources – far more than had previously been thought.

"Once mercury has been released into the [environment], it bounces around for a long time, on the order of hundreds of years to millennia," says Elsie Sunderland at Harvard University, who contributed to the inventory.

Andy Ridgway is a freelance writer based in Bristol

# Time to look on the bright side of death

People in the West would benefit from a more positive, intimate approach to dealing with the death of a loved one, says **Caitlin Doughty**

**You advocate the idea of “death positivity”.**

**What does that mean?**

For so long in the US and the Western world, we’ve taken the attitude that having an interest in death is morbid. But in fact, it’s morbid to try to cover it up, sterilise it and not think about death. Death positivity doesn’t mean that when your mother dies, you are just supposed to accept it and buck up. It means that it’s OK to be interested.

**Why do we need to be positive about death?**

When I joined the funeral industry, I saw how broken it was and how distant the families were. If a grandparent or even a parent dies, children are kept from the funeral, because it would be “too much” for them. Our children watch TV shows about zombies and cartoon anvils and crimes, but never see a single real dead body or funeral. I had this moment of awakening when I realised I was born into a system, a culture, that sets me up to feel this incredible fear about death. There’s no way to have a logical, healthy relationship with death if everyone around you treats it like a myth. Changing that became my passion project.

**What’s the typical interaction with death in the US?**

The biggest thing is that death is treated as an emergency, that the body is taken away immediately into the hands of the professionals. Then there is a real lack of education about what options there are. Because there is such a taboo around death, people always assume the funeral professional is the expert and that the options they give you are all that exist. But it’s a business. If you walk into a luxury car dealership, they’re not going to show you their cheaper cars first, they’re going to show you the Mercedes.

There are very real economic consequences to this: if you go into a funeral home and walk out with a \$12,000 bill, that can bankrupt families. A lot of people aren’t aware that [in many countries, including the US and UK] you can keep the body at home for a simple wake, and that’s free. You can still have everybody over, have a big potluck meal and a respectful service. The consequence of the silence over your options isn’t only estrangement from death, it’s also the risk of spending thousands and thousands that you may not have.

**Why do many people in the West maintain such a distance from death?**

It’s a perfect storm of reasons. At the beginning of the 20th century, you had funerals put into the hands of funeral professionals, dying and death in the hands of medical professionals, and slaughterhouses placed at the edge of town so people were no longer killing their own animals. Death was part of the fabric, and then suddenly it wasn’t.

But we had gone through several wars with serious loss of life, so people thought OK, let’s hand over death to a professional. And now we are discovering it’s not that easy: you can’t outsource the actual grief or mourning.

**Wasn’t death taken out of our hands for good reason - to prevent the spread of disease?**

There’s this myth that corpses pose a health risk, but it just isn’t true. The World Health Organization states this clearly. At the end of the 19th century, people believed in miasma – the concept of disease floating up off everything that stank or rotted, including trash and dead bodies. Early funeral directors used this to convince people that embalming was necessary to sanitise the body. They still say that today, even though by law they are

**PROFILE**

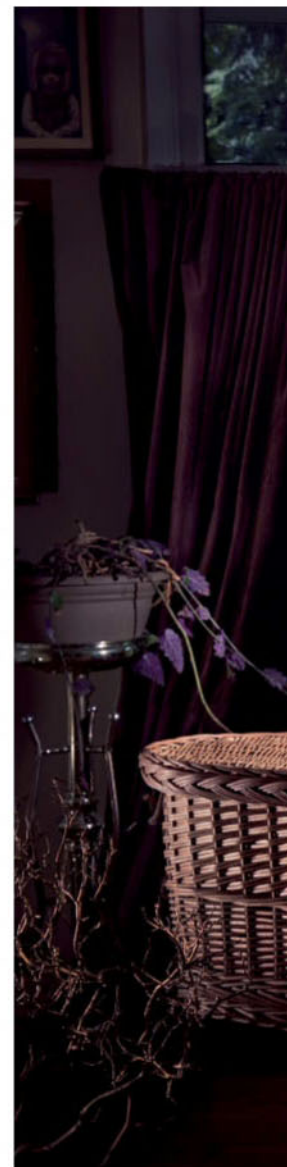
Caitlin Doughty is a mortician and funeral home owner in Los Angeles. Her latest book is *From Here to Eternity: Travelling the world to find the good death* (W.W. Norton)

not allowed to claim it does. It is virtually never true, except when the person dies of something like Ebola.

**You recently travelled the world to learn about death rituals in other cultures. How do they compare with those in the US?**

There is a sense in the Western world that the distance we maintain is somehow more respectful. Many people assume other cultures are showing less respect if they mummify the bodies of their dead, as they do in Tana Toraja, Indonesia, or have animals eat the bodies, as they do with vultures in places such as Tibet. But there is no culture that doesn’t conduct a death ritual with respect, love and the desire to be dignified.

