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WEEKLY August 5 - 11, 2017

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**PROPAGANDA MACHINES**

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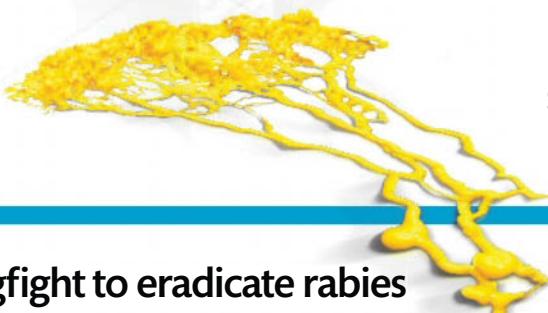
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**Professor Dame Carol Robinson**

2015 Laureate for United Kingdom

By Brigitte Lacombe



# Science needs women

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Dame Carol Robinson, Professor of Chemistry at Oxford University, invented a ground-breaking method for studying how membrane proteins function, which play a critical role in the human body. Throughout the world, exceptional women are at the heart of major scientific advances.

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ROB DALY/GETTY

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MATT MAWSON/GETTY



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# KeyMission

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# A game of monopoly

Internet giants may need to be treated like water suppliers

ARE Facebook, Google and Amazon monopolies that need to be regulated like utility companies? That anti-free-market position has reportedly won an unlikely champion in the White House, in the form of chief strategist and presidential right-hand man Steven Bannon.

Bannon's position is that these services have become an essential component of modern life, yet tend towards a natural monopoly status. Hence, like water and energy suppliers, they should be regulated to protect consumers.

His contention was met with widespread derision in the tech world. After all, these services are both free and optional; nobody will freeze to death in their house or catch dysentery because they can't pay their Facebook bill. And even if they are monopolistic, their particular monopolies do consumers no harm.

The idea went down badly in political circles too. It flies directly in the face of the US government's bid to abolish net neutrality, which demands that broadband is treated as a public utility and obliges internet service providers to make it available at a reasonable price. Opponents want to allow ISPs to privilege certain websites, loading some faster than others, for example.

Never mind the apparent contradiction. Bannon and co are clearly aware that there are pressing issues around monopoly and public good that need to be settled sooner rather than later.

But how? The starting point has to be that web services are neither as optional nor as free as their providers would have us believe.

Search, online shopping and socialising are woven into the fabric of life, and avoiding them is increasingly inconvenient. The currency we exchange for them is personal data.

A much bigger issue is the social cost of information monopolies. Facebook's footprint as a

**"There are issues around internet monopolies and the public good that need to be settled soon"**

distributor of news, for example, is expanding without any of the oversight you might expect from a press freedom watchdog. Yet we know that Facebook is a prolific vehicle for fake news, and that political agitators exploit the platform for their own ends (something that also makes Bannon's position appear incongruous, given that he practically invented the genre).

This week, the first proof

emerged that Facebook's news feed can be systematically hijacked to sway people's political opinions (see page 8).

Right now, efforts to filter out the most harmful content are largely a voluntary exercise undertaken by Google and Facebook when their bottom lines are under threat. Such action is better than nothing, but as the old saying goes, self-regulation stands in relation to regulation the way self-importance stands in relation to importance.

The sensible option would appear to be some form of regulation, and the utilities model is a good starting point.

That doesn't mean government ownership. Anyone who wants to supply tap water, for example, simply needs to obey a certain set of agreed standards. And while a city's water supply has to meet certain minimum criteria, individuals remain free to get their water from unregulated and free sources.

Regulating the internet giants like utilities could bring similar standards to information. People would still be free to poison their minds with the internet equivalent of sewage, but nobody would have it dripped into their pipeline by an unfettered and unaccountable monopoly. ■

## North Korea goes long

NORTH KOREA has fired a second intercontinental ballistic missile (ICBM), stoking fears of its potential nuclear capabilities.

The ICBM launched nearly vertically, reaching a height of 3700 kilometres before splashing down off the coast of Japan about 1000 kilometres away. However, video analysis of the glow as the missile re-entered the atmosphere suggests it may have broken up.

David Wright at the Union of Concerned Scientists estimates that if the missile were fired at a normal angle, it could travel 10,400 kilometres or more, putting the west coast of the US in range. Allowing for Earth's rotation, it might even be able to reach New York City, he says.

"This was so much longer range

than their last test," says Wright. "We don't know yet whether they did something to change the missile or what payload they were carrying." They could have pared down the ICBM's mock warhead, rather than improving the rocket itself, he says.

ICBMs exit the atmosphere, so they need protection from the heat during re-entry. North Korea says its ICBM had heat shields to protect the detonation machinery for a nuclear device. But video analysis by the US-Korea Institute at the Johns Hopkins School of Advanced International Studies in Washington DC suggests they still need to do more work on re-entry.

After the launch, South Korea's president, Moon Jae-in, and Japan's prime minister, Shinzo Abe, called emergency security meetings.



Lift off

## US embryos edited

THE results from the first CRISPR experiments done in the US on human embryos are now out, although the gene-editing technique has already been used in several human embryo studies conducted in China.

Shoukhrat Mitalipov at Oregon Health and Science University and his colleagues used CRISPR to target a genetic mutation that causes thickening of the heart wall. The disorder can lead to heart failure, and is often behind

being fertilised. They say this approach prevented mosaicism – a situation in which some of an embryo's cells carry the edited gene, but the "problem" gene remains intact in other cells.

The team also found no evidence of unwanted edits elsewhere in the embryos (*Nature*, DOI: 10.1038/nature23305). Such "off-target" mutations are another reason why some researchers have expressed concern over using the technique in people.

But Fredrik Lanner of the Karolinska Institute in Stockholm, Sweden, who wasn't involved in the study, points out that even with the researcher's thorough analysis, it is hard to be sure that the treatment didn't impact genes they didn't specifically look at.

Even if it is safe, CRISPR is unlikely to be used to prevent inherited diseases like this heart condition. Genetic screening can already be used in IVF to select embryos that don't carry these diseases. "We are still far away from doing this in the clinic. But this work takes us closer," says Lanner.

**"We are still far away from doing CRISPR gene editing in the clinic, but this work takes us closer"**

the sudden deaths of apparently healthy young athletes.

For the study, the researchers recruited a male volunteer who carries the mutation. He provided the sperm to fertilise donated egg cells and create embryos.

Unlike in other similar experiments, the team injected the CRISPR-Cas9 gene-editing machinery while the eggs were

## Gravity quantified

QUANTUM tech is poised to find a whole new purpose: making ultra-precise gravity measurements. Existing gravimeters are bulky, hard to use and not as sensitive as a quantum version would be.

Kai Bongs at the University of Birmingham, UK, and his colleagues have now created such a device. Using two clouds of cold rubidium atoms, they put each atom into a superposition of two quantum states – think Schrödinger's cat, simultaneously

both alive and dead. Laser pulses zap the clouds as they fall under gravity, tracking their paths.

If the two clouds fall at different speeds, the ground below each of them isn't uniformly dense. Densely packed ground will exert a stronger gravitational pull than an area with pockets beneath.

The quantum gravimeter could come in handy for mapping valuable deposits of oil or minerals. Construction crews could use it, too, to find deeply buried pipes – and so avoid digging in the wrong places.

## Voyage to the eighth continent

THIS week, geologists will reach, and drill into, Zealandia – dubbed the world's hidden continent by geologists earlier this year.

Zealandia is a 4.9-million-square-kilometre region of continental crust to the east of Australia, 90 per cent of which is submerged. Just New Zealand and New Caledonia poke above the water line.

"This is the first dedicated drilling expedition to understand the history of this mostly submerged region,"

says Gerald Dickens of Rice University in Houston, Texas, co-chief scientist on research ship JOIDES Resolution.

Zealandia became a separate continent 85 million years ago. Then, 50 million years ago, the Pacific plate dived beneath Zealandia, pushing what is now New Zealand above the water, and creating an arc of volcanoes. "We're looking at the best place in the world to understand how plate subduction initiates," says Dickens.

## 60 SECONDS

### Cigs with less buzz

TOBACCO firms in the US may have to cut the nicotine in their cigarettes to non-addictive levels if the US Food and Drug Administration gets its way.

Scott Gottlieb, commissioner of the FDA, unveiled the pioneering

**"The danger is you create a black market in imported or counterfeit, high-nicotine cigarettes"**

proposal last week. If it becomes a reality, the US would be the first country to do this. Trials of reducing the nicotine in cigarettes have shown promising results, making smoking less appealing and addictive, with some evidence it helps users cut down or quit.

Linda Bauld, professor of health policy at the University of Stirling, UK, says it is an interesting move, but warns of potential problems. It could result in a black market in imported or fake products, and might also mean smokers take in more toxicants by puffing harder and for longer. "It is important to remember that nicotine is not the harmful constituent in cigarettes, but the many nasties present in the tar," she says.

In a parallel move, the FDA is also relaxing the deadline for e-cigarette-makers to get products approved – from 2018 to 2022 – amid growing evidence they are hastening a decline in smoking.

REUTERS/STEVE MARCUS



Not immune from security flaws

### Spoilt ballots

A VOTING machine hacked to play Rick Astley's *Never Gonna Give You Up* might seem amusing, but there's a sting in the tale. At the annual DEF CON security conference in Las Vegas last week, researchers proved that in the time it takes to watch a movie, someone could access and alter votes cast on the machines used in US elections. Some of the hacks were even done wirelessly.

For the event, DEF CON

**"Ninety minutes on, the first voting machines were hacked, with vote-rigging occurring soon after"**

purchased 30 voting machines from eBay and government auctions. Ninety minutes after participants were let loose, the first machines succumbed, with vote-rigging and "Rickrolling" occurring soon after.

One of the machines was still running Windows XP, so delegates used an exploit known since 2003 to gain access via its Wi-Fi. Hackers anywhere could use this trick to attack.

Other exploits involved prying open mechanical locks covering USB ports or spotting uncovered ports on the back. One team then simply plugged in a mouse and keyboard to gain control.

SHUTTERSTOCK



The tip of a submerged continent

### Fate of the Canaanites

DNA extracted from five skeletons buried 3700 years ago in what is now Lebanon confirms that the enigmatic Canaanite people live on. The area has seen waves of immigration throughout history, but people in Lebanon today still share 90 per cent of their DNA with the ancient skeletons (*The American Journal of Human Genetics*, doi.org/b93p).

### The Greater Firewall

Apple has pulled nearly all major virtual private network (VPN) apps from its App Store in China, following a change in the law. China had passed regulations requiring official approval for VPNs, which can be used to circumvent technical barriers aimed at censoring the internet.

### Chips in space

Breakthrough Starshot, the \$100 million project to send tiny ships deep into space, has flown its first minisatellites. The craft, called Sprites, are each 3.5 centimetres square and carry a computer chip, solar panels, a magnetometer, a gyroscope and a radio transmitter. The ultimate aim is to send similar craft all the way to Alpha Centauri.

### Jellyfish blooms

The Adriatic Sea is full of jellyfish – and numbers swelled as we began installing gas platforms in the water. The two events may be linked: a computer model suggests the platforms aid jellyfish dispersal and survival, by providing surfaces on which the juvenile polyps can attach (*Environmental Research Letters*, doi.org/b95t).

### Chronic fatigue clues

The severity of chronic fatigue syndrome is linked to a set of 17 inflammation chemicals: their levels in the blood are higher in people with more severe forms of the condition (*PNAS*, doi.org/b96p). The finding could lead to diagnostic tests for the syndrome, as well as giving clues to new treatments.

# Dark ads pick you out

Political beliefs are an easy target on Facebook, finds **Timothy Revell**

COULD Facebook really tip the balance in an election? Over the past year, firms like AggregateIQ and Cambridge Analytica have been credited with using AI-targeted ads on social media to help swing the Brexit referendum and the US presidential election respectively. But a lack of evidence meant we have never known whether the technology exists to make this possible.

A study detailing the process from start to finish is finally providing some insight. "This is the first time that I've seen all the dots connected," says Joanna Bryson, an AI researcher at the University of Bath, UK.

At the heart of the debate is psychographic targeting – the directing of political campaigns at people via social media based on their personality and political

political dials by much to influence an election, just a couple of percentage points to the left or right."

No one yet knows how much such ads can permanently change people's views. But Sumner's study clearly reveals a form of political campaigning with no checks and balances.

Facebook allows targeted advertising so long as a company's use of external data adheres to the law.

To get to grips with the complex issue of psychographic targeting online, Sumner and his colleagues created four experiments.

In the first, they looked at what

divides people. High up on the list was the statement: "with regards to internet privacy: if you've done nothing wrong, you have nothing to fear". During the Brexit referendum, the team surveyed more than 5000 people and found that Leave voters were significantly more likely to agree with the statement, and Remain voters more likely to disagree.

Next, by administering various personality tests to a different group they found traits that correlate with how likely you are to agree with that statement on internet privacy. This was turned into an "authoritarianism" score: if you scored high you were more

likely to agree with the statement. Then, using a tool built by researchers at the University of Cambridge, they reverse engineered the Facebook interests and demographics that people with those personalities were most likely to have.

Just 38 per cent of a random selection of people on Facebook agreed with the privacy statement. But this shot up to 61 per cent when the tool was used to target people deemed more likely to agree and down to 25 per cent for those who they deemed more likely to disagree. In other words, they showed that it is possible to target people on Facebook based on a political opinion.

Finally, the team created four different Facebook ad campaigns tailored to the personalities they had identified, using both pro and anti-surveillance messages. They found that the tailored ads resonated best with the target groups. For example, the high-authoritarianism and pro-surveillance advert had 20 times as many likes and shares from the high-authoritarianism group compared with the low one.

The picture may be becoming clearer but we should be careful not to equate a short-term choice to share or like a post with long-term political views, says Andreas Jungherr at the University of Konstanz, Germany. "Social media is impacting political opinions. But the hype makes it hard to tell exactly how much."

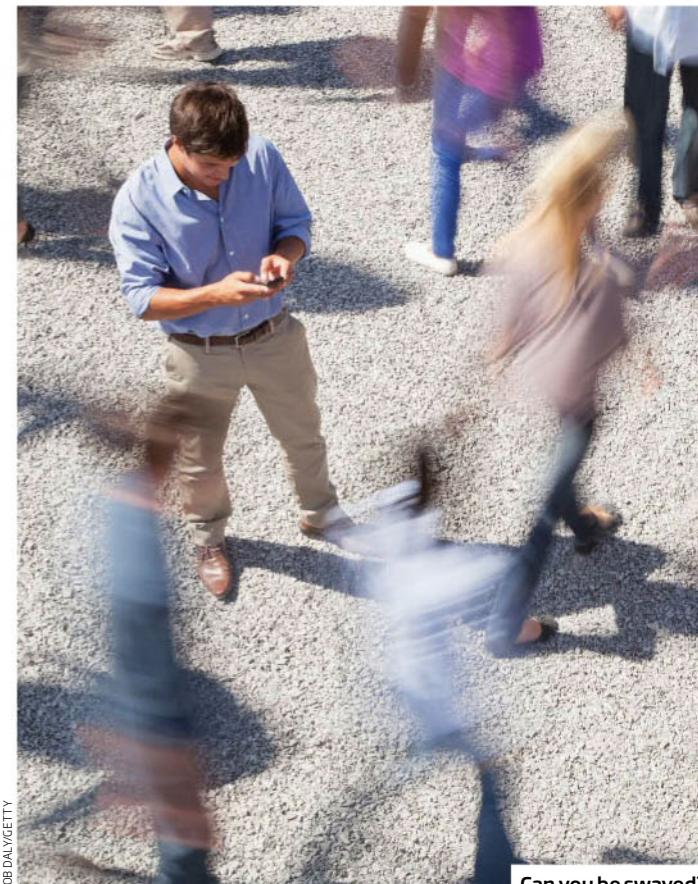
Changing political opinions doesn't have to be the endgame, however. What about simply dissuading people from voting? "We know it's really easy to convince people not to go to the polls," says Bryson. "Prime at the right time and you can have a big effect." ■

**"You don't need to move people's political dials by much to influence an election"**

interests. It is aided by vast amounts of data filtered by artificial intelligence.

Facebook doesn't explicitly provide the tools to target people based on political opinions – but the new study shows how the platform can be exploited. Using combinations of people's interests, demographics and survey data, it's possible to direct campaigns at individuals based on their acceptance of ideas and policies. This could have a big impact on the success of campaigns.

"The weaponised, artificially intelligent propaganda machine is effective," says Chris Sumner at the Online Privacy Foundation, who is presenting the work this week at DEF CON in Las Vegas. "You don't need to move people's



ROB DALY/GETTY

Can you be swayed?

## In this section

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## Learn better by counting your calories

EATING less can sharpen your thinking – if you’re a worm, at least. We already had an inkling of the benefits of calorie restriction, such as greater longevity in flies, mice and monkeys. Now Kaveh Ashrafi at the University of California, San Francisco, has found it may also boost the brain.

His team trained *Caenorhabditis elegans* roundworms to associate the scent of a chemical, butanone, with a food reward. The proportion of worms that migrated from the centre of a circle to one side laced with butanone, rather than the opposite side that smelled of alcohol, showed how well they had learned this lesson.

The worms tested had either eaten freely, or fasted for 1 hour, or had a calorie-restricted diet. The proportion of worms on a diet of half the normal calories that migrated was double that for those allowed to eat freely. The same was true for worms that fasted, suggesting low-calorie diets and short-term fasts have similar effects.

Eating fewer calories may work by depleting a brain chemical called kynurenic acid, which in turn activates neurons involved in learning. When the team reduced kynurenic acid, the worms' learning improved without calorie restriction (*PLoS Biology*, DOI: 10.1371/journal.pbio.2002032).

There are signs of a similar phenomenon in mammals, says Ashrafi. A 2008 study found that people around the age of 60 who cut their calories by 30 per cent were better at learning lists of words.

This makes evolutionary sense, says Devin Wahl at the University of Sydney. "Your brain needs to be functioning at a high level when you're on the hunt for food because you're trying to beat competitors," he says. "Once you've had a big meal, you just want to sleep."

