New Scientist

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THE LOOP

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Resistance is futile

A renewables revolution is afoot – but who will benefit?

LAST week, President Donald Trump ordered the Department of Energy to "prepare immediate steps" to prevent the closure of unprofitable coal and nuclear plants. This comes almost a year to the day after he withdrew the US from the Paris climate agreement.

The move was dressed up as a way of ensuring the country's electricity grid remains reliable and secure. But given Trump's campaign promises, and recent reports identifying no immediate threat to US grid reliability, it is hard not to conclude that his true aim is to prop up the dying coal industry.

It is a stance as forlorn as it is misguided. In the US as elsewhere, it is because of sound economic reasons, not just environmental concerns, that coal and nuclear are struggling to compete with natural gas and renewables such as wind and solar. Thanks to an explosion of technology designed to counter the variability of wind and solar (see page 26), the reliability issue is a red herring that's getting redder. Covering 100 per cent of our energy needs through renewable resources is no longer the impossible dream.

The question is whether we can muster the political will to make it happen by mid-century, as we must do if we are to limit dangerous climate warming. Political will is a slippery concept, typically defined only in its absence. While clearly not present at federal level in the US, it is thankfully emerging elsewhere. Individual US states and cities are falling over themselves to commit to ambitious renewables targets, as in Europe. China, meanwhile, is investing heavily to position itself as a global leader in renewable technology, a strategy that will only accelerate its rise.

Trump's short-sighted vision is ultimately America's loss. When it comes to 100 per cent renewables, the answer is clear. Yes, we can. ■

The roots of extremism

MANY of the increasing – or perhaps just increasingly voluble – numbers of people in the West who self-describe as white nationalists talk of legitimate economic or social grievances. They shouldn't kid themselves. They are part of a movement that, at its most violent fringes, is what it always has been: pure racist thuggery.

As their poisonous ideology infiltrates wider political discourse, so these extremists feel emboldened. In the UK, security services claim to have thwarted four far-right terrorist plots in the past year.

To combat racist white extremism, we must grasp its roots. As studies of violent white supremacists in the US show (see page 34), these are often different roots to those assumed to underlie other forms of terrorism. Rather than devotion to the cause inspiring violence, pre-existing emotional trauma and a propensity to violence find expression in the cause.

That in no way excuses any crimes white supremacists may commit. But by helping us to understand society's ugliest elements, such research can help society as a whole. ■

Advanced cancer hope

Immunotherapy has wiped out terminal breast cancer for the first time

Sam Wong

A TYPE of immune therapy has worked in breast cancer for the first time, raising hopes that the treatment could tackle other types of advanced cancer, even after they have spread.

Judy Perkins (right) had breast cancer that had spread to other organs. "She had tennis ball-sized lesions throughout her liver," says Steven Rosenberg at the National Institutes of Health, Maryland. "It probably would have killed her in the next two to three months."

She had tried seven other cancer treatments without success. Six weeks after receiving the novel immune therapy, Perkins's tumours had halved in size. A year later, they had disappeared. She remains cancer-free two-and-a-half years on from treatment.

Perkins said she was "planning on dying" before she enrolled in the trial. Since having the treatment, she has resumed her normal life, including kayaking.

The treatment, developed by Rosenberg and his colleagues, targets genetic mutations that cancer cells acquire as they grow and multiply. Some mutations can trigger the immune system to attack the cancer, but this reaction usually isn't powerful enough to fight a cancer on its own.

Boosting this natural attack has become a popular strategy for new cancer therapies, but it is a difficult approach because mutations can vary so much between people with the same cancer.

A personalised approach, in which doctors multiply someone's immune cells in the lab and then give them back, has had some success against cancers with a lot of mutations, like skin cancer. But until now, approaches like this haven't worked in cancers with fewer mutations, such as breast cancer.

Typically, only 2 per cent of the mutations in a breast cancer are capable of provoking an immune response. To maximise this, Rosenberg and his colleagues take immune cells called lymphocytes from a patient and screen them to identify individual cells that have become primed to recognise mutations in their cancer.

The researchers identify these mutations by sequencing the DNA of a person's cancer cells, and comparing it to the DNA of their healthy cells. They then test a sample of the person's lymphocytes to see which mutations are capable of triggering a response, before multiplying those cells capable of recognising them.