If you want to talk about who is disrespectful of their dead, it’s our culture that comes closest to just ditching the body, putting it out of sight and out of mind. I think we really need to examine that urge to push death away.





HOLLY ANDRES

**You seem to suggest that many other cultures have a more intimate relationship with death. Why is it important to have that?**

This is someone you loved; or even if you hated the person, they took up a lot of your mental space and emotional energy when they were alive. You had an intimate relationship with them – not to acknowledge that with intimacy in their death is like cutting off a limb and hoping it will just heal itself. Plunging in and being involved is really the way to come out the other side and feel like you've done something. That interaction is what we are missing.

Japan is a great example. It is a developed, technologically advanced country. Its people are exactly like us in the West in many ways,

**“Having my dead body consumed by vultures is something I really want”**

and they have a culture in which they can show up and be with the body. For instance, they have a custom called *kotsuage* where, after cremation, family members use chopsticks to pick up the remains of their loved ones' bones and place them in the urn.

**So you think people in the West need to be more hands-on in death rituals?**

Humans have been engaging in ritual for tens of thousands of years. Ritual consists of action plus belief. The US funeral industry is designed to promote inaction: don't touch the body, don't dig the grave, don't clip the hair, don't sing, don't even cry if you can help it. We are missing the small physical actions that are the work of grief. Showing up, being present, changes how you feel about the death. People don't know they can be involved and do things like take a lock of hair or witness the cremation – and basically just interact with the process.

**What about the people who don't want to interact with their dead loved ones?**

I'm absolutely saying these interactions are for everyone. But do I think everyone will choose to participate? No, there's a lot of built-up bias and fear. But the more that people embrace this and have positive, meaningful experiences, the more others will feel confident in trying it.

The basic interaction of human-plus-dead-body had been the equation for thousands of years. This modern approach of removing the dead body to the hands of professionals is unprecedented.

**What do you want to happen to your body when you die?**

Having my body consumed by vultures is something I really want. It's not accepted, or legal, in our culture, though. Maybe by the time I die it will be. If so, sign me up. ■

Interview by Tiffany O'Callaghan

# The amazing power of the conversation machine

The to and fro that happens when we talk is key to understanding language, challenging our view of human nature. And what if those first exchanges began much earlier than we thought? **Alun Anderson** explores

*How Language Began: The story of humanity's greatest invention* by Daniel Everett, Profile Books  
*How We Talk: The inner workings of conversation* by N.J. Enfield, Basic Books

DO LINGUISTS need to get away from the library and spend more time talking? Ever since Noam Chomsky revolutionised linguistics in the 1950s, research has focused on the structures underlying grammatically correct sentences and on our astonishing ability to both generate and understand an infinity of expressions. Now two new books separately argue that the to and fro of conversation is key to understanding language. If they are right, the idea of language as a computational system needs to make some room for that of language as a tool for cooperative communication.

Daniel Everett of Bentley University, Massachusetts, and Nick Enfield at the University of Sydney start from different places. Everett's wide-ranging *How Language Began* is rooted in his 30 years working with tribal groups in the Amazon as an anthropologist. Enfield's *How We Talk* comes out of the lab and speeds through extraordinary experiments on the fast-paced, interactive flow of conversation.

Everett has already had a famous debate with Chomsky and his colleagues, related in Everett's

bestseller *Don't Sleep, There Are Snakes*. He set out as a missionary to live with the Pirahã, a group of Amazonian hunter-gatherers, aiming to learn their language and translate the New Testament into it. Instead, his encounter with this happy culture, which values "immediacy of experience" over unsubstantiated tales, led him to lose his faith and to discover that their language was unlike anything studied before.

Pirahã appears not to use recursion, the way in which other languages tuck phrases inside other phrases to build more complex sentences. That seemed to challenge core ideas about language and sparked a huge controversy. Now it is more accepted that languages can be

**"Homo erectus, who lived over 60,000 generations before us, led the way: we are merely an upgrade"**

expressive without necessarily using recursive forms.

Surprisingly, the hero of *How Language Began* is not modern humans, but *Homo erectus*, who lived over 60,000 generations before us. "The greatest hunter. The greatest communicator. The most intrepid traveller. Perhaps the greatest distance runner on Earth" is how Everett sees our ancestor. *H. erectus* led the way: we are merely an upgrade.

Everett's speculative account

of our forebear's life and travels are the most remarkable parts of a remarkable book. I felt I had been born 1.8 million years too late. Although my brain would have been just two-thirds of its modern size, a pristine world would have lain before me.