But strong hunger has been found to impair cognitive function – possibly because it makes us preoccupied with thoughts of food. Alice Klein ■



There's a new target for Hubble

## Glimpse of a huge moon in another solar system

WE MIGHT have spotted a moon outside our solar system for the first time. And if the readings are accurate, it's larger than any moon we've seen before.

David Kipping at Columbia University in New York and his colleagues have used the Kepler Space Telescope to search for moons around other worlds for years, without luck. "We've had candidates in the past and investigated them, and most of them have evaporated," he says.

This latest possible moon was detected because of greater dips than we'd expect in the amount of starlight we can see as the planet passes in front of its star. Kipping and his team saw these additional dips, feasibly caused by a moon, over three of the planet's orbits around its sun-sized star, Kepler-1625. That gave enough data for the team to say there's only a roughly 1 in 16,000 likelihood of seeing such a signal by chance (arxiv.org/abs/1707.08563).

"It is consistent with the signal that we might expect from a moon, but it might be consistent with other things as well," says

Kipping. The system is almost 4000 light years away and fairly faint, so more observations are needed to verify that the signal isn't just a statistical blip.

The Hubble Space Telescope is more powerful than Kepler, so the group wants to point that at the star's system in October, when the planet is expected to transit its star again, to get a clear view.

"We anticipate that the proposed measurements would be sufficient to confirm the first

**"It's such a faint star that it'd have to be a planet-sized moon for them to have seen it transit"**

unambiguous detection of a moon beyond our Solar System," the team writes in its request for time on the Hubble telescope.

The group says the moon, if it exists, is probably the size of Neptune, and orbits a Jupiter-sized planet. Given what we know about how planets are born, it seems unlikely that the two formed together, but the large moon could have been

captured by the planet later.

"If there really is something there, it's such a faint star that it'd have to be a planet-sized moon for them to have seen it transit," says David Waltham at Royal Holloway, University of London. Because of the many diverse moons in our solar system, most astronomers assume that there are lots of moons around more distant planets as well. "I think we're pretty sure that they're going to be there," says Waltham. "It would be pretty odd that there are hundreds of moons in the solar system but none anywhere else."

If Kipping and his team verify this detection, it would be the largest moon we've seen, as well as the first exomoon. And it would imply that there are more types of moon than the many we've already observed.

"It would be analogous to the first exoplanet detections, which defied our prejudices from the solar system," says Duncan Forgan at the University of St Andrews, UK.

We'll have to wait a few months to find out more. "It may prove to be nothing, or it may prove to be a really fabulous discovery," says Waltham. "We won't know until the Hubble data comes back."

Leah Crane ■

# Chimps show signs of Alzheimer's

Helen Thomson

WE MAY not be alone in our struggle against Alzheimer's disease. For the first time, the plaques and tangles that characterise the condition have been found in the brains of elderly chimpanzees, although it is unclear if they cause dementia in the animals.

A protein called beta-amyloid accumulates in the brains of people with Alzheimer's and forms sticky plaques between brain cells. These plaques trigger changes in another protein called tau, causing it to form tangles. Together, these plaques and tangles are thought to kill brain cells, leading to dementia.

It has been difficult to study the disease and develop treatments for it because other species seemed not to develop plaques and tangles. The only time they had been seen together in another animal's brain was in a 41-year-old chimpanzee, but they were thought to be the result of a stroke.

But Melissa Edler, now at Northeast Ohio Medical

University and her colleagues have had the rare chance to study 20 brains from older chimpanzees, aged between 37 and 62. The team examined four areas of the chimps' neocortex and hippocampus – brain regions most commonly affected by

Alzheimer's in humans. They discovered beta-amyloid plaques and early forms of tau tangles coexisting in 12 of the chimp brains and, as in humans, they saw increasingly larger volumes of plaques in the brains of a more advanced age (*Neurobiology of Aging*, DOI: 10.1016/j.neurobiolaging.2017.07.006).

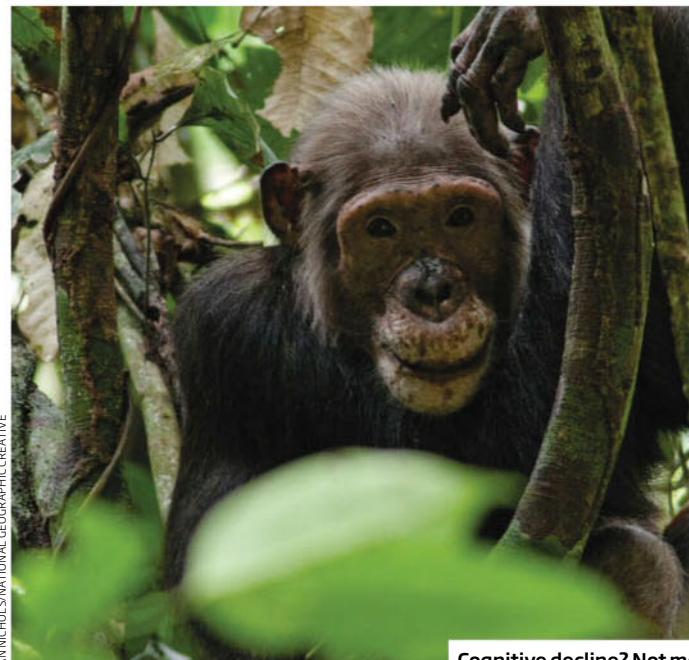
It is not clear whether these plaques and tangles lead to the same kind of cognitive decline that we experience. "Our samples had been collected over decades,

without any consistent or rigorous cognitive data accompanying them," says Mary Ann Raghanti of Kent State University, Ohio, in whose lab the work was performed. "So it wasn't possible to say whether the chimps had devastating cognitive loss or not."

However, so far, there are no examples of chimps with Alzheimer's-like dementia. "I'm cautious to say that they don't get this kind of devastating decline, but we haven't seen it yet," says Raghanti.

This study contributes to growing evidence that the classic plaques and tangles of Alzheimer's disease may be byproducts rather than the cause of the disease, says Gary Kennedy, director of the Division of Geriatric Psychiatry at Albert Einstein College of Medicine in New York. "That great apes demonstrate the pathology but not the precipitous decline of dementia reinforces this notion."

Humans may have something unique about their brain that predisposes us to the cognitive decline that accompanies plaques and tangles, says Raghanti. "If we can identify those differences between the human and chimp brain then we might be able to pinpoint what is mediating the degeneration. That could be a target for drug treatment." ■



Cognitive decline? Not me

## Titan could host building blocks of alien cells

SATURN'S largest moon is looking more promising for life. For the first time, the building blocks of possible cell membranes have been detected in Titan's atmosphere – along with potential seeds of cell machinery these membranes could help grow.

On Earth, cells are packets of mostly water surrounded by thin membranes made of lipids. Neither of these would fare well on Titan. It is far too cold for

liquid water, with average surface temperatures of -149°C. And its seas are made of liquid methane, in which lipid membranes couldn't develop.

Maybe life on Titan could be made of different stuff. Maureen Palmer at NASA's Goddard Space Flight Center in Maryland and her colleagues detected traces of vinyl cyanide in Titan's nitrogen atmosphere. A 2015 study found this chemical is good at forming the stable, flexible structures needed to build a type of cell membrane.

Palmer says Titan has enough vinyl cyanide to make up to 30 million cell membranes per cubic centimetre in one of its largest seas (*Science*

*Advances*, doi.org/b95g). This ups the chance that membranes could grow large enough to support complex structures, such as cell innards.

"Membranes are necessary for life, we think, but you also need some sort of genetic material and some sort of metabolism," says Palmer.

Evidence for another type of chemistry that could assist life comes from the last phase of the Cassini mission. High in Titan's atmosphere,

the probe found a molecule called a carbon chain anion that might help life along. Ravi Desai at University College London and his colleagues think these anions may form the seeds for larger, more complex molecules closer to the surface (*The Astrophysical Journal Letters*, doi.org/b93v).

"If they can survive long enough to reach the sea, perhaps they can play a role in any chemical reactions that take place there, maybe even the ones within the shelter of the vinyl cyanide membrane that could lead to a metabolic process," says Paulette Clancy at Cornell University in New York. Leah Crane ■

**'High in Titan's atmosphere, the Cassini spacecraft has found a molecule that might help life along'**

## Fungi have mini water cannons that fire spores

SOME fungi have a special talent: they shoot out their spores at high speed. Travelling just a centimetre away from the fungus is enough for the spores to catch the breeze and disperse, but exactly how fungi eject them has been a mystery for a century.

"Spore launching is responsible for [reproduction in] tens of thousands of species – about one-third of the fungal kingdom," says Chuan-Hua Chen at Duke University in North Carolina, whose team has observed a cannon-like aspect to the process.

We have long known that the trick involved spores with a half-egg shape and two water drops: an elongated drop that forms on the flat side, and a small, spherical "Buller's drop" near the spore's rounded base. When the drops merge, the energy that maintained surface tension in the original drops is converted into kinetic energy, which launches the spore away from the parent fungus.

Chen's team mimicked this in the lab for the first time. Using an inkjet printer, they built up a pair of droplets on a 200-micrometre-long styrofoam "spore" and watched with a high-speed camera (*Journal of the Royal Society Interface*, doi.org/b93m).

When the droplets merged, energy spread down the length of the new drop on the flat side of the spore. "This is like a cannon, with a spore as the cannonball," says Chen. "The Buller's drop is like the ammunition."

The merger imparts momentum that can briefly move the spore at up to 1 metre per second, though air drag quickly slows it down.

"We knew about the droplets: basically, how much gunpowder there was," says David Hu at the Georgia Institute of Technology in Atlanta. "But now they know if you put it all together what direction the cannon will fire."

Such knowledge is key to applying it, such as in self-cleaning surfaces where water droplets latch on to dirt and fling it into the air. Leah Crane ■



They shun light, no matter what

## Flatworms still 'see' even after losing their heads

OFF with their heads – they'll cope. Planarian flatworms shy away from light even after being decapitated, a finding that might help us better understand how our bodies respond to light independently of our eyes.

The flatworm (*Schmidtea mediterranea*) is a light-averse creature known for its ability to regrow lost body parts. Akash Gulyani at the Institute for Stem Cell Biology and Regenerative Medicine in Bangalore, India, and his colleagues wanted to learn more about its vision.

First, they confirmed that the two eyespots on its head encourage it to move away from light in the visible spectrum. Next, they explored how it responded to light when headless. It turned out that the flatworms still reacted, but to ultraviolet rather than visible light.

This suggests that flatworms have evolved two independent ways to respond to light, say the researchers – one controlled by the eyespots and brain, and the other a body-wide reflex

that involves neither. Existing evidence suggests that a protein called TRPA1 may be implicated in that reflex, but the exact details are not yet clear.

Over the week that it took for the flatworm heads to regenerate, the team monitored how quickly the brain and eyespots regrew, and when the flatworms began responding to visible light again.

After four days, the eyespots had grown back, but still the worms reacted more strongly to

### "Decapitation-regeneration experiments seem to copy the sequence that may have occurred in evolution"

UV than to visible light. Only after seven days did they regain their preference to slither away from visible light – suggesting that their eyespots and brains were retaking control (*Science Advances*, doi.org/b95h).

Gulyani's team speculates that the "gut instinct" response to UV light may be an ancient mechanism, whereas the eyespot

and brain-controlled response to visible light evolved later. As such, the experiments might "replay" evolution in fast forward, showing how flatworms went from responding to ultraviolet light as an unthinking reflex to responding to visible light via a brain pathway.

"It's a fascinating coincidence that decapitation-regeneration experiments appear to copy – chronologically, at least – what may have occurred in evolution," says Gulyani.

Wendy Beane at Western Michigan University wonders whether there are implications for human biology. For instance, our skin responds to light independently of our eyes by generating the pigment melanin, and Beane says recent studies suggest that this process involves TRPA1.

Because this same protein may crop up in the UV response in the flatworms, there may be parallels between the two species.

"This means that using planarian to study the integration of [light-sensing] inputs may help us better understand how these sensory networks are integrated in humans," she says.

**Aylin Woodward ■**

# Genome clues to tardigrade powers

Aylin Woodward

TARDIGRADES are spilling more secrets about their seeming invincibility. Genetic analysis of the tiny creatures, also known as water bears, is helping to unlock the mystery of how they can survive desiccation, and may also help place them on the tree of life.

For most animals, dehydration spells disaster: the membranes inside their cells collapse without water to hold them in place, killing the cells. But for two species of tardigrade whose genomes were examined in the new study – *Hypsibius dujardini* and *Ramazzottius varieornatus* – a lack of water isn't fatal.

A team including Mark Blaxter at the University of Edinburgh, UK, and Kazuharu Arakawa at Keio University in Tokyo has confirmed that the two species make tardigrade-specific proteins. These help the insides of the cells avoid damage by maintaining their shape even in the absence of water.

However, one of the two

tardigrades needs a heads-up. "The strategies are the same, but *H. dujardini* needs 24 hours' warning to make these proteins, and *R. varieornatus* is ready at all times," says Blaxter.

This difference relates to how fast the species might dry out. *R. varieornatus* is often found in moss on concrete roads, where the animal can become desiccated within 30 minutes, while *H. dujardini* lives in ponds where it might take 24 to 48 hours to dry out. But the genome studies show that the two share an almost identical set of genes that kick in when water vanishes, says Arakawa. The only difference is how those genes are regulated, he says (*PLoS Biology*, doi.org/b93j).

"We can learn a lot from these animals and there is an obvious potential for applications in medicine and biotechnology," says Ingemar Jönsson at Kristianstad University in Sweden.

Blaxter and Arakawa agree that unlocking the secrets of tardigrades' water-free survival



Water is for wimps

MECKE + OTTAWA SCIENCE PHOTO LIBRARY

could be valuable. For instance, it might offer new ways to preserve and transport vaccines. Currently, some must be kept frozen using liquid nitrogen. Technology developed from water bear genetics could instead allow vaccines to be dried and stored at room temperature.

The new genetic work might also help settle the debate on what exactly tardigrades are. Despite

looking a little like arthropods, tardigrades might be genetically closer to nematode worms.

This conclusion comes from examining the *Hox* genes – responsible for the position and alignment of animal limbs – in tardigrades and some of their invertebrate animal relatives. Tardigrades are missing five of these genes – and nematodes lack exactly the same ones. ■

## AI tricked into seeing what's not there

SEEING isn't always believing. Facebook has found it is easier than you might think to trick machine-learning systems into detecting things that aren't really there. Hackers could exploit this anomaly to dupe driverless cars into ignoring stop signs or prevent a CCTV camera from spotting a suspect in a crowd.

Show an algorithm a photo of a cat that has been manipulated in a subtle way and it will think it's looking at a dog instead. The technique – known

as an adversarial example – works by adding digital noise to images in tiny amounts that are typically imperceptible to a human.

Moustapha Cissé, an AI researcher at Facebook, and his colleagues figured out that a similar technique they call Houdini can also be used to fool voice-recognition systems. They inserted a small amount of digital noise into a recording of a person speaking a phrase. When they played that recording to the Google Voice speech-recognition app, it picked up a completely different sentence to the one spoken.

There is no evidence that these kinds of attack have actually taken place, but Marta Kwiatkowska at the

University of Oxford says it is only a matter of time. "At the moment, we have no protection," she says.

Cissé found that the types of image-classification algorithm used in driverless cars could be made to ignore pedestrians or parked cars. "I think we should worry about how we can ensure that the neural networks we put in cars are safe," he says.

But not everyone is sure attacks will work in the real world. David Forsyth at the University of Illinois at Urbana-Champaign digitally altered

a stop sign to fool such algorithms. He found that the signs worked fine when viewed by a moving camera, as they would be from a driverless car. He says adversarial examples might work under perfect conditions, but may be less effective in practice. Yet AI research lab OpenAI responded by showing it is indeed possible to trick image-recognition algorithms even if an image is viewed from different distances and angles.

The main problem is that we don't know why algorithms are so susceptible to minute changes that humans would never notice, says Forsyth. "We basically don't understand what's going on inside them." Matt Reynolds ■

**'Image-recognition systems in driverless cars can be made to ignore pedestrians and parked vehicles'**

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What's the weight?

## IVF babies grow up to be heavier

Jessica Hamzelou

SINCE the first "test tube" baby arrived 39 years ago, an estimated 6.5 million children have been born thanks to IVF and similar techniques. But we are only just starting to learn about the long-term health of people conceived using assisted reproduction techniques (ART), who may have a higher risk of obesity in later life.

"Today, 1 in every 30 babies in Japan is conceived by ART," says Tomoya Hasegawa of Tokyo Medical University. These babies are usually healthy, but tend to have a lower birth weight. Large studies that didn't look at conception method have previously found that low birth weight is linked to adult obesity and diabetes.

To investigate further, Heleen Zandstra of Maastricht Medical Centre, the Netherlands, and her team have been comparing the effects of using two different culture media to support the growth of early IVF embryos. Earlier they had found that one

of these was associated with babies that were 112 grams lighter at birth than those beginning life in the other medium. "That's a big difference, considering babies only weigh about 3 kilograms," says Zandstra.

Now the team have followed up on these babies at the age of 9, recording the height, weight and fat mass of 136 children, as well as blood pressure and heart rate.

They were surprised to find that, while children conceived

**Given that heavier children are more likely to develop obesity later on, the results are worrying"**

using each type of culture medium were around the same height, the BMI of the group that had been lighter at birth was an average of 0.9 lower than those who had been heavier babies. "There was a difference in weight of 2 kilograms," says Zandstra.

However, both groups were heavier than average 9-year-olds living in similar circumstances,

and had more abdominal fat. Given that heavier children are more likely to become obese later in life, the results are worrying, says Zandstra, who presented her findings at the annual meeting of the European Society of Human Reproduction and Embryology (ESHRE) in Switzerland in July.

At the same meeting, Hasegawa presented his analysis of 1830 children in Japan. His team found that babies conceived using ART were heavier than naturally conceived babies when they were born, but there was no real difference at 18 months. However, the ART children were heavier again at 6 years old. "The results were surprising," says Hasegawa.

What this might mean for adult health is unknown. Louise Brown, the first person born via IVF, is only 39 – we don't know yet what will happen to IVF-conceived people in their 50s, says Zandstra.