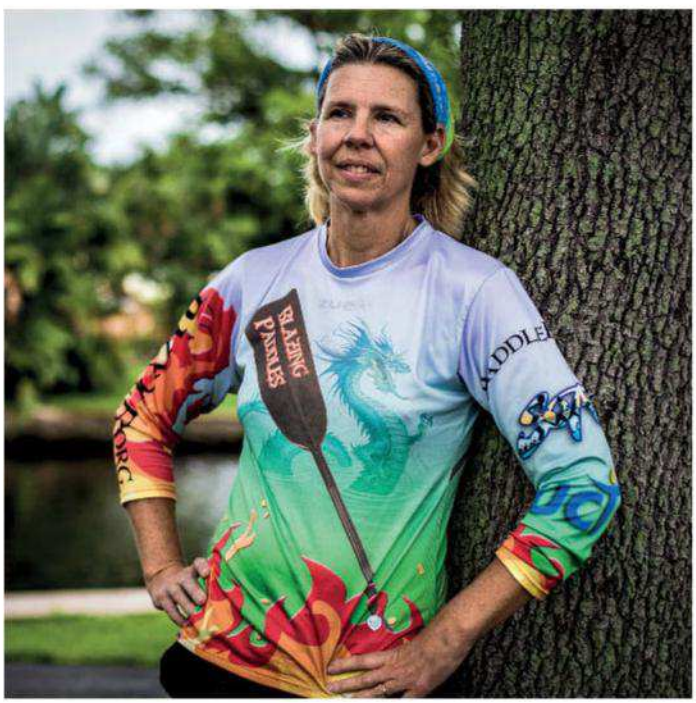
In this way, the researchers found and multiplied lymphocytes that could recognise four mutations in Perkins's cancer. They then infused 80 billion of them back into her blood, along with a drug that boosts immune activity (*Nature Medicine*, doi.org/cqjx).

"Six weeks after receiving the novel immune therapy, Judy Perkins's tumours had halved in size"

The same approach has already successfully treated some cases of liver, colon and cervical cancer. Together, these results raise hopes for treating advanced cancers that have resisted other treatments. "These are patients with common cancers for which there are no effective treatments once the cancer metastasises, so it represents a new approach to using immunotherapy for the treatment of cancer," says Rosenberg.

"I think it's an extremely exciting and promising strategy," says Charles Swanton of the Francis Crick Institute in London.

Until a clinical trial has been conducted, we won't know how effective the approach is. So far, the team has treated two other women with breast cancer, one of whom didn't respond, and one who died before they could evaluate the treatment. ■



SCOTT MCINTYRE / FOR THE WASHINGTON POST VIA GETTY IMAGES

Judy Perkins is cancer-free two-and-a-half years after treatment

GENETIC TREATMENT FOR LIVER CANCER

The toolkit for treating advanced cancers is expanding beyond usual treatments and immunotherapies (see main story). A completely new approach has had good preliminary results in advanced liver cancer.

The novel drug works by ramping up the activity of a gene that stops cancers growing. It contains a carefully designed piece of genetic material – called a small activating RNA – to artificially boost this gene.

The 28 people enrolled in a small trial of this drug are the first in the world to receive this kind of treatment. The recipients all have advanced liver cancer, which is usually fatal within two years.

The best result came with a patient whose tumour has reduced in size by almost 75 per cent, says team leader Debashis Sarker of King's College London. Tumours have stopped growing in another four people. The results were presented at a meeting of the American Society of Clinical Oncology in Chicago this week. Andy Coghlan

REUTERS/LUIS ECHEVERRIA

Guatemala eruption

A FIERY volcanic eruption in Guatemala sent lava, ash and pyroclastic flows surging into rural communities. At least 69 people have been killed. Rescuers struggled to reach people in areas where homes and roads were blanketed with ash.

The Volcán de Fuego, or "Volcano of Fire" (left, in the background), exploded on 3 June in a hail of molten rock, blanketing nearby villages in heavy ash.

Later, lava began flowing down the mountain's flank, destroying roads and homes. Eddy Sanchez, director of the country's seismology and volcanology institute, said the lava reached temperatures of about 700°C.

Pyroclastic flows made of hot rock, superheated air and volcanic gases also gushed out of the volcano and flowed rapidly downhill. These caused the majority of the deaths.

Dramatic video footage showed a "lahar", a flow of pyroclastic material and slurry, slamming into and partly destroying a bridge.

Guatemala's disaster agency said 3100 people had fled from nearby communities. Ash fall was affecting an area in which about 1.7 million of the country's 15 million or so people lived, it added. Shelters were opened for those forced to leave.

Ash fell on Guatemala City as well as the departments of Sacatepéquez, Chimaltenango and Escuintla, which lie around the volcano in south-central Guatemala. Streets and houses were covered in Antigua Guatemala, a colonial town popular with tourists.

Aviation authorities closed the capital's international airport because of the risk posed to planes by the ash.

Meteors strike a double whammy

TWO meteors have just hit Earth only 27 hours apart. The first fell over south-west China on 1 June. It was captured on video, but we have little information beyond that.

The other burned up over Botswana on 2 June. It was detected by researchers at the Catalina Sky Survey in Arizona 8 hours before entering Earth's atmosphere. After a streak showed up on a series of time-lapse telescope images, astronomers determined that the rock – dubbed 2018 LA – was heading for our planet.

At just 2 metres or so across, 2018 LA wasn't deemed to be a risk because it was likely to burn up almost completely as it hurtled through the atmosphere. This is only the third time an object set to hit Earth's atmosphere has been detected before it arrived.