*H. erectus* left their home in Africa and spread throughout Europe and Asia, ever onwards. Their tools, settlements, use of fire and crossing of waterways in boats or rafts all shout to Everett that it was "upright man" who first had symbolic thought and culture, and must have invented the first forms of language, too.

Everett begins his argument with the life of *H. erectus* and the origins of symbolic thought, moving through millennia of "upgrades" to our brains, vocal apparatus and language in all its varieties. We travel from *H. erectus*'s simple exchanges to our ability to pour out over 100 words per minute in conversation.

By pushing language's origins back so far, Everett again collides with Chomsky, who sees language emerging in *Homo sapiens* about 80,000 years ago. But Everett doesn't merely dispute the "when" of language, but also why it was invented and how it changed. By "invented", Everett means just that: language was a creation of culture, growing out of humans' developing social cognition and capacity to use symbols. For him, language is a



BRUCE GILDEN/MAGNUM PHOTOS

communicative tool and not the product of sudden genetic change that gave *H. sapiens* new powers of thought, as Chomsky argues.

What kind of language might *H. erectus* have spoken? The earliest languages might simply have had a series of loosely ordered words and gestures. The shared context and culture would have been enough "to determine the interpretation needed", writes Everett. More complex languages, with hierarchy and recursion, could have evolved from there.

At each step, language would have to fit our cognitive and perceptual limitations, auditory range, vocal apparatus and brain structures. At the same time, the advantages of communicating successfully would create new selection pressures on humans:



brains evolved for languages, and languages evolved for brains. But, stresses Everett, language didn't begin with the first word but "the first conversation, which is both the source and the goal of language". Language is about interaction, about the simplest exchange in a shared culture.

Everett's "baby steps" version of how language evolved is at odds with Chomsky, who explains in *Why Only Us*, his 2016 book with Robert Berwick, that language did not emerge for communication, but from a "slight rewiring" giving some individuals new powers of thought. Chomsky is adamant that "there is no room in this picture for any precursors to language – say a language-like system with only short sentences". There is a clear

choice: communication and conversation came first and grammar later, or a language of thought came first and was later "externalised", as Chomsky puts it.

Conversation is central for Enfield, too. His sparkling book, *How We Talk*, sets out to show that the power of the "conversation machine" is as astonishing as any of our grammatical achievements, and that how we direct our fast-paced exchanges challenges how we think about human nature.

The action, Enfield explains, is concentrated in a 1-second window that opens as soon as someone stops speaking. Taking an average from 10 languages, an answer to a question will appear in around 200 milliseconds – the time it takes to blink. English speakers average 236 ms, while

#### All modern human languages depend on fast-paced exchange

the Japanese manage it in an astonishing 7 ms and the deeply thoughtful Danes in 468 ms.

We soon discover the timing of replies can be manipulated. "Do you want to go for a drink?" Reply "yes" inside 200 ms and you are off to the bar; delay another 400 ms and you will be asked if you really want to go. But choosing "no" in the first 100 ms signals flat rejection. Say nothing in that 1-second window and you may face a frown for your lack of cooperation and be asked again.

Then there are the "uhs" and "ums" of English: "uh" says hold on for a short time (about 250 ms), while "um" indicates you should expect a longer delay (about

700 ms). Both delays can either signal "Hold on, I'm processing what you've said", or warn that a negative response is coming.

Finally, there is "huh". In 2013, Enfield and his colleagues found that this, or something sounding very similar, was the one universal "word" in all languages. It is, he explains, the quickest, easiest sound humans can make, and a speedy sound is needed to interrupt fast when you lose track of a conversation and need help.

There is a deeper significance here, too. "This little word, like the turn-taking system it operates in, suggests a moral architecture to communication," says Enfield. "Huh" symbolises "universal cooperation", the commitment people make to "help each other, where necessary and possible, to stay on track in conversation". That requires social cognitive skills unique to our species, writes Enfield, for even 2-month-old babies love to take turns in their interactions with adults.

Enfield closes his slim book with an inspiring chapter. We are, he argues, "on the verge of a full-blown scientific revolution in research on the human capacity for language". He lays out the two current big ideas: that language can't exist without specifically human forms of social cognition and interaction; and that language is a "private, purpose-specific computational system for operating upon information".

For Enfield, though, there is no need for one idea to triumph over the other. Rather, we can draw on all sorts of research. We can, say, welcome what has been learned about the structure of language while looking at how the flow of conversation may have shaped grammar. Despite the dismissive and brutal arguments common in linguistics, he is optimistic a new generation will build bridges.