But people needn't be wary of fertility treatment. "We know that IVF is safe, because we have so many children," says Arianna D'Angelo, who coordinates the ESHRE group on safety in assisted reproduction. "We shouldn't worry, but we should be doing more to monitor children. Studies might flag up problems later in life," says D'Angelo. ■

## Donate your voice to help Siri understand

DOES Siri struggle with your accent? Crowdsourced recordings of people talking could help iron out kinks in voice-recognition systems.

Voice-controlled assistants like Siri and Alexa are trained on huge databases of recorded speech. But if these contain too few examples of a particular accent or dialect, the assistants will struggle to understand people who speak that way.

So Mozilla – the foundation behind the Firefox web browser – is turning to crowdsourcing to help create voice-recognition systems that avoid this problem. Through Project Common Voice, Mozilla aims to collect 10,000 hours of spoken English from people with a wide range of accents.

"Historically, most collections of speech and language tend to be more male and white and middle class," says Rachael Tatman at the University of Washington. And while companies like Google and Amazon are getting better at balancing their data sets, especially in terms of gender, voice-recognition systems still have a harder time understanding Americans who speak with certain accents, she says.

The accents and dialects that tend to be under-represented in training data are typically associated with groups that are already marginalised in US society. One consequence is that the software sometimes has lower recognition rates for African Americans, says Tatman.

At the moment, a few firms hold most voice-recognition data sets, says Kelly Davis, who leads the Mozilla project. Once Mozilla has collected enough audio clips, it plans to release them to allow anyone to train their own voice-recognition system.

To add your voice to the project, visit the Common Voice website, record a clip of yourself reading a preselected sentence and add a few demographic details. You can also listen to other people's recordings to ensure they are accurate.

Matt Reynolds ■



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**NewScientist**

# Atoms hitch a ride on galactic winds

Aylin Woodward

HALF the atoms that make up everything around you are in fact intergalactic interlopers. Large galaxies such as our Milky Way amassed that much stolen matter from neighbouring star clusters up to a million light years away, according to a new simulation.

"We did not realise how much of the mass in today's Milky Way-like galaxies was actually 'stolen' from the winds of other galaxies," says Claude-André Faucher-Giguère at Northwestern University in Evanston, Illinois.

The theft occurs after a death. When some stars reach the end of their life cycle, they become massive supernovae, spewing high-speed gas into the universe. The matter in these ejections is picked up by galactic winds – streams of charged particles themselves driven by supernovae.

We used to think that these winds couldn't be the source of much intergalactic matter transfer because they were not powerful enough to cross the vast distances between neighbouring

galaxies. But it turns out they're stronger than we realised.

"We assumed that the winds were confined to the galaxies they came from – that they could recycle by falling back into the galaxy that ejected them, but not transfer much mass from one galaxy to another," says Faucher-Giguère (*MNRAS*, doi.org/b9x9).

Over a galaxy's lifetime, it will swap matter continuously with

**"Galactic winds ferried in about 50 per cent of the matter present in the Milky Way today"**

its neighbours, and the journey time could be anywhere from several hundred million to 2 billion years, he says.

Using 3D models of galaxy evolution, Faucher-Giguère and Daniel Anglés-Alcázar, also at Northwestern University, simulated the path that matter inside galaxies would have taken through the universe from the big bang until now. More detailed simulations of supernovae showed that the galactic winds move



We're all stolen stardust

ESO PHOTO AMBASSADOR SERGE BRUNIER

matter faster than we thought.

They found that in galaxies with 100 billion stars or more, the winds actually ferried in about 50 per cent of the matter present today. For larger galaxies such as our own, this intergalactic Gulf Stream is the primary contributor to growth, allowing matter to be snatched from smaller counterparts.

Such transfers are less crucial for smaller galaxies, which rely more on local galactic winds to

retain any matter that might be ejected from supernovae within their system. Faucher-Giguère thinks the Milky Way gets its matter from the nearby Small and Large Magellanic clouds, two dwarf galaxies between 160,000 and 200,000 light years away.

Jessica Werk at the University of Washington in Seattle says that understanding where our galaxy's atoms come from is "one of the holy grails of extragalactic cosmology". ■

## Parchment DNA is window on medieval past

WHEN medieval scribes sat down to preserve the literature and records of their day, they often wrote on a paper-like material made from animal skins: parchment. The DNA it holds is now revealing details about medieval life, and might even offer clues to how better to preserve the documents.

"We realised all these dead cows have a date written on them," says Matthew Collins at the University of Copenhagen, Denmark. "We thought:

why aren't we exploiting this?"

Collins and his colleagues at the University of York, UK, and Trinity College Dublin in Ireland, turned to various ancient texts to see what the DNA in their pages could show. One was the York Gospels, thought to have been written around AD 1000.

Conservators periodically clean such books with rubber erasers. The waste rubbings are usually thrown away, but Collins and his colleagues analysed them to see what proteins and DNA were present.

The proteins helped identify the animals used to make the pages – mostly cattle in the case of the York Gospels. That's valuable information

for conservators trying to restore manuscripts as faithfully as possible.

The analysis also identified bacterial DNA including some from *Saccharopolyspora*, a genus associated with unsightly spots on old parchment. Finding its DNA could alert conservators to the likelihood of this problem affecting their manuscripts.

The DNA revealed other secrets. "You can even see the use to which the text is being put, which is kind of amazing," says Collins. For example, pages containing oaths, which would have been touched and kissed regularly, carried higher levels of human DNA (*bioRxiv*, doi.org/b93r). Chris Baraniuk ■



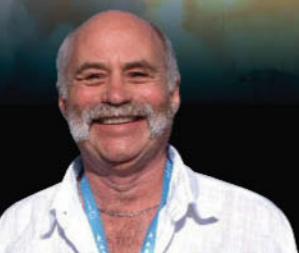
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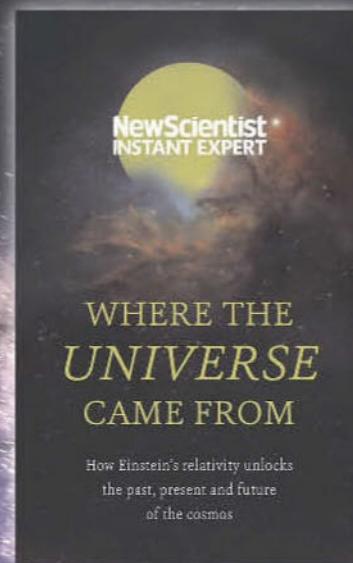
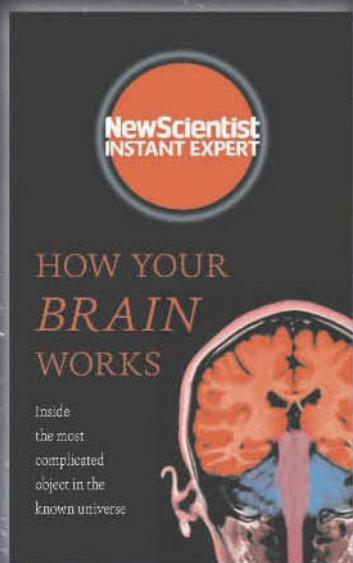
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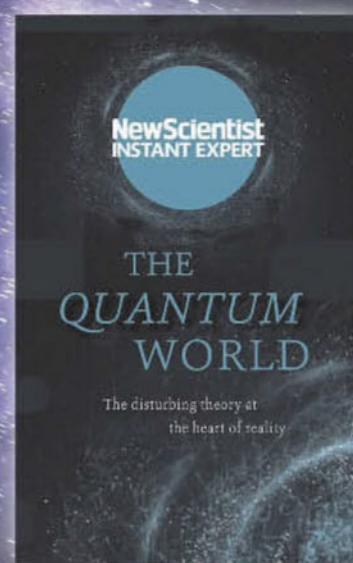
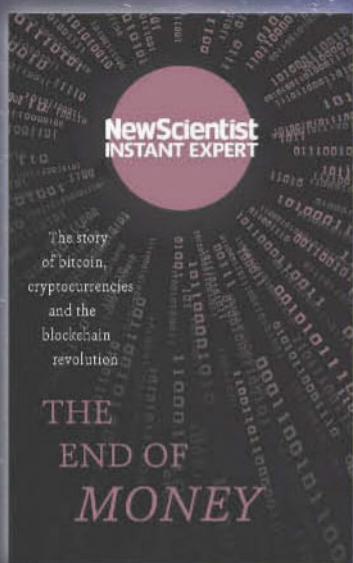
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## Nightmares linked to getting more than 9 hours of sleep

HAVE you recently arrived at work naked? If you want to avoid nightmares like this, you might try sleeping less.

To investigate why people have nightmares, Stephanie Rek at the University of Oxford and her colleagues asked 846 volunteers to do an online survey. The questions probed matters such as how many nightmares they'd had over the past two weeks, and how bad they were.

Each volunteer was also asked about other aspects of their life, such as recent divorces, legal troubles, their tendency to worry and how much sleep they got.

The team found that worrying about the future, or

about doing things wrong, had the strongest link with the frequency and severity of nightmares. Rek's team suggests that worrying before bedtime stores up material for bad dreams, increasing the chance of nightmares.

There was also a link between the frequency of nightmares and sleeping more than 9 hours a night (*Social Psychiatry and Psychiatric Epidemiology*, doi.org/b93c). Rek says that sleeping for longer might increase the amount of rapid eye movement sleep late at night - the time when nightmares most commonly occur.

There could be interventions that make nightmares less likely. "Worry can be effectively treated using cognitive behavioural approaches," says Rek. "It would be interesting to do more research to see whether these alleviate nightmares."

## Doing it the 'turkey baster' way

PUTTING sperm directly into a woman's uterus may be worth a shot before couples with unexplained infertility try IVF.

The "turkey baster" method of placing sperm into the vagina has been around in some form since at least the 1400s. In improved versions of this procedure, aka intrauterine insemination (IUI), the sperm is first washed to lower the infection risk and fertility

drugs may be given too. IUI is much easier than IVF, and often around a quarter of the price.

But the technique has fallen out of favour in recent years, in part because studies have shown that a single round of IVF is more likely to result in pregnancy than IUI.

Now Cindy Farquhar at the University of Auckland, New Zealand, and her team have found that IUI is much more likely to

lead to pregnancy than we thought. The team compared three rounds of IUI paired with a drug that boosts ovulation against three months of trying to conceive naturally, in 201 couples.

The team told a conference of the European Society of Human Reproduction and Embryology in Switzerland last month that IUI seems to lift the live birth rate from 9 to 31 per cent in couples who have had unexplained infertility for three to four years.

## Fish can't recognise upside-down faces

ONE fish shares our problem with inverted faces. The medaka (*Oryzias latipes*) has no trouble identifying a familiar face the right way up – but it struggles when it isn't.

Mu-Yun Wang and Hideaki Takeuchi at the University of Tokyo observed female medaka that had become familiar with males. When the researchers used a prism to invert the males' faces, the females' behaviour suggested they no longer recognised them (*eLife*, doi.org/b93f).

In humans, the face inversion effect occurs because we use a specific brain pathway to process faces, says Wang. When faces are upside down, the brain resorts to general object processing pathways – and the faces seem less familiar.

The fact that the fish behaves like we do, says Wang, could be a sign that it too has a unique brain pathway for face recognition.

## How the primeval flower took shape

THE very first flower probably had petal-like tepals and pollen-bearing stamens arranged in rings of three. It would have shared features with the blossoms of magnolias, buttercups and laurels, while remaining unlike any living flower.

That's according to Hervé Sauquet of the University of Paris-South and his colleagues. They spent six years analysing nearly every type of flowering plant to identify their most ancient traits.

They then deduced when these appeared, using biomolecular markers. The results let them build evolutionary models of the earliest steps in flower evolution – something not visible in the fossil record (*Nature Communications*, DOI: 10.1038/ncomms16047).

## Bat your lashes to control your home

**BLINK** and the lights go out. A pair of glasses that picks up the movement next to your eye when you blink could be used to switch lights on and off, or help those with limited or no mobility write messages on a computer.

"The good thing about the technology is the high sensitivity, which may become particularly useful in places where the motion is very limited," says Ambarish Ghosh at the Indian Institute of Science in Bangalore, who wasn't involved in the research.

The arms of the glasses contain a sensor called a triboelectric generator, made from polymer layers with a metal coating that acts as an electrode. When the wearer blinks, the motion of skin to the side of the eye causes the polymer layers to touch and release, generating an electrical signal.

One, two or three consecutive blinks can be used to scroll through the alphabet to spell out a message on a computer, for example (*Science Advances*, doi.org/b95f).

However, blinking is involuntary, and unless you enjoy a disco effect, it may turn appliances off and on when you don't want it to. "You can set a threshold for the switch," says team leader Zhong Lin Wang at the Georgia Institute of Technology. Then, only blinking hard would trigger the switch.



EUSABETH SCHMITT/GETTY

## Men's sweet tooth could lead to depression

DON'T eat that biscuit. It seems that men who consume a lot of sugar in sweet drinks and snacks are more likely to develop depression or anxiety.

Excessive sugar intake has been linked to diabetes, obesity and dementia. There also seems to be a connection between sugar and mood disorders, but whether eating sugary snacks is a cause or consequence of these wasn't clear until now.

Anika Knüppel at the University College London and her team studied data from more than

8000 adults in the UK who had regularly answered health, lifestyle and mental health surveys since the 1980s. They had also had their weight and height assessed regularly.

The team analysed this data set, controlling for factors like health and socio-economic status. They found that when men appeared in the top third of the group for sugar consumption, they were 23 per cent more likely to have a bout of depression or anxiety over the following five years (*Scientific Reports*, doi.org/b92k).

There was no sign that mood disorders were boosting sugar intake, and the pattern in the men was not repeated in women. "It turns out people underestimate that men's sugar intake is super-high," says Knüppel.

She thinks there may be more than one explanation for sugar's effect on mental health. Highly sugary foods may reduce levels of a protein that affects the growth of nerve cells in the brain, or increase inflammation in the body, something which has been implicated in depression.

## Maths solves flight of the bumblebee

A BEE shouldn't be able to fly, maths insists. Its tiny wings shouldn't create enough lift to get its big body off the ground.

But now a new mathematical analysis has figured out how bees do it (*Journal of the Royal Society Interface*, doi.org/b92q).

Until the 1990s, bees were assumed to fly like planes, using airflow over their wings to create lift – but the sums didn't work. Then in 1996, it was found that tiny, tornado-like airflows called LEVs form on the leading edges of their wings. These were thought to provide the extra lift required.

But Mostafa Nabawy and William Crowther, both at the University of Manchester, UK, have now shown that LEVs don't directly add lift. By creating three mathematical models with different lift mechanisms and comparing them with experiments on eight different bee species, they found that LEVs simply let a bee angle each wing more sharply to the sky, improving the airflow over them.

If the LEVs stop, the pressure difference between the top and the underside of the wing that creates lift would drop, and the bee would fall from the air.



LISA D'AZZI/ISTOCK/GETTY

## World's oldest mass animal stranding

HOW apt: the oldest mass dying event ever found has turned up in Death Valley, California.

On a rocky area of about one square metre, and in loose rocks nearby that were once part of that surface, Aaron Sappenfield at the University of California, Riverside, and his colleagues discovered the fossilised remains of 13 jellyfish (*Geological Magazine*, doi.org/b93h).

They date to about 540 million years ago, a time when Death Valley lay on the edge of an ancient continent, lined with sandy beaches.

The discovery is surprising, given

that the remains of jellyfish don't survive long on today's beaches.

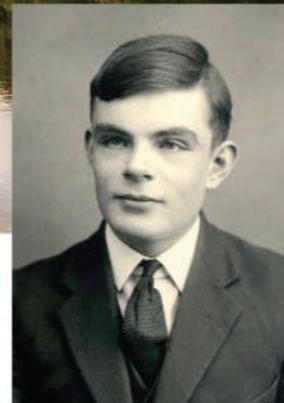
"Preservation of soft-bodied organisms is exceptionally difficult in a modern beach setting," says Sappenfield.

One reason why the jellyfish that washed up on the ancient beaches were preserved as fossils is because there were few or no terrestrial animals at the time to disturb their carcasses, he says.

By about 520 million years ago, though, early animals were spending some time on land – reducing the chances of jellyfish becoming fossils.

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# The green revolution is stalling

Renewable energy isn't taking off fast enough to save us from climate change. More than ever, big nations must get serious about it, says **Michael Le Page**

THIS year has seen renewable records smashed in the UK. On 21 April, the country went a whole day without using coal to generate electricity – the first such day for 135 years. Then on 7 June, particularly sunny and windy conditions meant that renewable sources supplied more than half the UK's electricity.

Achievements like these make it sound like the green revolution is well under way. Many think the growth of renewables is now unstoppable, and that clean energy will entirely replace fossil fuels in the not-too-distant future.

They may need to think again. Spending on renewables in the UK is set to plummet 95 per cent over the next three years, according to a study by the London-based Green Alliance think tank, as the ending of subsidies strangles investment. Other big countries are also cutting back on subsidies, including Germany and Japan.

Globally, renewables are still growing extremely fast, led by China, but some detect signs this is tailing off. "What you read in the media does not fit with the facts and figures," says Jan Petter Hansen at the University of Bergen in Norway. His research suggests renewables could peak by 2030, before they supply even a tenth of the world's energy.

## Beyond the headlines

So is the green revolution already faltering? Do we need to do more to ensure a clean energy future?

Let's start with the current situation. Despite the headlines, wind, solar, geothermal and bioenergy supply just 8 per cent of the world's electricity, according to BP. That's not great, considering that converting

electricity generation to clean energy is the easy part of cutting carbon emissions.

Looking beyond electricity, renewables supply only 3 per cent of the world's total energy use, which is dominated by industries

**"Just 14 per cent of our energy isn't from fossil fuels, and this has barely changed in 25 years"**

like aviation and shipping. Even counting hydro and nuclear, just 14 per cent of our energy isn't from fossil fuels – and this figure has barely changed over the past 25 years (see graph, below right).

Coal is far from dead, although the world has at least burned less of it in recent years. Hundreds of new coal plants are planned in countries such as India, though some people argue that most

will never be completed.

Meanwhile, oil and gas are growing fast enough to negate the fall in emissions thanks to declining coal and rising renewables. At the rate we are going, a clean energy system is still centuries away – yet we are nearly out of time to limit global warming to 2°C.