On average, about six objects this size hit our atmosphere every year, says Peter Vereš at the Minor Planet Center in Massachusetts. Despite the fact that both these meteors arrived so close together, they are probably unrelated.

Apple's plan to help your digital detox

APPLE wants to help you use its tech less. A new app called Screen Time will show iPhone and iPad users how many notifications they receive, how often they pick up their device and how much time they spend on different apps. It will then compare each of these to the average.

With Screen Time, people will be able to set daily time limits for individual apps, to avoid spending too long on social media, for example.

Parents will be able to access reports on their children's activity from their own devices, helping them to control how their kids spend their time.

Apple's Craig Federighi announced Screen Time this week at its annual developer conference in California (pictured below). It will be available later this year.

Last month, Google revealed a similar set of tools for its mobile operating system Android.

Apple also announced tools at its conference to improve privacy by making it more difficult for other companies to track users online.

MARCIO JOSE SANCHEZ/AP/REX/SHUTTERSTOCK

Kerala watches for deadly Nipah virus

A NIPAH virus outbreak in Kerala, south India, appears to have been contained, but health officials warned this week that more cases could yet emerge.

Discovered in 1999, when it killed at least 100 people in Malaysia, the Nipah virus can spread to humans via saliva, urine and faeces from bats or pigs. The Kerala outbreak is thought to have started from a well that was contaminated by bats.

The virus causes flu-like symptoms and vomiting, often leading to acute respiratory problems and a fatal brain inflammation.

So far, 17 of the 18 people initially confirmed to have the virus have died. Two people diagnosed at a later date are responding to treatment with an antiviral drug, and 22 remain under observation.

There have reportedly been no new confirmed infections since 17 May, but vigilance will continue throughout June. Around 2400 potential contacts of confirmed and suspected cases are being quarantined at home.

Early Earth had much shorter days

Leah Crane

IT'S not just you – the days really are getting longer. Geological evidence from ancient rocks confirms that more than a billion years ago, our planet's day lasted less than 19 hours.

Earth's motions undergo cyclical changes over the course of many thousands of years. Its elliptical orbit shifts around the sun like a hula hoop, and the shape of the orbit itself wobbles between clearly elliptical and nearly circular. Earth's axis of rotation also rocks back and forth and gradually moves in a circle like the handle on a spinning top.

Working out whether these variations were under way long ago is a challenge. "When we look up in the sky at other stars, we're looking back millions or billions of years into the past. We can't do that with our solar system," says Stephen Meyers at the University of Wisconsin-Madison. "If we want to look at the ancient solar system, we have to look at the rock record."

Sedimentary rocks were able to record Earth's movements back in deep time, because their chemical make-up altered with changes in the climate caused by these shifts. "All of those astronomical cycles influence how sunlight is distributed on the planet's surface, and sunlight is what drives our climate systems," says Meyers.

He and Alberto Malinverno at Columbia University in New York have now exploited this to figure out Earth's behaviour in the early solar system. They worked backwards using data from two ancient rock formations – one about 55 million years old found in the Atlantic Ocean, and one in China that is 1.4 billion years old.

The moon is gradually getting further away, prolonging our day

GUSTAVO MUNIZ/GETTY

They used a statistical program to match chemical signatures in the rocks with a range of models of the early solar system, and the corresponding environmental conditions on Earth. In the one that matched best, the moon would have been about 341,000 kilometres away – or some 40,000 kilometres closer than now – at the time when the Chinese rock formed.

The moon's distance has a strong influence on how long days are on Earth: the closer the moon is, the faster Earth rotates. Meyers and Malinverno found that 1.4 billion years ago, our days were only about 18.7 hours long (*PNAS*, doi.org/cqkb).

"It's a huge step forward for geology," says Linda Hinnov at George Mason University in Virginia. Were it not for this statistical method, the only way to probe Earth's rotation rate and its relationship with the moon more than 500 million years ago would be to look for clues to early Earth's tides. That means analysing an extremely rare kind of rock called a tidalite, and so far we have found fewer than 10 of these, she says.

"Now we can use this [statistical] method to go back and fill in, for very specific times, what the day length and Earth-moon distance was," Hinnov says. ■

The gene that made human brains boom

HOW did humans get so smart? It could have been a genomic reshuffle more than 3 million years ago that let our brains grow three times as large.

When David Haussler at the University of California, Santa Cruz, and his colleagues compared brain development in humans and monkeys, they found one key difference. Human brain growth seemed to be driven by a gene called *NOTCH2NL*, one not found in monkeys (*Cell*, doi.org/gdkxhq).

Further studies revealed that *NOTCH2NL* delays the transformation of stem cells into brain cells. The upshot is that more stem cells can divide and grow and ultimately turn into brain cells.

By comparing the genomes of humans and other primates, the researchers determined that *NOTCH2NL* first appeared between 3 and 4 million years ago. This came about due to an extremely rare genetic disruption that reshuffled part of the genome.