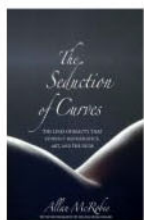
I suspect Everett would welcome that future too. ■

Alun Anderson is an editor emeritus of *New Scientist*

# Fetching figures

Maths, perception and beauty are close bedfellows, finds **Philip Ball**

*The Seduction of Curves: The lines of beauty that connect mathematics, art, and the nude* by Allan McRobie, Princeton University Press



CAN you find your own butterflies, swallowtails and wigwags? They are right there on your body: the geometrical figures that appear

when smoothly curved surfaces are viewed from the right angle. Structural engineer Allan McRobie's *The Seduction of Curves* is your guide to these most intimate of mathematical objects.

McRobie's underlying point is a good one: why do we teach geometry as a rectilinear discipline when so much of what we encounter in life, from bodies to landscapes to drapery, consists of curves? And not just the familiar parabolas and valleys of quadratic and cubic functions, but the singularities that result from a three-dimensional view of surfaces. McRobie explores these familiar yet unrecognised shapes, navigating with the aid of mathematician René Thom's catastrophe theory.

Thom was a formidable expert in topology who won the coveted Fields medal in 1958. Yet his catastrophe theory feels now like the mathematical equivalent of flares and patchouli oil: very much of its time, namely the 1960s and 1970s. It was the chaos or complexity theory of its day, allegedly pertaining to pretty much anything from economics to fundamental physics – without

**No accident: renaissance nudes boast complex geometries**

ever quite explaining any of it.

Thom wrote in a dense, obscure and quasi-mystical style, full of enigmatic definitions that postmodernists like psychoanalyst Jacques Lacan lapped up and mimicked. Jean-Luc Godard made a documentary about him; Salvador Dali painted an homage to him. That's the kind of thing that turns you into a cult figure with a finite shelf-life.

Yet McRobie's revival of Thom's taxonomy of curves is persuasive, showing how they define the landscape of the artistic nude. They progress in a series of increasing complexity from the

parabolic fold to the cusp (that point where the two arcs of a loop of wire just start to visually overlap, making a sharp apex), the double-cusped "swallowtail", triple-cusped "butterfly" and so on. These curves feature even more prominently in optics: they are the bright bands and cusps of caustics, seen as light passes through a wine glass or a pool.

Mathematically, cusps are singularities: places where things

**"Why do we teach geometry as a rectilinear discipline when so much of the world consists of curves?"**

get infinite. They are related to critical points in statistical physics – which is one reason why catastrophe theory wasn't much of a revelation to physicists.

But it was useful to structural engineers, since cusps are also related to the point at which stressed surfaces buckle and wobbly structures topple. McRobie ignores, however, the extensive recent literature on buckling and wrinkling, such as the analysis of the folds of drapery and paper, or the dimples and ridges of seed pods and fruits – a shame, since these issues too beg for aesthetic investigation.

No, it's bodies that are the focus here, particularly in relation to art. Was Leonardo da Vinci's recommendation that bodies be depicted in twisting posture an implicit claim for the aesthetic appeal of the fleshy cusp? Thom's curves involve surfaces hidden but implied behind cusps and folds: a kind of geometry of desire. McRobie has some sly fun with it: "I once spent the best part of a pleasant evening trying to find a butterfly [cusp] on my wife's hip," he tells us. (What he found instead was a rare form called a gull.)

In taking on not just the artistic but the evolutionary and sexual aspects of his subject, he could have gone further. His notion of the nude is the idealised form of Velazquez's *Rokeby Venus* or Michelangelo's *David*, and the book hovers on the edge of saying something provocative about whether there's a geometry of maximal arousal, both aesthetic and erotic. That would set a cat among the pigeons. ■

Philip Ball is a freelance science writer



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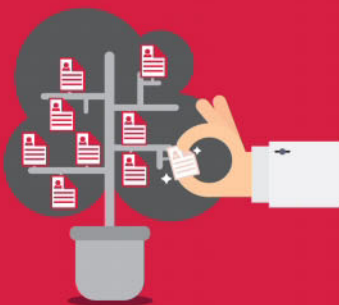
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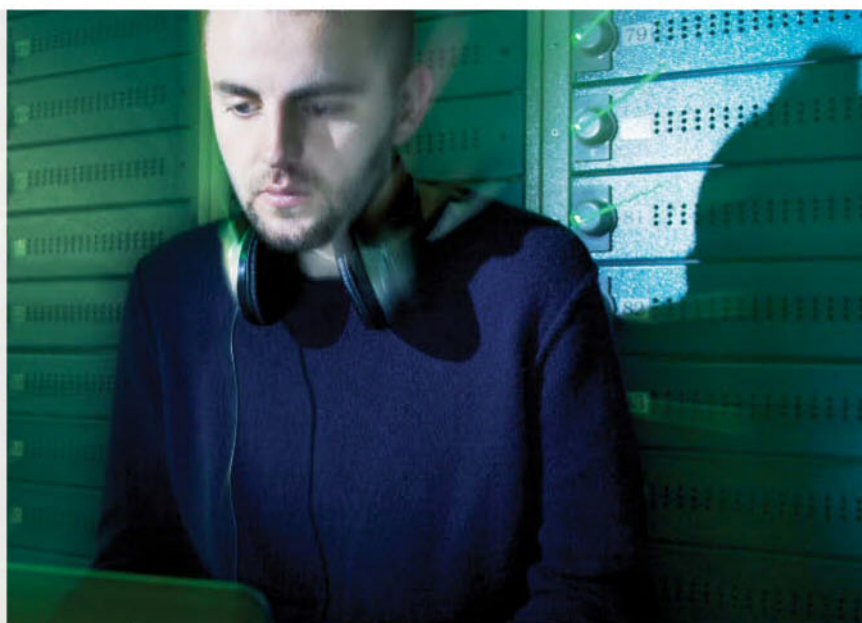
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## EDITOR'S PICK