But there's no need to despair, say the optimists. The cost of



Things are looking gloomy

electricity from wind and solar is becoming competitive with that from fossil fuels, even without subsidies. Once renewables are cheaper, their growth will accelerate and continue until they displace fossil fuels.

These optimists also point out that the growth in wind and solar has consistently beaten forecasts of fossil fuels companies and even the International Energy Agency.

Is the future really this rosy? On the face of it, the announcement last month of a subsidy-free solar farm, to be built by UK company Hive Energy, appears to back such a view. But subsidy-free projects remain unprofitable, says Giles Redpath, the firm's CEO – despite building costs for solar farms falling considerably, and low interest rates making investment more affordable. "Realistically, the numbers don't quite work. People are taking a bit of a risk," Redpath says.

So it is a bad time for many developed countries – including the UK, Germany, Japan, Spain and Italy – to be cutting subsidies, which will inevitably put the brakes on renewables.

Of course, it could just be a blip. Growth could pick up again in a few years as costs fall further, making wind and solar truly competitive with fossil fuels.

Here, history isn't encouraging. In the 1950s, during the golden age of nuclear, many predicted that it would grow inexorably and displace fossil fuels, at least for electricity generation. In reality, the adoption of new ways of producing electricity has taken decades and tailed off far short of sweeping the old methods aside.

In general, successful technologies grow slowly at first, relying on early adopters, then exponentially once they hit the mainstream, before finally levelling out. Researchers call it the S-curve, after the shape you get when you plot this on a graph.

Wind and solar are now in the exponential growth phase. But according to Hansen and

colleagues, their growth curve shows early signs of levelling off (*Renewable and Sustainable Energy Reviews*, doi.org/f92686).

Of course, this is just one study. But there is no doubt that we need renewables to take off even more steeply if we are to get anywhere near the goals set out in the Paris climate agreement (see graph, right).

The optimists respond that renewable energy has unique advantages that will allow it to do just that. For instance, it is more flexible and scalable. "In Africa you see a single panel tied to a tree and someone is charging a phone," says Redpath.

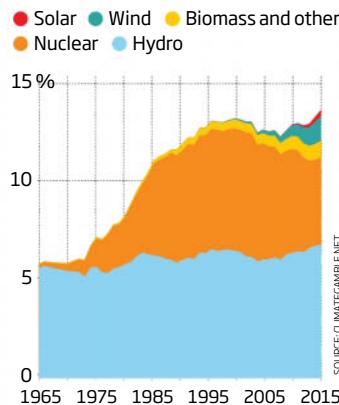
However, renewables also have a huge disadvantage compared with other energy sources: intermittency and variability.

What's more, this isn't just a practical headache: it also makes renewables less profitable as they scale up. In generating systems with a high proportion of renewables, there's a surplus of electricity when it is sunny or windy, so its price plummets.

Part of the answer is to change the way the system works so that devices such as electric cars can take advantage of the surpluses, says Juliet Davenport of UK green energy provider Good Energy.

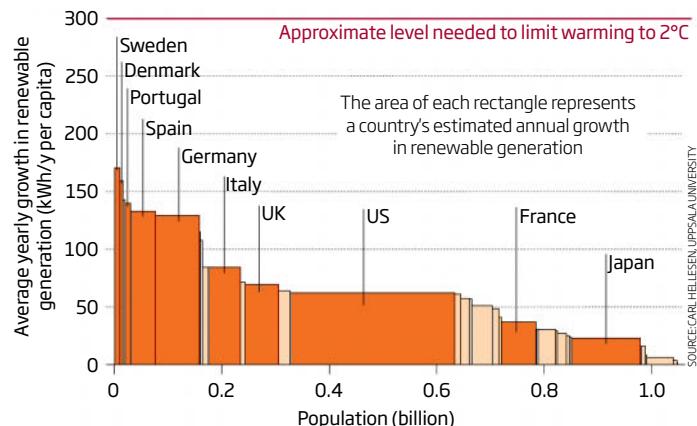
## Flatlining

The global share of non-fossil fuel energy has barely grown in the past 25 years, with growth in wind and solar offset by falling nuclear



## Falling short

To avoid major global warming, each year the world's richest nations must all add renewable power generation equivalent to 300 kWh/y per capita. But they are far from this goal, and the largest nations have some of the biggest shortfalls



And part of it is to store energy by using it to make hydrogen, or by charging batteries.

The cost of battery storage is falling so fast that in just two or three years it could be feasible to store solar energy for just a few hours and sell when demand, and thus prices, are higher, says Redpath. But batteries are not going to solve the lack of sunlight in the winter.

This is why there is still debate about whether it's even feasible to get all our electricity from renewables, which would require vast amounts of storage or supergrids to connect generators to distant areas where there is demand. Both are hugely expensive.

Davenport is one of the optimists. "There is a pathway to 100 per cent renewables," she says. "I think it can be economically viable [in the UK]."

But we should not focus only on wind and solar, argue many energy researchers. We have to hedge our bets, pursuing every option including carbon capture and storage as well as more nuclear power.

And clearly, the market alone cannot be relied upon to deliver a clean energy future. The message politicians need to hear loud and clear is that they must do even

more to promote renewables. The good news is that expensive subsidies are far from being the only option.

The first priority should be ditching subsidies that funnel state money into dirty fossil fuels like coal, and imposing a high and rising price on emissions.

Then there are all the policy and infrastructure changes needed to ease renewables' access to the

## "There was nothing inevitable about France's nuclear power revolution: the state made it happen"

grid. Planning approval is the biggest obstacle to onshore wind in the UK, says Davenport, who is seeking the go-ahead for a subsidy-free project.

France's past shows what can be done: the country gets three-quarters of its electricity from nuclear. But there was nothing inevitable about France's nuclear power revolution. It happened because the state decided to make it happen, after oil prices skyrocketed in the 1970s.

All countries need to follow this example and redouble their efforts to boost renewables. "The pace has to be increased," says Hansen. "It's an important message." ■

# Hard to swallow

First came the gluten-free fad; now the lectin-free diet is trying to demonise more perfectly healthy foods, warns **Anthony Warner**

JUST in case there wasn't enough fear and misinformation about food, the latest restrictive fad sent to cure us of all ills is the lectin-free diet. Lectins, a family of proteins found in many foods, have been described as "the new gluten". If that refers to them being wrongly demonised, it might not be far from the truth.

A lot of this stems from overblown claims in a recent book, *The Plant Paradox*, by US heart surgeon Steven Gundry. In it, he outlines his belief that lectins are toxins driving obesity and many other conditions. The resulting diet vilifies a long list of foods, including grains, legumes, pulses, beans, peas, corn, soy, tomatoes, peppers, squashes, courgettes and even quinoa, usually a darling of health writers.

The main focus of the book is weight management. When speaking of the clients he treats in



his exclusive California clinics, Gundry, who also sells a range of pricey supplements, notes that "the more supposedly healthy foods that I eliminated, the more their health improved". If we substitute the words "their health improved" with "they lost weight", then the apparent paradox is perhaps not so surprising. It is not hard to imagine that you will lose weight if you cut out staple foods after a doctor tells you that many contain toxins able to tear holes in your gut.

But Gundry's theories on the damaging effects of lectins are not supported by mainstream nutritional science, and any lectin-free diet is a long way from what any qualified dietician might recommend as healthy.

It is true, and has been known for decades, that lectins can be harmful in some cases, especially in raw or undercooked kidney

## Dream on

Evoking sleeping aliens is a very long shot to solve Fermi's paradox, says **Geraint Lewis**

THE size of the universe suggests advanced alien civilisations, or at least evidence of them, ought to be out there. Signs in the shape of transmissions or megastructures should be obvious. Instead, we find nothing.

This "eerie silence", as cosmologist Paul Davies puts it, inspired physicist Enrico Fermi to

ask: "Where are they?" Many have proposed solutions, but now another is on the table. What if aliens are indeed out there, but are sleeping, awaiting a glorious future when the universe provides the right conditions for them to fulfil their ultimate ambitions?

According to this idea, advanced life arose and flourished

in the early universe, growing in size and amassing technology to harness the energy of stars and galaxies, before turning to more philosophical pursuits, pondering the big questions of the cosmos.

Addressing these needs lots of thinking, not only with organic brains, but with synthetic ones – like Deep Thought, the immense supercomputer dreamed up by writer Douglas Adams to ponder the ultimate question of life, the universe and everything.

**"The aliens 'aestivate', waiting for the universe to cool to a point when conditions are right"**

But there's a limitation in the thermodynamics of computation. Such immense computing requires a flow of energy from hot to cold, ultimately curtailed by the background temperature of the universe. Early on this was a few tens of kelvin above absolute zero. But each degree of cooling creates potential for an immense quantity of extra computation.

So the aliens "aestivate", or slumber, through the cosmic summer, waiting until the universe is cool enough for mega calculations.

There is a troubling caveat though. This cooling is slow, taking many billions of years,

beans, lentils or other dried pulses. However, in properly prepared food in the quantities that most of us experience, they do us no harm. There is even some evidence lectins can be beneficial.

Furthermore, when the foods being vilified are consumed as part of a normal diet, any potential injurious effects are hugely outweighed by other beneficial nutrients. Evidence of benefits from a diet high in lectin-containing fruits, vegetables, seafood, pulses and wholegrains is so overwhelming as to render Gundry's arguments laughable.

Fear about lectins is easy to create, because it relies on a misunderstanding about the nature of food, a belief that all constituent parts have to be just right for us. In reality, no food is wholly perfect; they all contain a spectrum of components with different effects. Those effects are often nuanced and complex, and sometimes poorly understood.

This is hard for our certainty-craving brains to accept – which leaves the door open for those who claim to offer definitive answers without solid evidence. ■

Anthony Warner works as a food industry development chef by day and blogs about pseudoscience by night. He is author of *The Angry Chef* (OneWorld)

and so our aliens would also have to prepare. While they sleep, stars will evolve and puff off their outer layers, and galaxies will collide. To counter this, they must engineer their environment to ensure that when they awaken, the matter and energy they need will still be on hand. That implies mega-engineering, yet to be seen.

How seriously to take this idea? It is little more than guesswork. While such speculation can inspire new thinking and new solutions, it should be taken with a suitable pinch of salt. ■

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

## INSIGHT Antibiotics



# Is it really OK to stop taking antibiotics early?

Jessica Hamzelou

RECENTLY, crippling pelvic pain landed me in hospital. A doctor prescribed a course of antibiotics lasting just three days. I couldn't help worrying that it wasn't long enough: what if my infection hadn't cleared by then? What if some of the harmful bacteria survived the treatment, and my body incubated the deadly, drug-resistant superbugs we have all been warned about?

Really, I had nothing to worry about: growing evidence suggests that short courses of antibiotics can be just as effective at killing bacteria as longer ones. And they don't increase the risk of antibiotic resistance, at least for the common infections that most people receive antibiotics for.

In fact, it is the longer courses that cause problems. In 2010, an analysis of 24 studies, which included thousands of patients with respiratory and urinary tract infections, found that people on longer courses of antibiotics were more likely to develop antibiotic-resistant infections.

That's because most of the drug-resistant infections we are worried

about stem from bacteria that normally live in peace on and in our bodies. When we take antibiotics, we wipe out friendly gut bacteria along with the harmful ones. This disruption to the ecosystem can allow once-friendly bacteria from elsewhere in the body to colonise, where they can turn hostile and cause problems. Because these species weren't killed by the antibiotic, any infections they cause are resistant to it. And this is more likely to happen with a longer course of treatment.

So why do many prescriptions tend to last one or two weeks?

**"Evidence suggests that short courses of antibiotics can be just as effective at killing bacteria"**

When Martin Llewelyn at Brighton and Sussex Medical School in the UK tried to find the origin of antibiotic prescription lengths, he struggled. "It appeared that people working in the 1950s arrived at these, probably because they were worried that people would otherwise skimp on treatment, or because they were

afraid of resistance," he says.

Antibiotics are often prescribed in multiples of five or seven days. This is probably because these numbers correspond to the number of fingers on a hand and the number of days in a week, but there's no medical basis, says Llewelyn, who co-authored a letter on the subject published last week (*BMJ*, doi.org/b9z8). In fact, it might be a better idea to stop taking antibiotics once you feel better and symptoms are resolved, he says.

The notion of cutting down overly long antibiotic courses isn't new. The UK health agency Public Health England and the US Centers for Disease Control have both changed their guidance on antibiotic prescribing in recent years, based on an understanding of the evidence. Both have ditched their "complete the course" messages for ones that focus on following a doctor's advice.

But the World Health Organization continues to promote the idea that completing a course of antibiotics is a vital way to avoid drug resistance. It's an outdated position, and it's time the WHO modified its stance.

In the meantime, people who are diagnosed with bacterial infections can discuss the course of treatment with their doctor – who also might not be up to date with the latest evidence. Three days of antibiotics worked in my case, and I'm pleased my doctor didn't saddle me with extra medication when I didn't need it. ■



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# APERTURE





## Mud bath from above

AFTER the storm comes the clean-up. In this satellite image, teachers are painstakingly scraping the mud from a school sports ground and running track in Yongji county in Jilin province, north-east China. Severe storms battered the entire area in the middle of July, leaving at least 18 people dead and more missing.

Flooding in the wake of torrential downpours has closed roads to more than 1000 homes and cut off the internet, according to China's official press agency, Xinhua. In Jilin City, the province's capital, around 110,000 people have had to be relocated. As the water subsides the city's streets have been left covered in a thick layer of mud.

With the worst of the storms over, rescue teams and volunteers are now engaged in the clear-up operation, repairing bridges, fixing phone lines and clearing debris from roads.

Niall Firth

### Photograph

Xinhua News Agency

Eyevine



# Where in the world?

It's time we reinvented the address, finds Joshua Howgego

**K**WANDENGEZI is a beguiling neighbourhood on the outskirts of Durban. Its ramshackle dwellings are spread over rolling green hills, with dirt roads winding in between. Nothing much to put it on the map. Until last year, that is, when weird signs started sprouting, nailed to doors, stapled to fences or staked in front of houses. Each consisted of three seemingly random words. *Cutaway.jazz.wording* said one; *tokens.painted.enacted* read another.

In a neighbourhood where houses have no numbers and the dirt roads no names, these signs are the fastest way for ambulances to locate women going into labour and who need ferrying to the nearest hospital. The hope is that signs like this will save lives and be adopted elsewhere. For the residents of KwaNdengezi in South Africa aren't alone – recent estimates suggest that only 80 or so countries worldwide have an up-to-date addressing system. And even where one exists, it isn't always working as well as it could.

Poor addresses aren't simply confusing: they frustrate businesses and can shave millions of dollars off economic output. That's why there's a growing feeling that we need to reinvent the address – and those makeshift three-word signs are just the beginning.

In itself, an address is a simple thing: its purpose is to unambiguously identify a point on Earth's surface. But, it also forms a crucial

part of the way societies are managed. Governments use lists of addresses to work out how many people they need to serve; without an address by your name, you can't apply for a passport or register to vote. That means an effective addressing system must do more than simply mark out a patch of land – it must also reflect the infrastructure there. One address shouldn't span multiple houses, for example; postcodes shouldn't split an apartment in two.

The favoured solution is one that comes naturally to most of us: a house number, followed by a street, a town and a country. The name for that combination is the S42 address standard, defined by the Universal Postal Union (UPU), a UN agency that works to ensure the 320 billion letters and nearly 8 billion parcels we send every year get to where they need to go. One of the main advantages of S42 is that it is hierarchical: houses are on streets in districts within towns inside countries. That makes it easy to group neighbouring properties together – a crucial asset for governments looking to evacuate citizens, or utility companies managing a district's power supply.

But the system has drawbacks, too. An S42 address doesn't tell you the physical location of a building, for example – for that, you need a list that can match it with a geocode, a lengthy combination of latitude and longitude, to identify the right spot.



NEIL STEVENS

Geocodes aren't foolproof either, though. Just ask Chris Sheldrick, who used to stage private gigs. That meant getting performers and equipment to venues on time.

"My attitude was: just give the driver latitude and longitude coordinates. They can stick them in their satnav; all satnavs accept them, and that'll bring them to within metres of me," says Sheldrick. But all those numbers can be hard to remember. One day, a driver got one digit of the code wrong and ended up an hour south of Rome instead of an hour north.

Sheldrick was still fretting over the affair a few months later, when he had dinner with an old friend named Mohan Ganesalingam. "I put it to him," says Sheldrick. "There needs to be a human solution where people don't make errors."



That got Ganesalingam thinking. If you divided Earth's surface into squares 3 metres across, would there be enough words in the English language to label each of the resulting 57 trillion plots of land with a unique three-word phrase? Simple arithmetic – the cube root of 57 trillion – showed that 40,000 words would be enough: a fraction of the 170,000 in the *Oxford English Dictionary*.

Five years later, Sheldrick and Ganesalingam had put the idea into practice. Their what3words software is free to the public, but licensed out to logistics firms. With offices in west London – otherwise known as *index.home.raft* – they have also raised £15 million in venture capital.

It might seem strange that what3words is in vogue when there are plenty of other

competing ways of dividing up the globe. Some use hexagons, others triangles. MapCode, created by the founder of the TomTom mapping and navigation service, has been using squares since 2001. But they all use unmemorable sequences of letters and numbers to label locations, whereas Sheldrick and Ganesalingam were desperate to create something easy to remember. They latched on to a 1951 study by two psychologists at the University of Miami, Florida, showing that people's capacity for short-term recall was far better for words than for letters and digits.

Whatever the reason for its success, what3words is becoming a routine part of life in some parts of the world. The postal services of Ivory Coast, Mongolia, Djibouti, Tonga, the Solomon Islands and Sint Maarten in

the Caribbean now use it as their official addressing system. Steve Coast, founder of the crowdsourced mapping service OpenStreetMap, credits their marketing. "That's why w3w is interesting," he wrote in a blog post. "They have truly great – some of the best I've seen – people who're pushing this solution all over the place."