The arrival of *NOTCH2NL* would have allowed us to grow three times as many brain cells, says Haussler. This fits the fossil record, which shows human skulls starting to expand soon after the gene appeared. "If it hadn't have happened, we wouldn't be here talking about it," says Haussler.

Our Neanderthal and Denisovan relatives also inherited the *NOTCH2NL* gene from our common ancestor, allowing them to grow bigger brains as well. However, they seemingly didn't develop the same level of intelligence as us. "That's the big mystery," says Haussler.

"The arrival of *NOTCH2NL* would have allowed us to grow three times as many brain cells"

It is possible that, while the gene laid the foundation for intelligence by providing extra brain cells, other genetic changes needed to happen later to wire them up in an effective way, he says. "There were probably hundreds of other genes involved."

One drawback of *NOTCH2NL* is that it can sometimes go awry. Babies occasionally get extra copies, causing their brains to grow too big. Or they can get too few copies, causing the opposite problem.

Meanwhile defects in the gene are thought to trigger certain forms of autism and schizophrenia. "That's the trade-off we had to make for bigger brains," says Haussler. Alice Klein ■

How some bodies can keep HIV in check

SOME people with HIV can keep the virus under control without any need for drugs, and we're now a step closer to understanding how they do it.

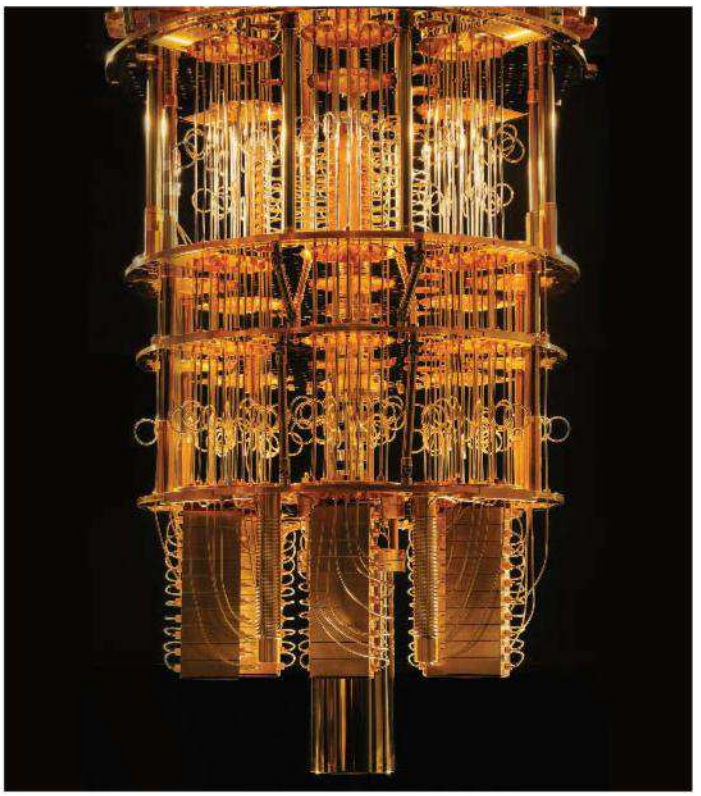
When HIV gets into the body, it infects certain immune cells called T-cells. Although these circulate in the blood, they spend most of their time in patches of immune and connective tissue – called lymphoid tissue – in places like the gut and lymph nodes. Almost all HIV research into T-cells has focused on those found in the blood, leading to a skewed picture of how our immune systems respond to the virus.

Marcus Buggert began investigating the T-cells in lymphoid tissue while at the University of Pennsylvania. He and his colleagues were interested in the lymphoid tissue of people who can naturally control the virus for decades without any drugs. These "elite controllers" make up only a fraction of 1 per cent of those infected with HIV.

Previous work has found that these people have immune cells – called CD8 T-cells – that are more effective at killing HIV-infected cells in the blood. But HIV can evade destruction by hiding out in the body's tissues, and Buggert and his colleagues have now found that elite controllers have an advantage there too. In such people, large numbers of CD8 T-cells move into the lymphoid tissue and stay there, where they switch to expressing different genes. People with HIV who are not elite controllers have only a few of these altered cells (*Science Immunology*, doi.org/cqkt).

This appears to keep HIV in check in the lymphoid tissue, but we don't yet know how. While CD8 T-cells in the blood simply kill HIV-infected cells they encounter there, that doesn't seem to be the case in the lymphoid tissue.

Because HIV-infected cells spend only 10 per cent of their time in the blood, this insight could have big implications for future vaccines and treatments. Bob Roehr ■



GRAHAM CARLOW/IBM

The dilution refrigerator for the IBM Q quantum computer

An all-knowing computer can't beat a quantum one

ONE of the biggest theoretical problems regarding quantum computers – namely just how much they differ from ordinary computers – has now been solved. The results suggest that these machines are far weirder than we thought.

"It's a big deal because this has been one of the fundamental unsolved problems of quantum complexity theory for a quarter century," says Scott Aaronson at the University of Texas at Austin.