## Focusing attention by wagging eardrums



From Marco Overdale, *Martinborough, New Zealand*  
Aylin Woodward reports research finding that our eardrums coordinate with our eyes to shift our hearing in the direction we are looking (29 July, p 12). Pauline Keyne asks whether our eyes are in fact following our ears (Letters, 30 September). This set me

thinking. Since I experimented with two turntables playing the same record, one to each ear, I have been fascinated by the way the brain detects the location of a source sound partly through minute differences in its arrival time at each ear.

The left and right eardrums both moving to the right would, by changing the sound arrival times at each eardrum, tend to make a sound appear to come from further to the right. A sound coming from the left might then appear to come from directly in front of the listener. Coordinating this change with an eye movement to the left would therefore make a sound from the left appear to be coming from the centre of view. Is the brain making it easier to identify sound sources by moving them to the middle of our vision, perhaps?

## Body cameras and the view from above

From Susi Arnott, *London, UK*  
Alice Klein asks whether body-worn cameras are defusing tense situations (21 October, p 22). What about closed-circuit television? This gives what fluid mechanics calls “Eulerian” data – collected from a fixed point overseeing a predetermined space. Body cams, meanwhile, record “Lagrangian” data – a flow of events befalling one “particle” or participant. Has any work been done on the effect of events being recorded from these two points of view?

## Big Brother is sniffing your mobile device data

From Sam Edge, *Ringwood, Hampshire, UK*  
You say a billboard in London’s Piccadilly Circus that displays

advertises on the basis of what cars are passing “will mitigate any dystopian overtones by providing free Wi-Fi, too” (21 October, p 4). That sounds suspiciously like a way to extract useful metadata from passers-by, rather than an altruistic gesture.

## History is never just one story, but a rambling tale

From Frank Aquino, *West Leederville, Western Australia*  
Phillip Ball’s piece asking whether a religious revolt created science was excellent (28 October, p 32). It reminds us that history is never just one story, but a disparate collection rambling ambiguously into the future.

Believing that science will eventually prevail over vested denial may be comforting for historians, but is problematic for those who live and die during

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**“With funding and good cooperation between nation states, yes, this can help rhinos”**

Jess answers a Tweet asking whether an international convention promising to protect sharks will help (4 November, p 4)

times when it doesn't, such as environmentalists in the US now.

**Reasons to ban smacking, part two**

*From Barry Cash, Bristol, UK*  
 Jessica Hamzelou argues that all countries should ban smacking (28 October, p 25). Having been to a school run by the infamous Congregation of Christian Brothers, may I point out a “benefit” of corporal punishment that she did not mention? Adults enjoy handing it out. That is another reason for banning it.

facial injuries treated at Queen Mary’s Hospital, Sidcup, UK (Signal Boost, 21 October). I would like also to remember Harold Gillies, the pioneer of plastic surgery who masterminded the whole operation there. He assembled a multidisciplinary team to carry out groundbreaking work. In 1930 he persuaded his cousin Archibald McIndoe to join his practice and they both continued the work during the second world war.

In 1946 he carried out the first sex reassignment operation in the UK. I cannot understand why he is not more widely known.

**Remember pioneering surgeon Harold Gillies**

*From David Bentley, Egham, Surrey, UK*  
 Ellie Grigsby seeks support for a memorial to the veterans with

**No shark fishery has ever been sustainable**

*From Brian Darvell, Neston, Cheshire, UK*  
 Lesley Evans Ogden’s Comment piece opposes a ban on selling

shark fin in the US (14 October, p 24). It draws on a paper arguing that this would undermine sustainable shark fisheries. But no shark fishery has ever been shown to be sustainable. The Walt Disney Company found this out at great expense some years ago and finally banned shark fin soup from its menu in Hong Kong (22 July 2005, p 6).