One of those places is KwaNdenegezi. Coenie Louw, who directs a charity called Gateway Health Initiative, coordinates a community-run hospital transport service in the area that is cheaper and more reliable than ambulances or taxis. The service's big issue was locating patients, says Louw. "We tried all sorts of things, like triangulating from cellphone towers, which never worked because they can't give you an exact location." ➤



Now Louw sends out fieldworkers with smartphones to teach residents their what3words addresses. In the event of an emergency, these can then be used to help guide the community ambulances. Although he is still piloting the scheme, Louw reckons the typical wait is now about 30 minutes – down from the previous average of 3 hours.

But for all what3words's usefulness, it doesn't do everything an address should. A single house could have multiple three-word addresses, for example, while flats on different floors of a building would be indistinguishable. What's more, the addresses give no clue as to how close or far apart they are. Sheldrick and Ganesalingam admit that their invention is just a smart way of specifying locations. "We're the solution to a specific problem; we want to do one thing," says Sheldrick.

But their idea of truncating coordinates into a more user-friendly code could still be more broadly useful. "An address is the currency you use to enjoy your rights and responsibilities in society," says Patricia Vivas at the UPU. So assigning people a code that can fulfil some of an address's functions without waiting for the authorities to get round to it could be a boon for unaddressed communities.

In 2014, the UPU launched a competition to wheedle out the best examples of geocoding innovation. Although what3words made it to the second round, it didn't win. One of the three that did was proposed by Serena Coetze

## "An address is the currency you use to exercise your rights in a society"

and Victoria Rautenbach at the University of Pretoria's Centre for Geoinformation Science in South Africa. Their idea was meant to help aid workers during the response to an emergency, such as a disease outbreak.

Coetze and Rautenbach set out how free satellite imagery could be augmented with an editable layer to assign each house a coded address. Fieldworkers could then use that to tick off addresses and upload information about them, creating a database as they went.

Of course, there was nothing inherently new about their ideas. They were simply a cheap way to help create and maintain an addressing system where no authority exists to do so. The one major advantage their version offered, however, was its editability. If new houses spring up in a neighbourhood, for example, or if a hospital wants to assign its entrances



LARRY TOWELL/MAGNUM PHOTOS

### Unclear addressing systems can be a drain on the economy

distinct identifiers to save time in patient triage, it can take ages for the official databases to reflect the change – even in countries where reliable addresses exist. An open-source addressing system could be the way forward.

But try creating something similar in a developed country and you could find yourself up against powerful interests. Almost 10 years ago, Richard Pope and Harry Metcalfe developed a simple web-based application that would take any UK postcode and convert it into a latitude and longitude. They hosted it at ernestmarples.com, named after the postmaster general who, in 1959, introduced what would become the postcode system. It quickly spawned several websites that used the tool to help people do nifty things, such as call up a list of applications to construct or modify buildings in a given area. It was also "a bit of a provocation", says Pope.

That's because Royal Mail and the government-owned firm Ordnance Survey own the authoritative geocoded lists of postcodes and addresses in the UK. Royal Mail, now privatised, makes about £30 million a year by licensing the data to firms ranging from couriers to insurance brokers, says Peter Wells, head of policy at the non-profit Open Data Institute in London. That means Royal Mail has a clear interest in defending its intellectual property. "They sent us nastygrams telling us to cease and desist – so we did," says Pope.

The irony is that an open database allowing users to convert postcodes to geocodes for free

would be a catalyst for innovation. Start-ups in fields ranging from home delivery to insurance would stand to benefit. Wells also points to the potential of driverless cars to automatically update such a database when they spot errors.

The economy, too, would benefit. Denmark adopted an open addressing system in 2002, and this boosted its economy by about €15 million a year, according to a study by the country's Enterprise and Construction Authority. If you were to crudely extrapolate that to the UK on the basis of population size, says Wells, it would work out as an annual windfall of £110 million.

What's galling for people like Wells is that open addresses seem to be catching on in most developed countries – France, for instance, introduced its open address database last year – making the UK a conspicuous outlier. A further irony is that at one stage, Wells had government funding to create an open address list for the UK, which he reckons could have been done in as little as two years. The project died principally because he could not find insurers willing to cover it against the risk of litigation.

There's no denying that creating and maintaining an addressing system is a complex and time-consuming business. Even the little things, like those eye-catching signs popping up in KwaNdenezi, have to be made by someone. But as ever shinier alternatives to the traditional address come to light, maybe the most important thing to consider is not what they look like, but who controls them. ■



# Think on this

Chips that multitask like the brain will soon deliver a computing revolution, says Liesbeth Venema

**S**OMETHING is going on outside your window. Rough oblongs zoom past, one of which sidles along and stops, disgorging a series of small irregular shapes in many colours. High-pitched sounds drift up as they messily assemble into a row behind a taller shape.

Microseconds pass and all becomes clear: a group of schoolchildren has pulled up in a bus and lined up behind their teacher. Your brain has taken a chaos of sensory inputs and produced a lucid experience – as it does day in, day out, throughout your life.

If only computers could do the same. We may talk about artificial intelligence learning human smarts like driving cars or playing

RAYMOND BIESINGER

poker, but when it comes to quickly making sense of a huge, disordered set of information, we can't build an AI that even comes close to our brains. That's partly down to mysteries about the workings of the human mind that we're hard-pressed to explain. But it's also down to a bottleneck baked into the architecture of nearly every computer for more than half a century.

Now we may be on the cusp of eliminating it thanks to a radical new computing paradigm, one that uses hardware that simultaneously stores and processes information – not unlike networks of neurons in the brain. Fulfil its promise and we could create machine minds that can parse rich streams of data in real

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time, spot patterns that elude us, and maybe learn without any help from humans.

Laptops, smartphones, tablets, you name it, they all adhere to an architecture that dates back to John von Neumann, one of the fathers of computing. Some 70 years ago, he proposed that computers should have separate processor and memory units. It may not sound like such a grand proposal, but it meant you no longer had to rewire a computer every time you wanted to run a fresh program. This division of labour has worked pretty well since then, allowing us to make ever-faster computers by souping up processors and memory in tandem.

But there is a catch. The von Neumann architecture means that whenever the processor needs information, it must retrieve it from the memory. That requires electrons to shuttle back and forth between the two, so the processor is often idle, waiting for data. This is

one reason why your laptop probably has multiple “cores”; installing more processor units – each with their own connection to the memory – means they can request data simultaneously, speeding up the machine overall.

These days the bottleneck is really beginning to constrict us. There is more data to shuttle than ever, especially with the “big data” revolution looming. We are already glimpsing its promise: for example, there are algorithms that are better at predicting who will have a heart attack than standard medical risk assessments. Designed by researchers at the University of Nottingham, UK, the algorithms achieved this prowess by digesting the electronic medical records of nearly 400,000 people, a massive data-crunching task. And with the so-called internet of things encompassing ever more everyday objects – from traffic lights to fridges – machines will have even more scope to provide insights into our lives.

Manage that correctly and it could be wonderful. But computers are already overheating under the volume of data. According to a US Department of Energy report, between 5 and 15 per cent of the world’s energy is spent on computing, much of it wasted on data trafficking. This is why the von Neumann bottleneck must be widened out or better still removed altogether.

## A bottleneck has been baked into computer architecture for 70 years

Many attempts have been made to do that, for example, by developing programming languages that encode data more efficiently, reducing the number of electrons that need to shuttle back and forth. And in the 1980s, scientists started to consider using photons instead of electrons to encode information. Photons in optical cables travel faster than electrons in wires, so the data transfer time would be reduced. Others wanted to stick with electrons but cram more information in by encoding it into a quantum mechanical property called spin. But so far neither strategy has quite come off, mainly because they are so complex to implement that the work involved outweighs any speed gains.

In short, we have been racking our brains for an answer for decades – which is ironic because our brains are themselves a supercomputer capable of amazing feats



RAYMOND BIESINGER

that need no more power than a 20-watt light bulb. They have nothing like the von Neumann bottleneck, of course, because the same network of neurons both stores information and processes it.

So how to copy them? There lies the rub. By no means do we have a complete picture of how the brain works, but there are probably at least three key features needed to mimic what it does.



First, it consists of a vast network of neurons with lots of connections called synapses. Second, those connections have synaptic plasticity; that is, they can be made stronger or weaker. We know that learning manifests itself as a strengthening of the connections between sets of neurons.

The third feature is called spike-time-dependent plasticity. This idea, less well understood than other features of the brain,

says that a synapse only strengthens if the two neurons fire at similar times; if they fire out of sync, then it weakens. Over the long term this process builds strong connections between neurons that are working together to pass messages around, and weakens connections that don't seem to be important. It is thought that this is essential to the way our brains manage to learn independently. Imagine you see a green traffic light; you immediately

know it means "go" because the sequence of neurons involved in that thought have developed strong connections over the years.

In truth we have been trying to ape the way the brain computes for a long time. And this field, today known as neuromorphic computing, has seen some neat progress.

**"Until the memristor came along, we'd never been able to mimic a synapse"**

One of our earliest efforts was the gloriously named Mark 1 Perceptron, unveiled in 1958 by a researcher named Frank Rosenblatt. This wardrobe-sized array of electronics was organised in a network reminiscent of neurons. Rosenblatt showed cards bearing circles or triangles to the machine's camera for it to name the shape, and he would then correct its mistakes. Within 50 tries, the perceptron had learned to output one signal for circles and another for triangles.

The perceptron was limited by the electrical engineering of the day, so its neural network wasn't particularly extensive, nor were its abilities that exciting. But things have moved on considerably. Today, Google DeepMind's neural networks can pull off impressive feats, such as when its AlphaGo program defeated the best human player of the game Go last year.

The thing about DeepMind's neural network, however, is that it is entirely simulated in software, and runs on standard silicon electronics. So although it learns in a similar way to a network of neurons, it does not get around the von Neumann bottleneck.

IBM's TrueNorth chip, which appeared in 2014, goes further. It boasts 5.5 billion silicon transistors arranged into a brain-like architecture of 1 million interconnected "neurons". It could recognise in real time objects like cars and bicycles in videos, using about as much power as a smartphone does in sleep mode. That sounds impressive, but if the chip were scaled up to match the 100 billion neurons of the human brain, it would consume 10,000 times more energy than the brain. "It is actually a wasteful approach," says Giacomo Indiveri, a neuromorphic engineer at the University of Zurich, Switzerland.

In short, while we've managed to mimic some of the features of the brain, we've never been able to combine all three in a physical system. The TrueNorth chip, for example, has a lot of highly connected "neurons" but it can't adjust the strength of the connections ➤

between them, except with software.

That failing is down to the fact that conventional electronics hasn't delivered a device that truly mimics a synapse. But we have a way out of that impasse, thanks to an idea that surfaced almost half a century ago.

In 1971 Leon Chua, an electrical engineer at the University of California, Berkeley, was looking at the equations connecting the basic circuit components students learn about – the resistor, capacitor and inductor – when he noticed that there was another way the terms could be arranged. This produced an equation for a fourth component whose resistance

would vary depending on the current. Chua called it a "memristor" because its resistance seemed to display a memory. But with no material or device known to behave in this way, his idea was largely forgotten.

Then, about a decade ago, a team at Hewlett Packard led by Stan Williams was working on a new type of memory that would, unlike a desktop computer, retain its data when the power was switched off. The researchers were investigating devices based on thin films of titanium when they noticed that their resistance was changing in strange ways depending on the current passing through

them. Eventually, they realised it wasn't just electrons that were moving within the films, but also atoms, which subtly and reversibly changed the material's structure and so its resistance. In other words, the team had inadvertently created Chua's memristor (*Nature*, vol 453, p 80).

Williams's work helped explain why memristance had never been seen before; it only manifests itself on tiny scales. But with that unearthed, a range of other materials have now been found to act as memristors, including some polymers.

The advent of real life memristors has animated researchers for several reasons, including opening up the possibility of computing in more sophisticated, efficient languages than 0s and 1s (see "Beyond binary", page 34).

But soon real action was happening on the neuromorphic computing scene. Shortly after Williams's discovery, Wei Lu, an engineer at the University of Michigan, took the crucial step and showed that memristors can act as plastic synapses. He used a device made of several thin layers of silicon, one of them with a smattering of silver ions, and showed this can mimic that second feature of the brain. Lu later showed that memristors can simulate the third ingredient too; the memristor synapse could be strengthened or weakened depending on the exact timing of applied electrical spikes.

This work shows that it is "really an exciting time for neuromorphic engineering", says

## "Memristor networks pull off all three of the brain's most crucial functions"

Indiveri. Beatriz Noheda, a physicist at the University of Groningen in the Netherlands, agrees. "It's time to give up on silicon transistors," she says, and focus on developing full-blown memristor-based neural networks.

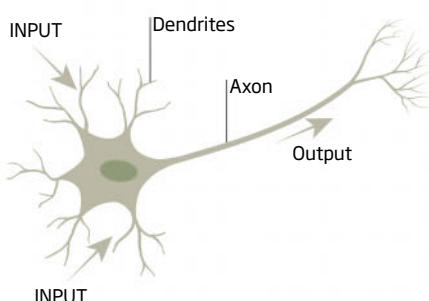
It might seem that would be simply a case of scaling up Lu's work. Although his efforts involved only a single synapse with an input and output neuron, it showed that memristors could pull off all three crucial functions of the brain. The way forward would be to build networks with more and more layers of networked memristor neurons; with each added layer, the network can "think" in more sophisticated concepts (see diagram, left).

Not so fast, says Geoffrey Burr at IBM's Almaden research lab in California. He says

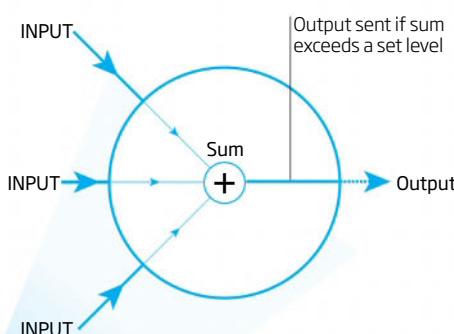
## Inside an artificial mind

Neural networks achieve amazing feats by mimicking processing in the brain

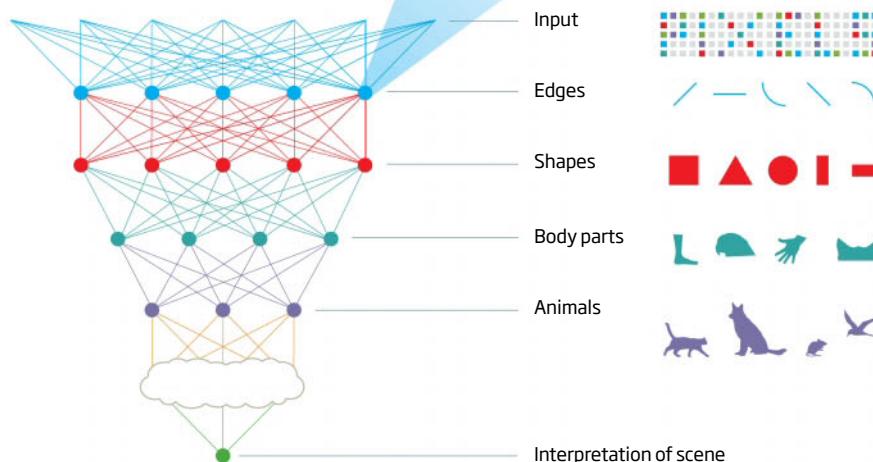
A biological neuron has dendrites that collect input signals. If their combined strength exceeds a certain level, the cell sends an output signal to the ends of a fibre called an axon, where it can form the input for thousands of other neurons



Artificial neurons emulate this behaviour using hardware, software or both



Assemble the artificial neurons into a network, and each of its layers can latch on to increasingly sophisticated concepts – with applications such as recognising objects in images





## Memristors could be perfect for making brain interfaces

Finally, we seem to be recreating with memristors the essence of what your brain does when you look out of a window. This is independent learning with no bottlenecks.

Suitably scaled up, such self-teaching systems could screen data in real time, for example, monitoring the behaviour of self-driving cars or the integrity of bridges or nuclear plants. This could reduce the need for more sprawling data storage centres, like the ones that store data for social networks. These are sometimes built near the Arctic because they require so much cooling. But if our data is parsed in real time by networks of memristors then maybe we don't need to keep it.

Computers made from memristors have one more potential benefit: because they work akin to our brains, they may be easier to interface with them. There are already silicon-based devices out there that pick up brain activity and relay it to things in the physical world, enabling paralysed people to control exoskeletons, for instance, or let someone control a computer while dreaming.

But many challenges remain. The behaviour of neurons in the brain is complex in the extreme, and existing neural interfaces find all that information hard to handle. "The electronics to process this very rich, high-bandwidth data, becomes unbearable," says Prodromakis. Memristors could be the ideal solution because they only record signals that spike significantly, ignoring the noisy background. This excites Prodromakis, who has recently started developing memristor-based neural interfaces with Galvani Bioelectronics, a UK company formed last year in a £540 million partnership between GlaxoSmithKline and a Google subsidiary.

One of the biggest questions hanging over memristor networks is whether we could ever manufacture them efficiently. Silicon circuits are pumped out by well-oiled factories; would anything like that be possible for memristors? The first step to answering that question is to properly scope out the best materials to make them from, and Noheda is now setting up a research centre in Groningen to do just that. If she and the other memristor champions are successful then the computers of the future could be made from a component that, for 40 years, we thought didn't even exist. ■

the spike-time-dependent plasticity Lu has demonstrated is all very well on a small scale, but neuroscientists aren't sure how this feature plays a role in learning on a large scale in the brain. "It must happen somehow," he says. "But we aren't even close to figuring it out." That means that implementing it in a large artificial neural network is no guarantee of getting closer to brain-like computing.

Burr prefers to stick with networks that don't have spike-time-dependent plasticity baked in. The one he uses is like those that power Google DeepMind's neural networks, which have plastic synapses controlled by software. But by running them on memristors rather than transistors he can potentially use thousands of times less energy.

In 2014, Burr constructed just such a network with almost 165,000 synapses. Training it on a database of handwritten letters, he then showed that it could accurately recognise them. Burr's memristors were made from a chalcogenide glass, a material that can switch between phases where its atoms are more or less ordered, altering its conductivity. Such phase-change memristors are becoming so reliable that chip manufacturer Intel this year began selling memory devices based on them.