While classical computers store information in bits that are 0s or 1s, quantum computers use qubits that can be a mixture of both at once. So, they should be able to solve some problems much faster than regular machines.

Now, Ran Raz at Princeton University and Avishay Tal at Stanford University in California have proved that quantum computing isn't just faster, but something much stranger. They showed that quantum computers could solve specific problems that no classical computer ever could, even if we let it "cheat" by giving it superpowers.

That might sound odd, but it is a common approach amongst theorists like Raz and Tal. They study complexity classes – sets of problems classified by how difficult they are to solve.

Here, they looked at two classes. The first is called bounded-error quantum polynomial time (BQP), essentially the set of all problems solvable by a quantum computer. The second, polynomial hierarchy (PH), is the set of all problems a classical computer can solve if we give it superpowers, such as instantly guessing correct solutions to a problem.

Clearly, a PH computer is very powerful, but it could probably never be built in the real world. Still, it is useful for studying computation. "As abstract and unrealistic as this sounds, we complexity theorists think of the polynomial hierarchy as something recognisable as

"There are some problems that can only be solved with the power of quantum physics"

'classical computation' at its core," says Henry Yuen at the University of Toronto, Canada.

Quantum computers also have a superpower – the ability to exploit quantum physics. Crucially, this trick can exist in the real world. So which superpower is better, BQP or PH? To answer this, Raz and Tal have shown that BQP and PH are not identical – there is an esoteric problem about the distribution of random numbers that a quantum computer can solve, but a PH computer cannot (*Electronic Colloquium on Computational Complexity*, bit.ly/2xJ9hXn).

"The quantum computing superpower is just so weird and different," says Yuen, that PH cannot match it. No matter how powerful you make an ordinary computer, there are some problems that can only be solved with quantum physics.

This is unlikely to affect real-world quantum computers being built by the likes of Google or IBM in their race for "quantum supremacy" – the ability to outdo classical supercomputers.

For one thing, the proof relies on a theoretical tool with little bearing on the real world, called an "oracle" – like a mystic sage, it gives instant answers to queries. But studies of PH have informed Google's quantum supremacy bid, so this new result may help devise practical ways to demonstrate the power of quantum computers, says Yuen. **Jacob Aron** ■

Ear mystery of Stone Age village

Colin Barras

IT'S a Stone Age puzzle: why did one-third of the people living in an ancient village far from the sea develop a condition typically seen today in avid surfers? There is no obvious answer – but the prevalence of "surfer's ear" in the ancient community might shed light on the way humans lived just before the farming revolution.

Körtik Tepe, a site in eastern Turkey, was first occupied between 12,400 and 11,250 years ago. This was a time of massive social change, when hunter-gatherers first began living in permanent villages. We know very little about the lives of those early villagers, other than that they continued to hunt and gather food rather than farm the land.

To find out more, a team led by Yılmaz Selim Erdal at Hacettepe University in Ankara, Turkey, examined 128 skeletons buried at the site. Some 39 adults – 48 per cent of the adult skeletons – had abnormal bony growths in at least one ear, and the condition was also seen in six of 16 children estimated to have died between the ages of 6 and 12 years old (*International Journal of Osteoarchaeology*, doi.org/cqjz).

Today, most researchers argue that such bony growths are a sign of regular exposure to cold water. They are seen in as many as three-quarters of surfers, which may explain why they have been dubbed surfer's ear.

Surfer's ear has been reported in ancient skeletons before but not so abundantly. "The frequency of near 50 per cent in the adult sample is amazingly high," says Sébastien Villotte at the University of Bordeaux, France. He thinks it is likely that the people at Körtik Tepe regularly dived into nearby cold rivers – perhaps to catch fish.

But Ian Kuijt at the University of Notre Dame, Indiana, isn't convinced by this explanation, given that it is possible to fish from riverbanks. "They are unlikely to have been diving for fish," he says.

Reuven Yeshurun at the University of Haifa, Israel, also dismisses the fishing idea. "Körtik Tepe is one of the richest of the earliest permanent settlements in the region," he says. "What it does not have, however, is solid evidence for fishing as a dietary staple." Relatively few fish bones have been found at the site, he says, and nitrogen levels in the human bones aren't consistent with an aquatic diet.

So what was going on? Erdal's team speculate that the ancient villagers spent plenty of time in the chilly waters of nearby rivers to keep clean, or even simply for entertainment. "They certainly could have engaged in swimming and diving activities, which is a kind of leisure activity we never really associate with Stone Age people," says Yeshurun.

Whatever the explanation, there is agreement that the new findings provide a fascinating – if still puzzling – glimpse into life just before the farming revolution. ■

ZGUR AYAYDIN/ANADOLU AGENCY/GETTY IMAGES

Human remains being excavated from Körtik Tepe in Turkey

Giant planets are worlds of two halves

THE hottest planets in the universe are half boiling hellscape, half cloudy oasis.

"We call them planets, but they're like an intermediate object: star-like on the day side and planet-like on the night side," says Vivien Parmentier at Aix Marseille University in France.