**A chance to research “young blood” effects**

*From Derek Hodges, Perth, Western Australia*  
 As a person in my late 50s I was fascinated by Sally Adee’s report on the use of “young blood” in rejuvenation efforts (30 September, p 39). I was intrigued by the suggestion that simply removing “bad blood” might be the prime mechanism. As a chemical engineer I am well

aware of the need for a purge stream in any closed-loop cycle.

Surely there is a population of blood donors who have donated every couple of months for more than 40 years. Do they have a longer lifespan or otherwise indicate a younger “biological age”? Has anyone examined that?

**In defence of raising meat on pasture land**

*From Don McDonald, Lake Audy, Manitoba, Canada*  
 Daniel Benetti suggests that land used for cattle raising should be converted to cropland to feed fish (Letters, 21 October). This misses the point. Cattle can be raised on pasture, usually unsuited for the production of annual crops. Light rocky soils erode rapidly under cultivation and are best left in permanent cover. Cattle are

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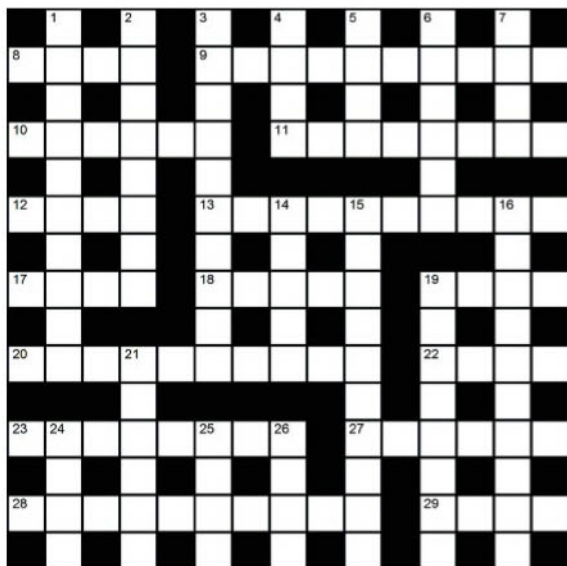






# CROSSWORD

Compiled by Richard Smyth



## Crossword No12

### ACROSS

- 8 Robert \_\_\_\_ (1843-1910), German bacteriologist (4)
- 9 Dinosaur of the Cretaceous, discovered in India (10)
- 10 Organic compound also known as carbolic acid (6)
- 11 State of drowsiness induced by a drug (8)
- 12 Precipitation resembling frozen (4)
- 13 In anatomy, relating to the collarbone (10)
- 17 Magnetite and bauxite, for example (4)
- 18 Of a chemical, to change in response to stimulus (5)
- 19 Name given to a hominin skeleton discovered in Ethiopia in 1974 (4)
- 20 Outdoor activity based on Global Positioning System technology (10)
- 22 Precipitation resembling molten (4)
- 23 Margaret \_\_\_\_ (b. 1936), MIT computer scientist noted for her work on the Apollo space programme (8)
- 27 The point of greatest distance between Earth and the moon (6)
- 28 Term descriptive of certain electronic devices, distinct from those using vacuum tubes (5,5)
- 29 Genus to which the holly belongs (4)

### DOWN

- 1 Desert plant also known as the yucca palm (6,4)
- 2 Viral disease characterised by a painful rash (8)
- 3 Electrical insulator that can be polarised by an applied electric field (10)
- 4 *River Out of \_\_\_\_*, 1995 work by Richard Dawkins (4)
- 5 The meaning of the "U" in UGC, with reference to social media (4)
- 6 Logic puzzle first popularised in Japan (6)
- 7 Photographic film company founded in 1934 (4)
- 14 Grouping of arachnids that includes mites and ticks (5)
- 15 \_\_\_\_ circuit, another term for a microchip (10)
- 16 Inventor and mathematician of ancient Greece (10)
- 19 In human anatomy, the normal curvature of parts of the spine (8)
- 21 (C<sub>8</sub>H<sub>13</sub>O<sub>5</sub>N)<sub>n</sub> - component of fish scales and arthropod shells (6)
- 24 Nerve fibre (4)
- 25 In computing, a unit of work (4)
- 26 Wiki for researchers in physics, maths and philosophy, established in 2008 (4)

### Answers to Crossword No11

**ACROSS:** 1 QUARTILE, 5 OBTUSE, 9 ATOM BOMB, 10 COGITO, 12 AMBERGRIS, 13 EPOXY, 14 SALK, 16 SURFACE, 19 ELECTRO, 21 INCH, 24 POLIO, 25 ISOGAMETE, 27 I, ROBOT, 28 SOLUTION, 29 TETRYL, 30 GENE POOL. **DOWN:** 1 QUASAR, 2 AMOEBA, 3 TUBER, 4 LAMARCK, 6 BIOMETRIC, 7 UNIPOLAR, 8 ECOTYPES, 11 ISIS, 15 ASTRONOMY, 17 DEW POINT, 18 CELL COAT, 20 OTIS, 21 IRON ORE, 22 MEXICO, 23 VERNAL, 26 ACUTE.