Others think memristors could lead to machines that can learn entirely on their own. That includes Themis Prodromakis, a nanoelectronics researcher at the University of Southampton, UK. Starting small, last year he built a network of four input and two output neurons connected by memristor

synapses. He could feed it electrical signals such as "1001" or "0110" – akin to showing circles or triangles to the 1950s perceptron. But unlike that machine, which required a human to tell it whether it had guessed the right shape, Prodromakis's network had spike-time-dependent plasticity, and learned all on its own to fire off one output neuron when it saw 1001 and the other for 0110. This worked even with noisy input signals, an important win given that real-life data is messy.



FREDERIC LEWIS/ARCHIVE PHOTOS/GETTY IMAGES

The Mark 1 Perceptron was an early neural network

Liesbeth Venema is a senior editor at the journal *Nature*

Man's best friend is all that stands between us and a rabies-free world, says [Clare Wilson](#)

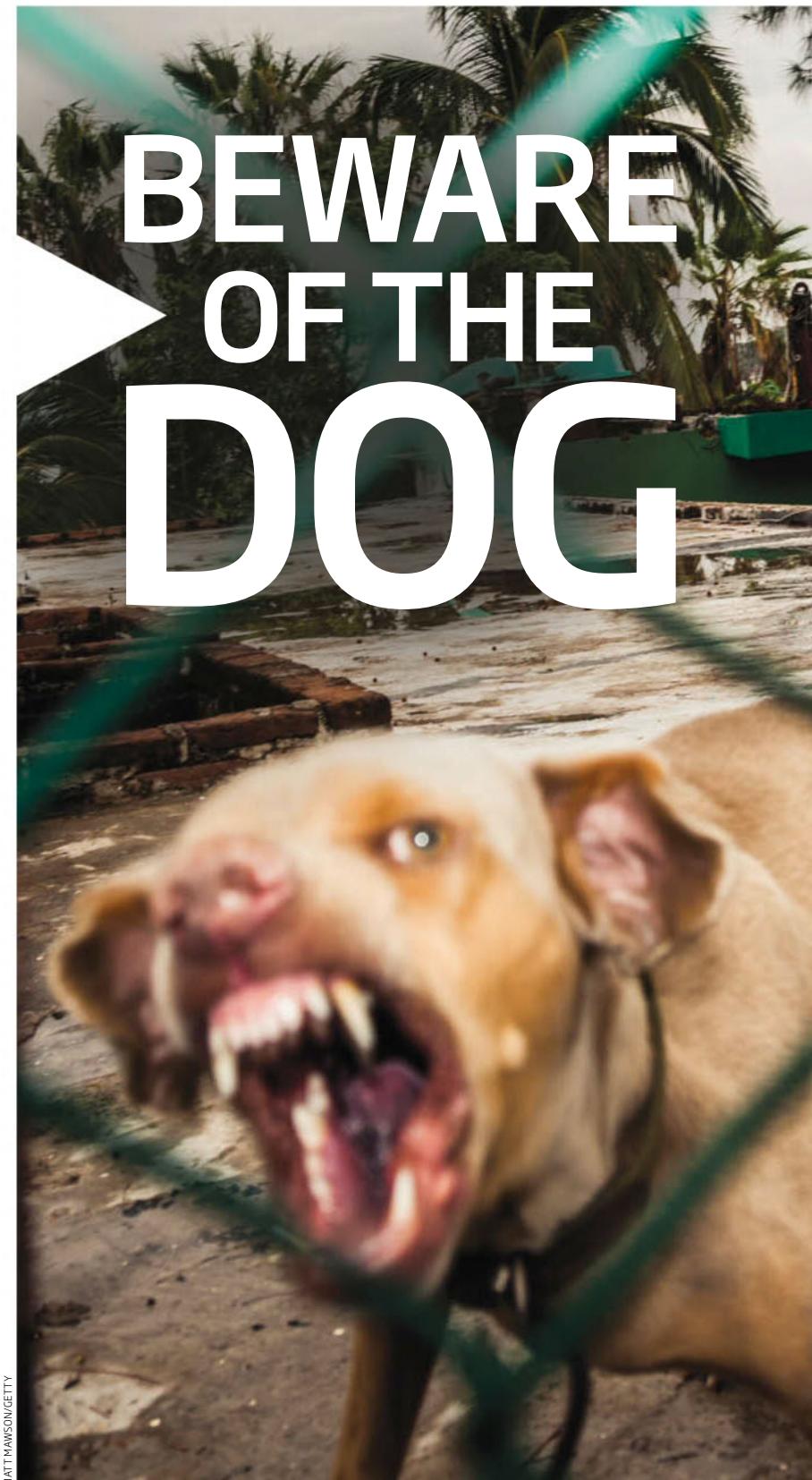
**A** CHILD dying of rabies is a particularly dreadful thing," says Neil Kennedy, a paediatrician from Belfast, UK. Kennedy last treated a person with rabies in Malawi in East Africa. The patient was a 10-year-old boy he calls David, who had been brought to the hospital after several bouts of delirium. Soon David began to show the telltale sign of the disease: being unable to swallow water and even his own saliva, leaving him foaming at the mouth. All that could be done was to keep him hydrated with a drip and sedated for the few days it took him to die.

The manner of death was horrible, but even worse was the knowledge that it was completely needless, says Kennedy. Rabies is one of the most lethal infectious diseases known to humankind. Once symptoms appear, it is almost always fatal. It kills 60,000 people a year, and disproportionately affects children. Almost all the deaths are in Africa and Asia, where people lack access to the vaccine and treatment.

Yet it may be possible to nearly eliminate human deaths from rabies – not by treating people, or tackling the many wild species that carry the disease, but by targeting dogs. Several small-scale trials suggest that this should make elimination possible in just a few years. If such an approach works, rabies would become only the third infectious disease to be eliminated, after smallpox and cattle disease rinderpest. "It's going to take a sustained effort for several years, but this is definitely achievable," says Kennedy.

Rabies is an age-old foe. While many animals from bats and skunks to monkeys and raccoons can carry the disease, in most of these species, the virus is specially adapted to the host. It is only rabies from dogs that poses a significant threat to people, causing over 95 per cent of human deaths, mainly ▶

# BEWARE OF THE DOG



MATT HAWSON/GETTY



## HOW TO SPOT A RABID DOG

The rabies virus incubates in dogs for between two and eight weeks before obvious symptoms appear. These might include a foaming mouth, staggering and extreme aggression. Yet saliva from affected animals can cause infection 10 days before symptoms appear. More subtle early warning signs include:

- ▶ Behavioural change - restlessness in a normally docile dog, laziness in an active dog
- ▶ Fever
- ▶ Loss of appetite
- ▶ Constant licking of wound
- ▶ Hiding in dark places and avoiding contact with people

through bites from dogs whose saliva is infected. In ancient Mesopotamia, failing to stop your rabid dog biting someone could land you with a fine of up to 40 shekels of silver: enough to buy 20 boats. There was good reason for this law. At the time, the only remedy for someone who was bitten was holy water and prayer.

A combined vaccine and treatment has been available since 1885, when Louis Pasteur treated a French boy of about David's age who had been bitten by a rabid dog. Pasteur's vaccine was made from the dried spinal cord of an infected rabbit, and, after several applications, saved the boy's life. Like that vaccine, the modern equivalent can be used as both prevention and treatment because of an unusual feature of the disease: the virus doesn't immediately take hold after entering the body. It can take weeks to travel up the nerves from the bite wound into the spinal cord or brain.

This slow process means that if someone bitten by a rabid animal gets treatment – up to five shots over a month – fast enough, they won't get sick. Thanks to this remedy, in the US, for instance, there are only one or two deaths a year from rabies, usually because someone was bitten by a wild animal that wasn't obviously rabid.

The vast majority of human deaths from rabies today are in Africa and Asia, where most dogs are allowed to wander the streets. The concept of dog ownership is often looser

## "I saw children playing and I thought, 'This is worse than a tiger loose in the village'"

than in the West. People might feed their favourite mutt with scraps and perhaps give it a bed for the night so it acts as a guard dog, but there's not nearly as much mollycoddling – or money for rabies vaccines. Similarly, if someone gets bitten, treatment with the rabies shots may be out of reach. In countries like Malawi, one of the poorest in the world, treatment costs more than a month's wages. Even if a family can afford it, local hospitals may not have it in stock.

That's why rabies control in developing countries often focuses on reducing the dog population. A common community response to a rabies outbreak is a cull, which can be as brutal as people seeking out dogs and clubbing them over the head.

But culling isn't a long-term solution, says Katie Hampson at the University of Glasgow, UK, who has studied rabies transmission in Tanzania. It does lead to a temporary drop in numbers, but other dogs soon move in to fill the gap. Street dogs breed so quickly that by the time half have been killed, the rest have had enough puppies to replace them.

What works better is leaving the dogs alive and vaccinating them. The vaccine for dogs is relatively cheap: around 25 cents a dose, compared with over \$100 for a course of

human treatment. If enough dogs in an area can be vaccinated every year for several years, there is a good chance of ridding the population of the virus for good.

A factor that works in the favour of such programmes is that, unlike a highly contagious disease such as measles, where each infected person passes it on to about 15 others, a rabid dog only infects an average of 1.2 others before it dies. This means that if 70 per cent of dogs in an area can be vaccinated, the disease will peter out – it's likely that the one or two dogs bitten by each infected animal will have immunity. And without the gap in the population left by a cull, there is no space for dogs from outside to move in, bringing the virus with them.

## Reservoir dogs

This approach hasn't always been taken seriously in the past because of the worry that so many other animals carry the virus. It has been argued that even if the disease were eradicated from one species, there will always be a reservoir in nature to replenish it. But that's misguided, says Sarah Cleaveland, a veterinary epidemiologist at the University of Glasgow. While a dog can be infected by a bite from a bat and might then bite a human, the bat variant won't go on being passed from dog to dog because the bat rabies virus isn't adapted to dogs, so is transmitted from one to another even less efficiently than the dog variant. "You might get occasional spillovers, but it eventually fizzles out," she says.

Proof comes from the great success that many South American and Caribbean countries have had using this approach. Typically, they have set up free vaccination clinics in the community for people to bring in their dogs, who are then given a distinctive red collar. This has worked so well in Uruguay, Chile and southern Brazil that they have been able to stop mass dog vaccination campaigns. Several other countries are still vaccinating, but have seen no or very few human deaths from dog rabies for many years. The list includes Argentina, Colombia, Costa Rica, Ecuador, Mexico, Nicaragua, Panama and Paraguay.

Other places, by contrast, have made little progress despite a great deal of effort. For instance, the Indonesian island of Bali has been struggling to rid itself of rabies for nearly a decade using a mix of vaccination and culls. Hampson, who has advised Bali on rabies control, argues that the two-pronged approach is part of the problem.

## GOODBYE DISEASES

So far, we have only managed to eliminate one human disease from the face of the earth: smallpox. It was declared gone in 1980, and now remains in just a few laboratory vials. There were good reasons why this was achievable with smallpox. Not only did we develop a cheap and effective vaccine that gave long-lasting immunity, but there were also no animal hosts; it was easy to diagnose and it had only a short incubation period during which the virus could be unwittingly passed on.

Since then, we've also got rid of the cattle plague rinderpest, which didn't infect humans, but caused famine in areas where people depended on cows for their livelihood. Mass vaccination campaigns saw it off in 2010.

Other diseases are more stubborn.

Polio, a childhood illness that causes paralysis and death, has now been reduced to a handful of cases a year worldwide, but is proving difficult to eradicate. That's partly because of political unrest in the few countries where it is still endemic, including Afghanistan, Nigeria and Pakistan, and the difficulty of reaching people in remote areas.

Guinea worm, a parasite passed on through the water supply, seemed like a good target for eradication. The plan of attack was to teach people to filter their drinking water and avoid bathing their wounds in rivers and other natural water sources. Last year, though, efforts hit a bump in the road when the worms, usually a human-only parasite, started spreading in dogs. Now it's a two-species parasite, it may take a little longer to beat.



MATT HAWSON/GETTY

Rabies is still a daily concern in parts of India, but may soon be a thing of the past

up a charity called Mission Rabies, aiming to provide proof of principle that dog vaccination could work even in India.

The approach has so far been used successfully in Goa, India's smallest state. It is a good target as it is bounded by the ocean on one side and mountains on the other. There, human rabies deaths have been reduced from 14 in 2014 to four in 2015 and one in 2016. Two years ago, the Goan government began funding half the costs. "They never would have done that if we hadn't shown it was possible," says Andy Gibson, a UK vet who works for Mission Rabies.

The charity has now expanded operations into Blantyre in Malawi, motivated by Kennedy's recent report of an outbreak there. That city, too, has since seen a dramatic fall in rabies cases. David was the last person at Kennedy's hospital to be treated for rabies, and he was bitten when staying with relatives in the countryside.

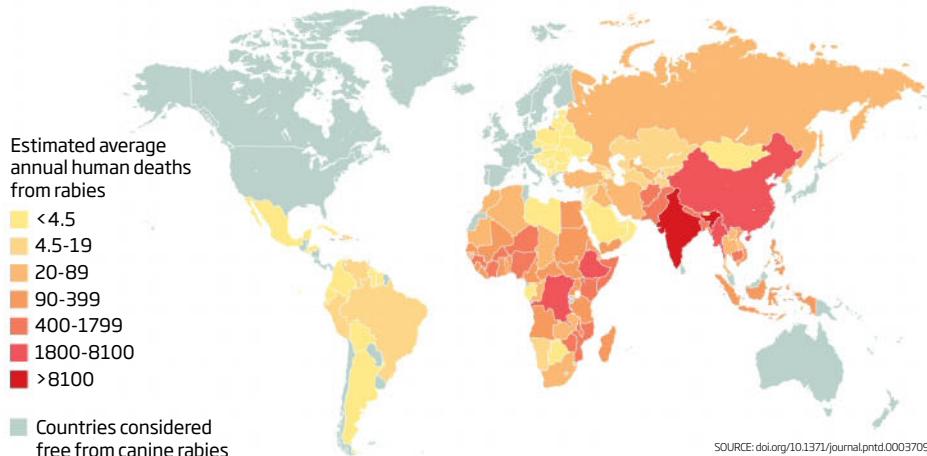
While these successes are encouraging, they are still relatively small-scale projects. Real progress in eliminating dog rabies will only happen with buy-in from national governments and international bodies. Rabies isn't as tempting a target as smallpox, for instance, which had no animal hosts to keep the disease going (see "Goodbye diseases", page 40). That's partly because even when a country has got rid of dog rabies, doctors still need to watch out for any cases in people, because of the handful of infections that come from wildlife. Yet wiping out rabies would still save health systems money by avoiding the need to give the human vaccine as treatment for dog bites. It would also avoid the unnecessary deaths of 60,000 people a year who are too poor to get that treatment.

Still, there are many other neglected tropical diseases crying out for more funding, so those campaigning for rabies elimination have to fight its corner. A shift came at the end of 2015 when the World Health Organization and several other international bodies set the goal of ending all human deaths from dog rabies by 2030.

The WHO can't dole out funds, but Cleaveland says the edict is galvanising people into action – helping to get governments on board and non-governmental organisations to open their purses. "This is a no-brainer," she says. "Rabies has the highest fatality rate of any disease and it's totally preventable. All it takes is the will." ■

## Reality bites

Only a few corners of the globe are free from the fear of rabies



Indiscriminate culling hinders vaccination campaigns, she says, because when vaccinated dogs are killed, it lowers herd immunity below the target 70 per cent level. It can also antagonise the public, who may be wary of bringing their dogs in for vaccination if they have seen other dogs being killed. At times, dogs were being shot with strychnine-loaded blow darts. "It's a horrific way to die," says Hampson. "People were upset."

On Bali, eradication should be easier since it's an island. By comparison, it seems India has a huge task on its hands. This country has a disproportionate share of global rabies deaths – 35 per cent of the total – mainly because of its high numbers of street dogs. Inadequate rubbish collection in towns and cities means they often feed off food waste. Some rubbish dumps are no-go areas after dark because of ferocious packs of dogs, says

Luke Gamble, a vet based in Fordingbridge in the UK, who also works in India.

Not only does India have the highest number of street dogs, but the animals are also wilder. Those that are semi-owned tend to have a looser bond with the person who feeds them. This means that person may well be incapable of catching their dog to bring it to a clinic for vaccination.

Gamble became passionate about eradicating rabies when doing charity work in India in 2012. A rabid dog was brought to him to be killed and he was told that it had bitten three other dogs that couldn't be caught. "I saw children playing in the dirt nearby, and thought these dogs are worse than having a tiger loose in the village," he says.

So Gamble hatched a plan to vaccinate India's street dogs by catching them in nets, jabbing them through the mesh and marking them with spray paint. Back in the UK, he set

Clare Wilson is medical reporter at *New Scientist*

# I put my finger on the pulsar

Fifty years ago, **Jocelyn Bell Burnell** discovered a mysterious, pulsing radio signal – and the downsides of being a young woman in science

In a way, it was the second signal that was the big one. The first signal I saw could have been a mistake. The second one meant this was something real. It took a while to realise what we had found: the very first pulsars, a new type of star. We're still working out the true significance of the discovery today.

It was 1967, and we were looking for quasars using a radio telescope designed by Tony Hewish, my supervisor at the University of Cambridge. Back then, we knew only that quasars were very distant objects, with radio signals that grew strong and weak in an irregular way. But this new signal was strong, not weak, and came in absolutely regular short bursts.

It didn't look like interference, either, although that was often a problem for us. Our telescope was a tangle of 2048 radio antennas covering about 4 acres just outside the city (see picture, far right). You pick up a lot of interference with such a vast collecting area. Once somebody mistakenly allocated our observation frequency to the local police.

The first unexpected signal was jammed into a quarter-inch of the chart recorder – just a pen moving mechanically over paper – which I'd set to run slowly for the longer quasar signals. So I ran the paper faster at the time of day the signal was appearing, to spread it out, a bit like a photographic enlargement. But nothing came. The signal had disappeared.