Known as "hot Jupiters", these gas giants orbit close to their stars, with one side always facing the star – where temperatures can reach over 4300°C. The other side never sees sunlight and can be a thousand degrees cooler.

We expect most planets, including these, to contain water in some form because it is common in the universe, notably in the discs of debris surrounding planet-forming stars. "We've been looking for water on planets since we've been able to look for things on planets," says Parmentier. But when astronomers found these extremely hot planets, some of their day sides showed no signs of water.

Parmentier and his colleagues hypothesise that this could be because the day sides of these worlds receive so much radiation from their stars that water and other molecules in the atmosphere get broken into their constituent atomic parts. It is so hot that some electrons even break free of their atoms.

The water molecules reform when the atoms are carried back to the night side by extreme winds created by the heat difference on the day and night sides. As the water cools, some of it condenses into clouds and rain.

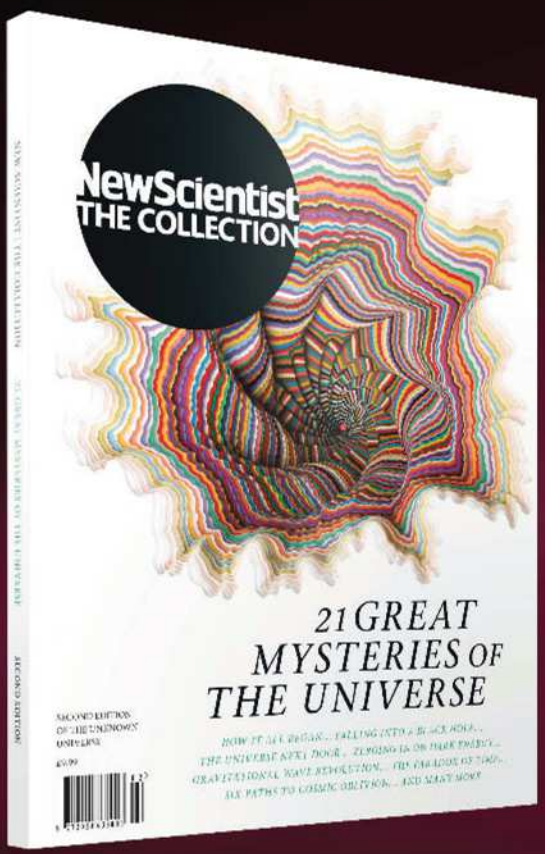
"We call them planets but they're star-like on the day side and planet-like on the night side"

That means there is no water on the day side, only hydrogen and oxygen. But on the night side, the atmosphere has plenty of water.

The team believes a similar process may produce clouds and rain of aluminium oxide, iron or liquid rubies.

Parmentier's team created a computer model of this process and tested it on data about a world called WASP-121b, as well as 13 other similar planets (arxiv.org/abs/1805.00096). Parmentier says that it was a good match for most of them, but some strange outliers remain. Leah Crane ■

SECOND EDITION OF
THE BIG QUESTIONS



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Pigeons that get probability

Colin Barras

PIGEONS seem to have an innate ability to grasp probabilities – the first non-primate shown to do so. The skill could help the birds forage for food and avoid predators, suggesting there are good evolutionary reasons for this instinctive understanding.

Even at 12 months old, humans prefer to be given a toy from a jar that they know contains a high rather than a low ratio of favoured to non-favoured toys. Non-human apes and even some monkeys seem to have this instant and innate ability with probability too, prompting researchers to wonder whether other animals do.

William Roberts and his colleagues at Western University in Canada decided to find out using pigeons – birds with a surprising flair for numbers. They placed eight pigeons individually in a cage with access to two buttons. Periodically one of the buttons lit up. By pecking it, the pigeon had a chance of receiving a food reward.

Each button lit up a total of 24 times, but one was far more likely to yield a reward: it did so 18 times (75 per cent chance of reward), while the second did so just six times (25 per cent chance).

Every so often, both buttons lit up at once and the pigeons had to choose which to peck. As soon as the birds were familiar with the set-up, they much preferred the "75 per cent" button when this happened, picking it more than 85 per cent of the time.

"The experiments suggest pigeons have an innate ability with probability – just like primates do"

However, it was unclear whether the pigeons preferred this button because it offered a greater chance of yielding a reward or simply because it had given out more rewards in total: 18 versus six.

In a follow-up test with eight different pigeons, Roberts' team tweaked the set-up. Now, one button lit up 12 times and yielded a reward nine times (a 75 per cent chance of getting food), while the second lit up 36 times and also yielded a reward nine times (25 per cent chance).

Again, both buttons sometimes lit up together. As in the first experiment, once the pigeons were accustomed to the set-up, they showed a strong preference for the "75 per cent" button, pecking it about 90 per cent of the time. In other words, it really was the probability that mattered (*Animal Cognition*, doi.org/cqjq).

Roberts says the experiments suggest pigeons have an innate ability with probability – just like primates do.