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IN VINO veritas, as the Romans would say, but the linguistic benefits of alcohol might include more than just a predisposition for blunt honesty. Researchers at Maastricht University in the Netherlands wanted to know if there was any truth in the belief that imbibing alcohol can also improve your second language skills.

Fifty native German speakers who had recently learned Dutch were given a “low dose” of alcohol or a placebo, and then took part in a standardised speaking test. Tipsy Germans were consistently rated as having better pronunciation skills than their sober counterparts.

Feedback thinks it's essential this study be replicated in other languages, not least to find out if Dutch simply benefits from sounds like slurred German phonemes, but also to know which languages we ought to learn to justify alcohol as a teaching aid.

MEANWHILE, US president Donald Trump seems keen on rejuvenating the US manufacturing industry by making the nation the leading exporter of alternative facts. Previously, Feedback noted his

selection for a role in the Environmental Protection Agency of energy industry attorney William Wehrum – a man who struggled to see the facts on climate change even when they were printed out on a giant chart in front of him (28 October).

And this trend, like the increasing concentration of carbon dioxide in our atmosphere, shows no signs of abating. Last month, Kelly Craft found herself sworn in as the US ambassador to Canada after she and her husband donated \$2 million to Trump's presidential campaign. Asked by CBC news whether she believes in climate change, Craft said she thought there was accurate science “on both sides”, and that she would “appreciate and respect both sides of the science”.

Well, it is the diplomatic answer, we suppose. But what prompted CBC to raise the topic of climate change at all? Could it be that Craft's husband is none other than Joe Craft, the billionaire CEO of Alliance Resource Partners, third-largest producer of coal in the US? What a coincidence!

The *Daily Mail* reports that Tottenham Hotspur manager Mauricio Pochettino keeps a bowl of lemons on his desk to “absorb negative energy”. Is he taking the pith?

AN IMPORTANT victory in the rise of the robots: Saudi Arabia has awarded citizenship to Sophia, an android built by Hong Kong-based Hanson Robotics. Sophia appeared at the Future Investment Initiative summit in the country's capital Riyadh to accept the distinction. Taking the stage without a male chaperone and with her head uncovered, it seems the animatronic puppet has already been granted more freedoms than the country's real women.

COULD drinking probiotic yogurt deflate troubled tummies? Researchers at the Seoul National University Research Park and their colleagues fed 21 healthy adults a mix of *Lactobacilli* and *Bifidobacteria* to see the impact on gut flora.

After 60 days, pathogenic strains such as *Citrobacter*, *Klebsiella*, and *Methanobrevibacter* were all significantly reduced – the last one correlated with a decline in flatulence.

Good news perhaps for the makers of probiotic supplements, such as CTCBIO Inc, which funded the study. But our attention is drawn to the disqualifications.

Two participants were dropped from the final analysis: one left the study for personal reasons, while another was rejected after their stool sample failed to pass a “quality control test”. And you thought your job was crappy.

FEEDBACK has been collecting theories on what the mysterious object discovered on a Rhode Island beach might be (28 October). Bob Ladd writes: “I can say with some certainty that donkey rides along the beach are not a feature of American life, and that this rules out Jo Watson's proposed explanation of a hay feeder.”

A Rhode Island native, Bob says he spent many summer hours at beaches in the north-eastern US as a child without spying donkeys of any variety. “In fact, I'm embarrassed to report that despite having lived in the UK for more than 30 years, it was only two years ago that I even became aware of

the British association between beaches and donkeys.”

Don't be too hard on yourself, Bob - there aren't that many beach days in a British summer... or even 30 of them.

NOT content with selling consumers remote buttons that can order household items directly from Amazon, the tech giant unveiled the latest in frictionless commerce: a smart lock that will allow the company's delivery personnel into your home.

What could possibly go wrong? Still, it is surprising that after resisting the UK home secretary's demands that back doors be added to their security software, tech companies are so keen on us giving up the keys to our own.



A SIGN of the times: University of Pennsylvania professor Justin McDaniel has started a gruelling 7-hour class on existential despair - and there's already a waiting list.

Every Tuesday from 5 pm, students sit in silence for 4-and-a-half hours while they make their way through the set text, and then take part in a class discussion. *The Huffington Post* reports that the material will include books on “religious struggle, the nature of faith, moral crises, illness, the end of life, the end of relationships and struggles with identity.” A little light relief for those keeping up with the news, we think.

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

## Survival of the fittest

The more physically attractive you are, the more likely you are to have lots of sex, reproduce and pass these traits on to the next generation. Or so the theory goes. So how come we don't all look like movie stars and supermodels? Or so it seems from looking round the train this morning.