One of the first questions my colleagues asked was whether I had wired the telescope up wrong. I was used to that. For one thing, I was a junior doctoral student. For another, I was a woman. It had been worse in Glasgow, where I'd done my undergraduate degree. There, whenever a woman entered the lecture theatre, all the guys whistled, stamped, banged the desks and catcalled. Cambridge



was more genteel, but also more snooty. I felt like an imposter there, as a girl from the provinces, from Northern Ireland. I was convinced that someone would find me out and then throw me out. I worked as hard as I could, so I'd have a clear conscience when that happened.

After a month or so, the signal reappeared. I immediately phoned Tony. If it was a signal, he said, it must be of human origin because it was so regular, pulsing once every 1.3 seconds, like a metronome beat. But I knew it couldn't be. Stars rise and set 4 minutes earlier each day as Earth orbits the sun. It had been early August when I first observed the signal. Now it was November, and the signal had kept pace with the stars. If it was something artificial, like radio interference from someone driving around in a car with a badly suppressed alternator, they would have had to religiously get 4 minutes earlier every day.

It was an anxious moment when Tony came out to the observatory the next day to look over my shoulder, but, sure enough, the signal came. That was when we had to start thinking about what on earth – or off it – it might be. I called it LGM-1, for “little green men”, as a joke. But if it was a communication from an alien intelligence, they were using a bloody stupid technique. For one thing, the signal was amplitude-modulated. There are many ways that natural phenomena can modulate a signal's amplitude. If you want to signal across light years of space, you wouldn't use AM, you'd use FM – it makes for a more obviously artificial signal.

We managed to estimate the source's distance. It was about 200 light years away: within our galaxy, but way beyond the distance our TV and radio signals had travelled into space since they'd started a couple of decades earlier. It really would have been a curious set of little green men signalling to our inconspicuous solar system.

## Aliens begone

That was when we found a different signal and, a few weeks later, a third and a fourth, each with its own periodicity. That demolished the little-green-men hypothesis, unless lots of aliens were signalling to us from opposite sides of the universe. Instead, it must be some new kind of star. We didn't know that when we published our paper in *Nature* – “Observation of a Rapidly Pulsating Radio Source” – in February 1968. Of course, the media only latched on to one line in the paper saying we had briefly considered the signals

Jocelyn Bell at Mullard Radio Astronomy Observatory and, right, with Anthony Hewish



HENCHUP ENTERPRISES LTD/SCIENCE PHOTO LIBRARY

might have originated on an alien planet.

I published under the name S. J. Bell, and at first the press didn't realise I was a woman, let alone a young one. When they found out, I suddenly had reporters on the phone asking if I was brunette or blonde – no other colours were allowed, apparently – and what my vital statistics were, which I didn't know. I was asked questions like how tall I was, and was that taller than Princess Margaret or not quite so tall? And then photographers were asking me if I could please undo the top buttons of my blouse. I have a sharp tongue and I would have loved to use it, but I wasn't in a position to do so. The lab needed the publicity and I needed good references for my next job.

It was a similar story in 1974 when Tony Hewish was awarded a share of the Nobel prize for the pulsar discovery and I wasn't. I said at the time it was only right, because he was my supervisor, but I didn't entirely believe it. I don't think the snub was because I was a woman. It was because I had been a student. In those days, students just weren't recognised. That's changed for the better since.

I got married soon after the pulsar discovery and moved away from radio astronomy, following my husband's relocations for his job. I've had a varied career since: I've done astronomy in most bits of the spectrum, and been a lecturer, a researcher, a tutor and a manager. But I still feel a bit proprietary about pulsars, so I've kept a friendly eye on them.

We now know of 2500 or so pulsars dotted around our galaxy. Like any family, they are a diverse bunch. But they are all very compact, very massive, spinning neutron stars. As they spin, they swing a beam of radio

waves around that regularly sweeps across Earth, a bit like a lighthouse beam. The signals are so regular that pulsars make very accurate clocks, allowing us to test Einstein's theory of general relativity and how massive objects make gravity by warping the space-time around them.

## “My colleagues asked if I had wired up the telescope wrong. I was used to that”

So far, Einstein's theory has scrubbed up really well, but we keep at it because gravity doesn't fit in with the other forces of nature. It stands out alone and that's a little bit suspicious. We've also only tested relativity in environments where gravity is relatively weak, like our solar system. Now we've found binary systems in which pulsars orbit other stars, so we can use these to test what happens when the gravitational effect is particularly strong.

We are also working to use disturbances in pulsar signals to detect gravitational waves affecting space-time. The LIGO experiment has detected gravitational waves sent rippling out when two stellar-mass black holes merge, but timing pulsar signals can allow us to see different things going on – what happens when two supermassive black holes at the centre of galaxies merge, for example.

These are all things I never could have imagined when I saw that first signal. I'm just glad I noticed it – and was persistent enough to believe it was real. ■

As told to Richard Webb

# Is our future better than we thought?

Two environmental visions are competing for our attention: an Anthropocene desert of homogenised mongrels versus a virtual supercontinent teeming with new species. **Fred Pearce** explores

*Inheritors of the Earth: How nature is thriving in an age of extinction*  
by Chris Thomas, Allen Lane  
*Confessions of a Recovering Environmentalist* by Paul Kingsnorth, Faber & Faber

**WELCOME** to the New Pangaea, a virtual supercontinent created by globalised human society. Able to hitch-hike on boats and planes, land species are no longer constrained by the oceans and can turn up anywhere and everywhere. Does that excite or appal you?

If the political world is divided between the globalisers and the localisers, so too is environmental thinking. And never more so than in these two compelling tracts.

In *Inheritors of the Earth*, ecologist Chris Thomas says that we are witnessing a virtual recreation of the single continent that dominated the planet until 175 million years ago. The subtitle to his book invites us to celebrate how “nature is thriving”, rather than buckling under the strain, with extinctions more than compensated for by a sudden upsurge in evolution, driven by globetrotting migrant species.

On the other side of the environmental aisle is *Confessions of a Recovering Environmentalist*, a series of touchingly written, but deeply pessimistic essays. Here, former eco-activist Paul Kingsnorth retreats into a world of nativist angst, offering an extreme version of the environmental longing to

protect what is local, whether it is an endangered species or a traditional way of living. He mourns “the breaking of the link between people and places”.

Both authors have been on a long road. In 2004, as a young ecologist, Thomas made front-page news for a prediction that up to a third of species would die out due to climate change. He stands by that apocalyptic forecast, but now reckons the plus side is even bigger. While most ecologists bemoan the sixth great extinction in the planet’s history, Thomas says we are also “on the brink of a

**“Obsessed with such global issues as climate change, modern eco-activists are detached from nature”**

sixth major genesis of new life”.

At almost the same time as Thomas was predicting ecological meltdown, Kingsnorth was an itinerant eco-reporter, responsible for a memorable book on the antiglobalisation movement, *One No, Many Yeses*. He chronicled a globalised response to corporate takeover, writing: “Our job now is to call for everything we want, as loudly as we can – and to keep calling until we get it.”

But now he rails against modern eco-activists and what he sees as their obsession with global issues such as climate change. They have become detached from nature, he says. Kingsnorth seeks salvation on a small patch where

he plants trees and grows crops.

Like Kingsnorth, Thomas has a patch of land. But he celebrates not its pristine wildness, but its dynamism and diversity. His corner of the Vale of York is replete with species moving in and moving on: “opportunists of the Anthropocene”, he calls them. He sees this not as evidence of an alien invasive force crushing nature, but as the essence of evolution. It is nature’s response to human activity and climate change.

For Kingsnorth, who mourns the loss of “the small and local, the traditional and the distinctive”, change is almost universally bad. For Thomas, change is good: it is about renewal.

Thomas isn’t an unthinking optimist. He charts unflinchingly the four massive human impacts on the planet: our hunting to extinction of megafauna; our destruction of habitat; climate change; and biological invasions. But in each case, he dismisses the idea that all is decline and loss. Almost anywhere you look on this supposedly blasted landscape, there are now more species than ever, says Thomas. Yes, there have been some extinctions, but in most places the losses have been overwhelmed by new arrivals.

“An inexorable march of the world’s wildlife is under way,” Thomas writes. “We are in the middle of the biggest biological pile-up in world history.” For him, we are reuniting Pangaea.



ANDREW SHAW/AFOLINE/GETTY

**Keep out – or not? Policing hybridisation may be hopeless**

We should embrace it, he says.

His flowing narrative is rich in stories of his fieldwork round the world (he is an evolutionary biologist at the University of York, UK). He details its lessons about how nature and humans coexist everywhere, and how what we often presume to be pristine rainforest or grassland turns out to be nature’s response to some past human invasion.

Of course, as he acknowledges, an increased local species-count might go hand in hand with lost biodiversity at the global level. Many experts do fear the great homogenisation of nature,



a world taken over by a few mongrel and ubiquitous species – brown rats and house sparrows, superweeds and cultivated crops.

Thomas's response is twofold. First, that the downside of invader species has been exaggerated. Perhaps only one in a thousand of the new arrivals harms native species. Second, the death of the old creates space for the new. Far from dousing biodiversity, he finds compelling evidence that our virtual Pangaea is already delivering an explosion of new species. "A global-scale spate of rapid evolution is in full flow," he writes. Migrant species are changing their traits in new environments and hybridising with local relatives, ultimately

creating new species.

Hybrids are the norm today. Japanese and European deer happily interbreed in the Scottish glens. In much of North America, red wolves are 80 per cent coyote. Alaskan grizzlies have polar bear genes in every cell. The tree of life, says Thomas, is actually a tangled bush.

### Nothing is pristine

In such a world, the prevalent conservation approach of trying to protect the genetic integrity of individual species is a nonsense, he says: "Policing hybridization is ludicrous." He insists that "it is time to stop yearning for a pristine, wild world". And he

rubbishes the Arcadian fantasies of nostalgists like Kingsnorth. There is nothing pristine and there never was. There is no "ought to be" state of the world.

For me, this a profoundly optimistic vision. And it has important practical lessons for even the most pessimistic conservationist. A conservation movement that snuffs out every newly arriving species is stifling the very evolution that will be nature's salvation. This is especially true in a world of climate change, where many species have no alternative but to migrate to keep up with moving climate zones.

We should be conserving nature's dynamism and adaptability, not endangered

species. Instead of trying to recreate the past, we could deliberately move species: to revive habitats, to protect species vulnerable in their current homelands, and to encourage the evolutionary spurt. Why not ship kangaroos or lions to the American savannahs? Rewilding is good – but it cannot recreate the past, it has to imagine the future.

Of course, Kingsnorth and the other mainstream conservationists have a right to mourn what is lost. But this says more about them than the true state of nature. Kingsnorth once embraced an outward-looking egalitarian radicalism. But, he writes, "By 2008, I had stopped

### A conservation that snuffs out newly arriving species stifles the evolution that will be nature's salvation"

believing this. Now I felt that resistance was futile... I'm not sure anybody really has any useful answers."

Once he had big ideas, but now he asks "what if big ideas are part of the problem?" In middle age, he seems to have settled for a dangerously romantic nihilism that is fearful of invasions of migrants, whether human or otherwise. In stressing the importance of identifying with the land, he has become wedded to a rather conventional pessimistic, right-wing ecological trope that "we are still wild animals". A dark ecology, indeed.

Thomas's vision in middle age, however, aspires to something nobler, more optimistic, more attuned to how the "wild places" of Kingsnorth's imaginings function. It is ultimately more human, too. What we are witnessing in the New Pangaea, he says, isn't the death of our planet, but "a fresh start for life on Earth... This is liberating." ■

Fred Pearce is a consultant for *New Scientist* and is the author of *The New Wild*

# Animal magnetism

**Matthew Cobb** is seduced by the latest natural history books

STUDENTS of animal behaviour are taught to resist thinking about animals as though they were human. In *Carnivore Minds: Who these fearsome animals really are* (Yale University Press), trans-species psychologist Gay Bradshaw deliberately ignores this advice to get under the skin of seven vertebrate predators.

Bradshaw blends behavioural, psychological and neurobiological knowledge with insights from a wide range of sources, from experienced naturalists to indigenous peoples. The results might raise eyebrows, such as her use of John Bowlby's infant attachment theory to explain the behaviour of grizzly bears, or the observation that white sharks are "individuals who are conventional with narrow interests". But Bradshaw's moving description of the effects of captivity on the physiology, behaviour and psychology of orca shows the value of this approach.

A different mixture of the subjective and the scientific shapes Simon Cooper's *The Otters' Tale* (William Collins). It combines a description of otter biology and the history of their persecution and recent recovery with the artistic recreation of a year in the life of a female otter, Kuschta, who lives by Cooper's watermill near Salisbury, UK.

As Cooper imagines himself into the lives of Kuschta, her mate Mion, and her pups Willow, Wisp and Lutran, he sometimes gives away which descriptions are imagined, which intuited and which observed. More often than not, he beguiles the reader into

suspending disbelief. There are shocking moments, a surprisingly intimate description of Kuschta and Mion's repeated couplings, and a rich portrayal of the natural world. Comparisons will be made with Henry Williamson's *Tarka the Otter* and Gavin Maxwell's *Ring of Bright Water*, but *The Otters' Tale* offers something new, and ultimately optimistic.

In *The Way of the Hare* (Bloomsbury), self-styled "wildlife-watcher" Marianne Taylor avoids subjective interpretations, concentrating on the biology, ecology and evolution of my favourite wild mammal. Nevertheless, she begins with a brief survey of hares' mythology and their place in culture (1970s TV character Hartley Hare pops up repeatedly). She broadens out to cover lagomorphs around the world, including both hare species (brown and mountain) and their many subspecies, as well as rabbits and the ultra-cute pika.

Her most fascinating sections

explore the ecological history of hares in the British Isles. Shooting and the Common Agricultural Policy (CAP) seem to have been responsible for the hare's decline in much of the region; the current, more environmentally friendly CAP may change things for the better. But as Taylor points out, it is impossible to predict what will happen after Brexit.

**"Everything has changed now the horse no longer has a key role in transport, warfare, food and sport"**

Getting into the mind of a mussel would be difficult, and Alabama vet Abbie Gascho Landis doesn't try. Instead, *Immersion: The science and mystery of freshwater mussels* (Island Press) focuses on the fight to preserve a creek near Landis's home, and reveals the vital role of molluscs as both indicators and preservers of water quality. Landis gets under the skin of not so much a single

animal, but a whole ecosystem. Part scientist, part observer and part campaigner against water pollution, she puts herself and her family at the centre of the story. This is neither cloying nor vain, and her growing fascination with her subject is infectious. *Immersion* is science writing at its best: rich, accurate and moving.

Ulrich Raulff's magisterial *Farewell to the Horse: The final century of our relationship* (Allen Lane) looks at the place of the horse in European history, culture and ecology. With the horse no longer playing an essential role in transport, warfare, food and sport, everything has changed: the city, the countryside, the horse, and ourselves. A bestseller in Raulff's native Germany, *Farewell to the Horse* is a moving epitaph to a one-sided and often brutal animal-human relationship that shaped the modern world. ■

Matthew Cobb is a zoologist at the University of Manchester, UK



**Otterly enchanting:** Simon Cooper weaves tales of riparian family life



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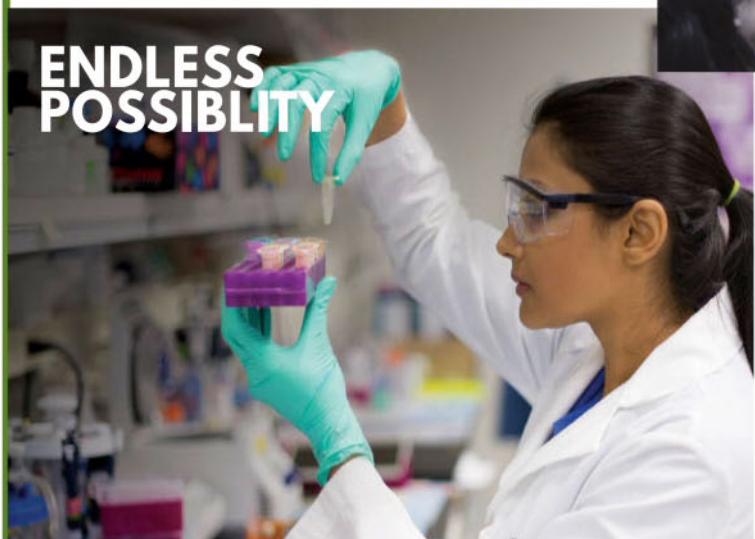
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## EDITOR'S PICK

**Blackbird pooping in the dead of night**

*From John Davnall,  
Manchester, UK*

You mention carbon pollutants as a specific problem inhibiting solar panel output (1 July, p 7). I find that sand, wind-eroded topsoil and salt left by fine sea spray are also detrimental.

A particularly insidious problem, however, is bird droppings. My 6-year-

old photovoltaic panels consist of strings of cells. If one cell in a string is obscured, that string will not function. In my small system, one well-aimed splat will wipe out one-third of a panel and 3.5 per cent of total output.

Washing works. Earlier this year, a complete wash improved output by 13 per cent when one splat and general dirt were removed. I see no evidence that annual washing has reduced performance.

I am rather surprised that panel-cleaning businesses have not sprung up to cater for the domestic market since panels are almost always on roofs too high for many people to feel safe accessing them.

I am tempted to suggest a solution to the bird problem for solar farms: site them near bird-culling wind turbines. I do fear the reaction...

**Coming off drugs is hard to do without help**

*From Jenny England, Sydney, New South Wales, Australia*

Clare Wilson reports on a movement to help people taking psychiatric medicines to hack their dosing (15 July, p 8). Having just come through a horrendous three-month taper to wean myself off the anti-anxiety drug diazepam, I applaud anyone who can provide the means to assist getting off any psychotropic drug.

I had to have my tablets made into a liquid solution by a compounding chemist at great expense. I also came off an antidepressant too quickly a number of years ago, only to end up in the emergency department of my local hospital.

These drugs have difficult side effects for those taking them and they are even worse when trying

to stop. You need courage to do it alone and I haven't found much advice or assistance from the medical profession.

**Power pose psychology problems persist**

*From Paul Hodgkinson, Cheltenham, Gloucestershire, UK*

I am disappointed to see gushing reporting of research relating positive effects from adopting a "power pose" (24 June, p 24). Joseph Simmons and Uri Simonsohn at the University of Pennsylvania Wharton business school suggest that selective reporting can account for the published studies replicating these findings. Of the original "power pose" researchers, Dana Carney has stated "I do not believe that 'power pose' effects are real", and Amy Cuddy stands by the finding of a psychological boost.