This is a reasonable conclusion, says Walter Herbranson at Whitman College in Washington, who has also explored whether pigeons can understand probability, but he adds some caveats. "That was a relatively strong 75:25 difference," he says. If the difference were more subtle, he thinks pigeons might have to learn over many trials which of the two buttons to peck. ■

An instinctive grasp of probability helps pigeons make better choices

You forget your most important dreams

DREAMING helps us learn new information, and the boring dreams we have during the deepest stages of sleep may be the most important.

As we drift off, our brainwaves slow and we enter progressively deeper stages of sleep, before returning to lighter sleep and entering a rapid eye movement (REM) stage. This cycle is typically repeated several times a night.

Until recently, we thought dreams only occurred during REM sleep. We now know that is not the case, although REM dreams are the vivid, story-like ones we tend to remember. Those we have during deeper, non-REM sleep appear to be simpler and vaguer. For example, when you recall being chased down the street by a dinosaur, that is from an REM dream, says Björn Rasch at the University of Fribourg, Switzerland.

To investigate the role of sleep in replaying memories and learning, Rasch and his colleagues recruited 22 volunteers. They were all asked to learn a list of 100 words that were each linked to a picture, for example, the word tree with a picture of a child sitting on a chair.

That night, the researchers used electrode caps to track what stage of sleep each person was in. Throughout the night, the team regularly woke participants up and asked them what they had been dreaming about.

The next day, the volunteers were tested on the word-picture pairs. Those who saw more of the pictures in their non-REM dreams did best. There was no such link when it came to REM sleep (*bioRxiv*, doi.org/cqjp).

Another night, the volunteers were given a new memory task and then allowed to sleep undisturbed. The following morning, they described the dreams they could remember – and none contained pictures from the task.

This is the first hint that dreaming about things in non-REM sleep might be more important than doing so in REM sleep, says Rasch. Clare Wilson ■

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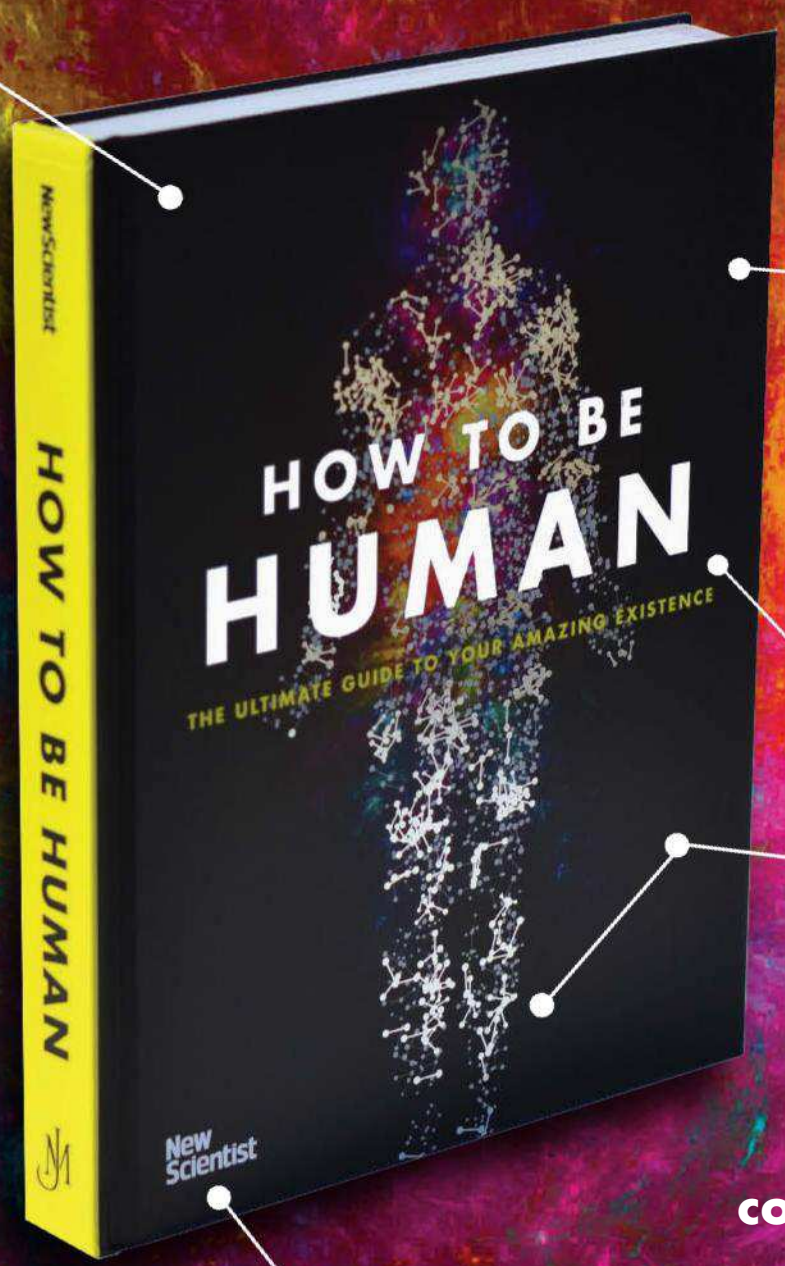

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Apps hunt for early signs of dementia

Jessica Hamzelou

SAFARIS and sea adventures could be testing in more ways than you might think. These are some of the scenarios featured in a spate of new games and apps, with the aim of identifying signs of dementia years or decades before a person might typically receive a diagnosis.