Three things work together to prevent all of us from looking like supermodels. First, standards of beauty change constantly. For one generation, it is Twiggy and Marlon Brando, while for another it is Pamela Anderson and Michael Jordan. As a result, even if the assumption about "beautiful" people being more likely to reproduce were true, it wouldn't lead to a population that met today's beauty standards.

Second, genetic inheritance doesn't produce slightly improved models of one's parents. Instead, there are myriad combinations, and it is possible that none of these may meet or exceed the beauty standards of the time.

Finally, when two people at the end of any distribution of attributes reproduce, their offspring will almost always move back towards the middle of the distribution, known as "regression to the mean". If the two tallest people in the world have a child, that child will almost certainly be shorter than their parent of the same gender.

*Stephen Johnson  
Eugene, Oregon, US*

To some extent, heterosexual humans behave like other animals in seeking a mate that will guarantee the highest lifetime reproductive success (LRS), as measured by the number of grandchildren they have. Certain physical features act as honest signals of "good genes" that will be inherited or indicate the capacity for parental care. Studies have shown that such features are widely perceived as attractive.

In general, men prefer women with more symmetrical faces and larger breasts, for instance, which have been linked to healthy genes and higher oestrogen levels.

Women's mate preferences are more complicated and vary with the menstrual cycle. At their most fertile, women prefer "masculine-looking" men with prominent jawbones and a "dominant" odour. These features are linked to higher testosterone levels and good genes. At other times, women prefer more "feminine-looking" men because they are perceived to promise better parental care. Women therefore choose feminine men for a long-term relationship and child-rearing environment, but may seek extra-pair relationships with masculine men when ready to conceive to ensure their children inherit good genes.

If physical attractiveness has a heritable basis and more attractive people did have greater LRS, then physically attractive traits would indeed spread through the population. But we

exhibit a great variety of sizes, shapes and appearances, which suggests this idea is incorrect.

The term "physically attractive" is highly subjective and physique is only one of myriad traits we consider when choosing a partner, including extrinsic traits such as wealth. Social circumstances could also constrain mate choice.

In addition, humans can consciously choose whether or not to have kids, and how many to have, and being physically attractive may be irrelevant in making this choice. In fact, certain traits that some may consider attractive can be detrimental to reproduction: very thin women tend to have lower fertility, for example.

Finally, some "attractive" physical traits have a non-genetic element, such as muscularity, which varies with exercise, or are "false signals", such as the use of make-up, Botox and implants, which are unrepresentative of genetic stock.

*Sam Buckton  
Cambridge, UK*

The moon's gravity creates a tidal bulge on Earth, both at the point closest to the moon and the point furthest away. This bulge occurs in both water and solid rock, although because the rock resists deformation, the effect is more obvious for the sea than the land. The movement of water in the water table will be somewhere in between these two, because its flow is impeded by the soil.

The height of the water table will rise anywhere, independent of the distance inland. But close to the sea, the tides coming up the rivers will slow the flow of water from the land into those rivers, with this effect extending as far as the river is tidal.

Land "tides", although too small to be easily visible, caused a distortion in CERN's Large Electron-Positron Collider, producing an effect on the ring energy that had to be allowed for in some of the measurements.

*Paul Kyberd  
Uxbridge, Middlesex, UK*

## Rising damp

I work on farms in the fens of East Anglia, UK, where the water table is quite high. Even when there has been no rain, the fields seem dry when tides at the coast are low, yet at high tides, the water seems to rise and make the fields wet. We all know that the moon affects tides at sea, but can it also affect the height of the water table quite far inland?

## This week's question

### THORNY PROBLEM

I am puzzled by brambles, raspberries and blackberries. They have sweet, juicy fruit, presumably so they will be eaten by animals who will spread their seeds. But they also have prickles. What's the good of that?

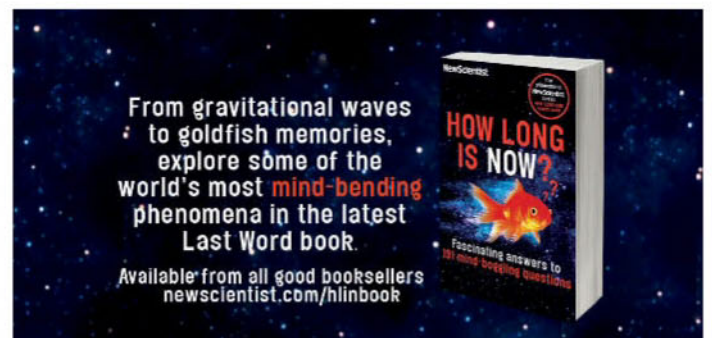
*Eric Kvaalen  
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