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## "What does that mean for health insurance? Knowing about genetic diseases affects it..."

Jette is immediately concerned by the implications of a blood test to detect Alzheimer's plaques building up in the brain (29 July, p 18)

### Lighting leading to better brain health

From Luce Gilmore,  
Cambridge, UK

Linda Geddes reports on the health benefits of fine-tuned lighting (8 July, p 6). Staring at a bright, white light is very soporific, in my experience.

When I switched from using a computer with light, chunky text on a black background to one with slender, dark characters on a bright background, I kept falling asleep. I wonder whether it is a coincidence that graphical applications usually have a dark background... Feeling sleepy, must sign off now.

From Derek Morris,  
Harpenden, Hertfordshire, UK  
Further to your report on the benefits of dynamic "solid state" lighting, how soon before

supermarkets introduce the technology so that retail therapy can be coupled with improved health outcomes?

### Capitalism, climate change and two futures

From Bryn Glover, Kirkby Malzeard, North Yorkshire, UK

Michael Le Page discusses how mismanaging moves necessary to combat climate change could precipitate the next big financial crash (8 July, p 20). I see this as one sign of a growing awareness that solutions to our environmental crises lie as much with politicians as with scientists.

Almost by definition, capitalism depends on continuous and perpetual "growth". That is physically impossible. But capitalism has, throughout its five centuries or so, fallen back on imperial

conquest to come to its rescue. The internet is one significant difference between now and the glory days of European empires – on top of the changes in availability of resources, the ability of Earth to absorb our wastes, and the burgeoning population. A century ago, the high-living of the imperial masters would be little more than vague notions to most people. Now the lifestyles of "affluent Americans" are clearly visible to any of our 7 billion fellow humans who has access to the net.

That lifestyle would need 30 Earths to support it, were it to be enjoyed by everyone. The way of life that most closely fits the capacity of our single Earth is that of Cuba – before it resumed links with the high-consumption US.

Will resources be divided equitably worldwide, or according to political or military might,

enabled by continuing unfettered capitalism? An equitable division will be possible only with international agreement and voluntary reduction of consumption by all those who now use resources at a rate greater than Cuba's.

### But quite how big is that big battery?

From Andrew Ward, Wotton-under-Edge, Gloucestershire, UK  
I am disappointed in your report of Elon Musk's planned battery in South Australia (15 July, p 6). It would be interesting to know what its capacity will be and its approximate efficiency.

The editor writes:

■ The planned installed capacity is 129 megawatt-hours (460 gigajoules). Maximum output would, as we said, be 100 MW – ➤

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### Is it that we took longer to become parents?

*From Elizabeth Belben, Nettlebridge, Somerset, UK*  
You report that sons born to older fathers are more likely to have "geeky" traits such as intelligence, an ability to concentrate and being unconcerned about fitting in (24 June, p 7). These traits are also often associated with autism.

Were the children in the study compared with siblings fathered by the same men at a younger age, or children of different men?

I am a geeky (and autistic) 36-year-old woman, recently married to a geeky (and possibly autistic) 50-year-old man. Neither of us had been in a successful relationship before. I wonder whether geeks like us tend to take longer than others to find a partner, and whether when we do

get married and have children, we tend to pass on geeky traits, both by genetics and environment.

### Once again, Stanisław Lem was there before

*From Paul Dormer, Guildford, Surrey, UK*  
So a neural network writes poetry in a given style and on a given topic (15 July, p 14). The Polish author Stanisław Lem anticipated this in the story "Trurl's Electronic Bard", in the 1965 collection *The Cyberiad*. Asked for a love poem in the language of higher mathematics, the machine begins, in Michael Kandel's English translation: "Come, let us hasten to a higher plane, / Where dyads tread the fairy fields of Venn, / Their indices bedecked from one to  $n$ , / Commingle in an endless Markov chain!"

### Killer robots will hunt you down after the war

*From Brian Horton, West Launceston, Tasmania, Australia*  
I was brought up on the writer Isaac Asimov's laws of robotics,

the first of which demands that a robot will not allow a human to come to harm.

But despite this, Asimov managed to write of robots causing a lot of trouble. Now we are asked whether war robots should be allowed to kill on their own initiative (8 July, p 32).

Have we learned nothing from landmines, which kill more people after a war than during it? These robots will do the same, except that they won't stay in the minefield: they will be smart enough to come and find you.

### Collapsing metallic stars go on and on and on

*From William Robinson, Slough, Berkshire, UK*  
I enjoyed Prabal Saxena comparing the early moon to a rock star: "a metal-dominated thing that collapsed quickly and intensely" (8 July, p 17). It rather depends on the rock star, though.

Some indeed demonstrate this form of behaviour. There are, however, some who are more like Betelgeuse: they've been around for a few million years, and

scientific theory suggests they must surely collapse soon, but they haven't yet. Just when you think they can't put out any more material, they do exactly that.

### The chart of many colours doesn't work

*From Greg Bell, Clifton Beach, Queensland, Australia*

I understand the difficulty of conveying multiple sets of data within a single image, map or diagram. But I ask you to give more consideration to the section of your readership who are colour blind or whose early cataract clouding causes dulling of colour.

As one example, your map of wildfires conveyed no useful data to such people (8 July, p 37).

*The editor writes:*

■ We use filter software to give a view of how graphics will be seen by someone who is colour blind. We checked the wildfire graphic to make sure that areas could be differentiated. As you say, it is difficult to convey multiple sets of data, but we do try.

### Oh, the ironing of a robotic home help!

*From Jo Spencely, Edinburgh, UK*  
I am glad to read that "robot butler" TEO will soon be doing my ironing for me (1 July, p 19), but how will the crease-targeting algorithm deal with pleats?

### For the record

■ The GameSpace game-finding tool was announced in a technical report (22 July, p 8).

Letters should be sent to:  
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## OLD SCIENTIST

What was *New Scientist* talking about in Augusts past?



DOES it matter which side of the road a country drives on? Well, in 1958 it worried Robert M. Stewart. Our 7 August issue reported his concern that too many nations drove on the right-hand side and so were affecting the rotation of Earth. Additionally, he fretted that a component of the vehicles' momentum might tip the polar axis. Stewart therefore "deplores

the indiscriminate adoption of right-hand driving, and looks to the British automotive industry and the underdeveloped territories to redress the balance". If this was an April fool story, it was 128 days too late.

A less loopy, but more frightening, dispatch from the war between planet and internal combustion engine was to come in our 3 August 1972 issue. The catalytic converters that spare us some of the engine's noxious emissions were newfangled then, and we warned that their high working temperatures could dramatically increase the risk of fire. The US Environmental Protection Agency had pointed out that a spark plug failure could allow unburned fuel to enter the car's exhaust system, where it would encounter a hot catalytic converter. Whoooomph! Of course, the "motor men" of Detroit thought the agency was worrying about clean air too much.

A new and less dangerous way of halting cars appeared in our 24 August 1991 issue. Police knew that spikes laid out across the road were the safest way to stop speeding criminals, but existing spike traps were too heavy to carry easily in police cars and needed more than one officer to deploy. Donald Kilgrow, a retired Utah highway cop, had come up with a design in which the stainless steel spikes were embedded in a lightweight "nylon alloy" called Zytel FN. As we pointed out, Kilgrow's design was unlikely to feature in an action movie. Who wants a car chase where the bad guys' vehicle just settles slowly into the tarmac? An explosive denouement – maybe involving catalytic converters and criminal levels of emissions – is far more cinematic. **Mick O'Hare** ■

To delve deeper into the *New Scientist* archives, go to [newscientist.com/article-type/old-scientist/](http://newscientist.com/article-type/old-scientist/)

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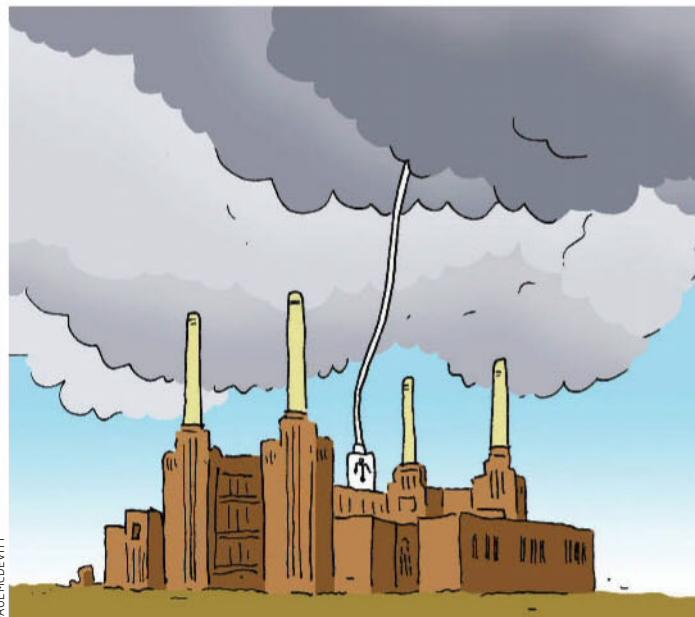
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PAUL MCDEVITT

**CHATTING** on your mobile during a church service would normally be frowned upon: but what if it's God on the line? Michael Zehse directs us to the case of Zimbabwean pastor Paul Sanyangore of Victory World International Ministries, who says he has God's private number, and was filmed in conversation with the Holy Father in front of his congregation.

Feedback has to wonder about the implications of this technological triumph. What kind of mobile plan is God on? Does the almighty use an iPhone or Android? And does dialling heaven count as a long-distance call, or is God always local?

Not only did Sanyangore swear he would share the number with the world, he delivered on this promise. And so, South Africa's East Coast Radio host Darren Maule dialled God. Sadly the call went through to voicemail, proving you can speak to God, but he won't always answer back.

However, the automated mailbox did offer an itemised list of options that callers could request from the big guy, including forgiveness, lost love,

winning lottery numbers, world peace and the tempting option to "press 5 to smite someone".

FEEDBACK previously asked for your help creating a pub crawl of scientific greats (15 July). Sadly, the reputations of many scientists have outlasted the establishments celebrating them.

Tom Jones sings a paean for the William Cookworthy pub in St Austell in Cornwall, UK, which celebrated the 18th-century chemist who discovered china clay in the area.

This allowed the local production of translucent white Chinese-style porcelain, much in demand at the time. "China clay is still used for making porcelain and bone china," says Tom, "but Cornish stone is used less as it contains quartz, which makes it difficult to grind into a powder."

SCIENCE-inclined drinkers might also have found refreshment in the Sir Humphry Davy in Penzance, says

Fiona Zachariasse. It's named in honour of the local boy who made the periodic table his personal bingo card, isolating no fewer than seven different elements and then inventing the Davy lamp to keep miners safe.

Sadly both pubs have gone the way of the Cornish mining industry: the taps have run dry at the Sir Humphry Davy, and the William Cookworthy is now a local supermarket.

ONE of our thirsty colleagues relays that the Alexander Fleming pub in Paddington, London, is also gathering dust (and, presumably, mould). And in Norfolk, says Ian Wakelin, "there is a pub next to King's Lynn bus station called 'The Lord Kelvin,'" now sadly on ice.

**THANKFULLY** things aren't so grim up north. Martin Wood tells us the Doctor Duncan's in St Johns Lane, Liverpool, remains popular, named in honour of William Henry Duncan, Liverpool's first medical officer of health.

Martin says there are "five real beers and a good deal on pies. What's not to like?" Interested drinkers may consider a chaser in Pi in Mossley Hill, he says, "for further good beers and (of course) more pies".

SPEAKING of pies, Joe Edwards writes in response to news of KFC launching a chicken sandwich to the edge of space (8 July), telling us "it won't be the first savoury snack to reach such heights".

He says that a meat and potato pie made a similar journey from Wigan in 2016, to celebrate the World Pie Eating Championships. After drifting for two hours at around 30,000 metres, the pie descended to Earth and was recovered by space-pie officials. Whether it was still edible – or if anyone was brave enough to find out – is not recorded.

AFTER a seven-year refurbishment of Birmingham New Street rail station in the UK, Peter Nicholson reports that managers have erected a sign boasting about the site's environmental credentials. It reads:

"New Street Station has low energy lighting and control systems that can save up to 50% less energy than the previous lighting system." Progress!

CHINESE technology is incredible, says Larry Constantine, after receiving a Tantek tempered glass screen protector that "came with a seal certifying 'Protection of God'". Ideal for those with a direct line to heaven, we presume.

Larry worries that maybe the claim refers to the sticker itself: "Might I be in cosmic hot water for breaking the seal to extract the screen protector?" By our maths, there are six other seals to be broken before things get really serious, Larry. Keep an ear out for the sound of trumpets and horsemen.

THE latest batch of junk mail delivered to Jim Jobe included a flyer advertising white goods, one of which caught his eye: "a frost-free fridge-freezer and,



according to the blurb, 'works in temperatures as low as -15 degrees'".

Jim wonders why anyone living in temperatures as low as that would need a fridge-freezer. "Then the penny dropped: these must be part of the batch ordered by that legendary salesperson who could sell fridges to those living in the Arctic!"

**Affinity Water** makes a less-than-enticing pitch to Ian Gammie. A flyer reads: "Be prepared for unexpected problems with this plumbing offer."

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.

## Feel the heat

On a beautifully sunny, windless day last summer, I sat in my back garden and felt very warm indeed. The air temperature was 16°C, but there is no doubt that it felt more like a day when the thermometer read 25°C.

Why the discrepancy?

(Continued)

■ A further factor that should be considered is that the humidity may have been higher on that day than on another 16°C day.

When the humidity level is high, the body cannot transfer heat to the atmosphere via perspiration as quickly. This will cause you to feel warmer or cooler even when the temperature remains the same.

Since 2015, I have been on the medical staff for the Badwater Ultramarathon, which is held in Death Valley, California, every year in July. During times when the humidity is around 5 to 10 per

## "Medical staff see far more runners with heat-related problems as the humidity level climbs"

cent, the runners can handle the 49°C temperatures much better than when it gets towards 15 per cent humidity. The medical staff see far more runners with heat-related problems as the humidity level climbs.

In July 2012, my friend Marshall Ulrich and I were the first to circumnavigate Death Valley National Park on foot,

unsupported, using buried caches of food and water. The summer monsoon started in that area about three days into our trek and the high humidity at times, along with the high temperatures, made parts of it much more difficult. It is very easy to "feel" the higher humidity when it's 46°C or more, and much more comfortable at that temperature as the humidity level drops.

Dave Heckman  
Ashland, Oregon, US

## Flat about fizz

Why does my wife like wine with bubbles more than flat wine? Do the bubbles add to the taste or does her preference come from marketing and cultural context? And why do I not like fizzy wine?

■ This is most likely a learned behaviour. Laboratory animals won't drink carbonated liquid, and people adjust to the feel of it (or don't) in the same way as they do to the bitterness of coffee or to spicy food.

Surprisingly, the bite you feel from the fizz doesn't come from the bubbles popping. When scientists got people to drink carbonated water in a hyperbaric chamber – where bubbles couldn't form but the carbon dioxide was still present in the liquid – subjects reported the same sensation.

Instead, it comes from a sour receptor called TRPA1, which is activated by carbonic

acid. A protein in your mouth called carbonic anhydrase converts the carbon dioxide to this acid, and the TRPA1 receptor detects this. At high acid levels your body goes into "get it out" mode and you will start coughing, choking and tearing up. But at low levels, the fizzy burn is pleasant for many people.

The acid also makes sweet things taste less sweet – just consider how much sugar is hidden in one glass of cola. So the carbon dioxide changes the taste too.

The same scientists found that once the acid sensation is present, injecting bubbles around the tongue enhances the feeling –

## "Laboratory animals won't drink carbonated liquid, and humans adjust to the feel of it (or don't)"

even if the bubbles are just plain air. The mechanism for this is unknown.

So, if you don't like fizzy wine, the most likely reason is you probably prefer sweetness or you don't find the acid bite pleasant.

Ron Dippold  
San Diego, California, US

## This week's questions

### SHADOW OF A DOUBT

Sitting outside with my back to the sun, I noticed that the shadow cast by the clear lens of my glasses

was equally as dark as that cast by the frame and my head. Why? Surely the clear lens would let the light through rather than casting a shadow?

Richard Batho  
Jersey, Channel Islands

### I SPY EWE

After I released a lamb that had got its head stuck in a fence, it ran halfway across the field to a ewe and immediately started suckling. I heard no calling, so how did the lamb recognise its mother from all the other ewes it ran past? It can hardly have been the coat she was wearing.

Gillian Coates  
Trefor, Anglesey, UK

### HAIR OF THE DOG?

I've watched TV documentaries that show people's pets receiving chemotherapy. It doesn't seem to cause them to lose their fur or hair, unlike humans. Why?

Ann Wills  
London, UK

### STING IN THE TAIL

Mosquito bites frequently induce a sharp sting in people and some animals, with severe evolutionary consequences for the mosquito when it gets swatted. Are any mosquitoes evolving with delayed-action stings or reduced sting secretions so they can drink blood without the threat of imminent death?

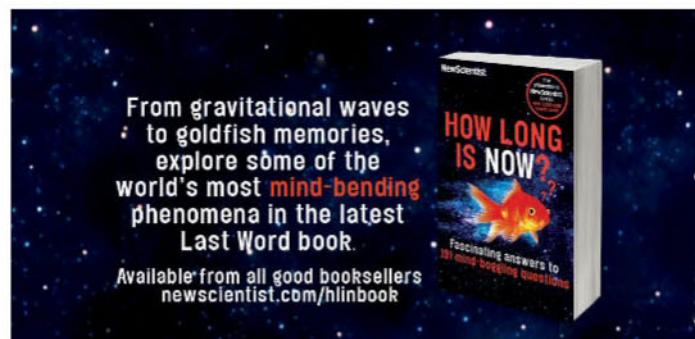
Clive Wilkinson  
Reef and Rainforest Research Centre  
Townsville, Queensland, Australia

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# COULD YOU REINVENT FUEL EFFICIENCY PIECE BY PIECE?



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