Though there is currently no cure for dementia, spotting it early enough might reveal the parts of the brain that are affected by the disease first, which in turn may help to slow its progression.

One skill that a game can probe is the processing of spatial orientation. Disruption to this ability is one of the earliest clear signs of Alzheimer's disease, says Hugo Spiers at University College London.

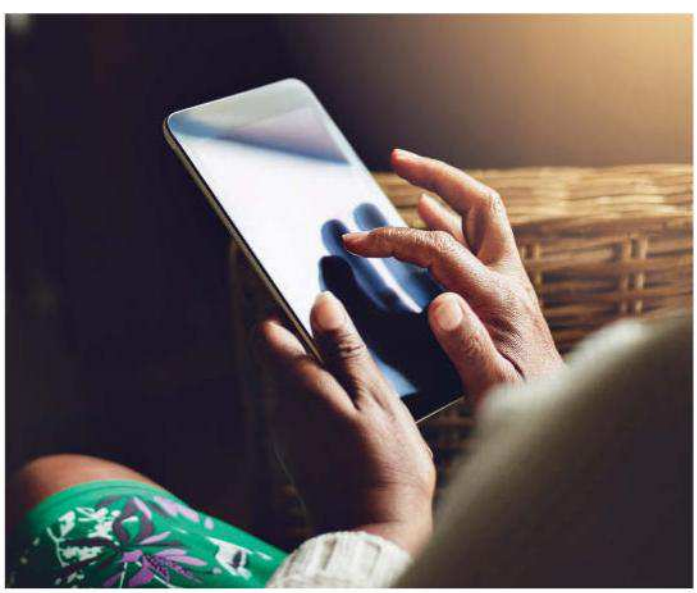
Spiers has collaborated on the design of *Sea Hero Quest*, a game that requires players to travel the oceans on a mission to regain lost memories. Although this is purely a game at present, Spiers and his colleagues are working on a version that uses a person's score to tell their doctor of any early signs of Alzheimer's.

Sina Habibi has a similar goal for an app released by his company Cognetivity, a University of Cambridge spin-out. Cognetivity's 5-minute test, played on an iPad, shows users a variety of scenes in rapid succession. Their task is to pick out those that contain animals as quickly as possible. Habibi's team chose to focus on visual processing because this is another of the first skills to decline in the early stages of dementia.

BrainTest takes yet another approach. Developed by a Canada-based company, it is based on existing tests that assess a range of cognitive skills, including the ability to perform calculations, spatial orientation and language.

If you ask any of the companies involved, they will say their own test is the best, says Carol Routledge, head of research at Alzheimer's Research UK, based in Cambridge. Given that all the tests focus on different aspects of brain function, which one gives us the best indication of dementia?

"We don't know," says Routledge, "because we don't [yet] diagnose dementia early enough." As more people use the apps, a winning strategy may eventually emerge.



DELMAINE DONSON/GETTY

However, even if one day we learn that visual processing, for example, is the first sign of the onset of dementia, it would take a lot more work to figure out exactly which form of dementia will probably develop.

"There are up to 80 different diseases that can cause dementia," says James Pickett, head of research at the Alzheimer's Society, a London-based charity. The various forms can affect different regions of the brain in their own ways and symptoms can vary, so it is important to be able to tell them apart.

Most people with dementia aren't diagnosed until their 70s and 80s, when symptoms are noticeable. The underlying brain changes are thought to start some two to three decades before then, so a simple test for early dementia is a worthy goal, says Pickett.

To date, all of the hundreds of clinical trials of drugs for dementia have failed – probably because the tests involved people whose brain damage was already too severe to be remedied, he says. If there were a way to identify such people in the first stages of the disease, we would have a much better chance of treating them successfully. ■

Add-on for surfboards can fend off sharks

AN ELECTRIC device that attaches to surfboards could halve a surfer's risk of getting attacked by sharks.

Although rare, shark attacks are on the rise, with the number worldwide going from about 20 to 80 cases a year over the past three decades. Many shark repellent products for surfers are now on sale, but few have been rigorously and independently tested.

Charlie Huveneers at Flinders University in Australia and his colleagues decided to assess five of the most popular products. These included two devices that create electric fields, two that create magnetic fields, and a smelly wax.

The researchers carried out 50 trials per product, attaching or applying it to surfboards placed 30 kilometres off the coast of South Australia – in waters where sharks are fairly common. A piece of tuna dangling below each board mimicked a surfer's foot, while an underwater camera filmed any shark interactions.

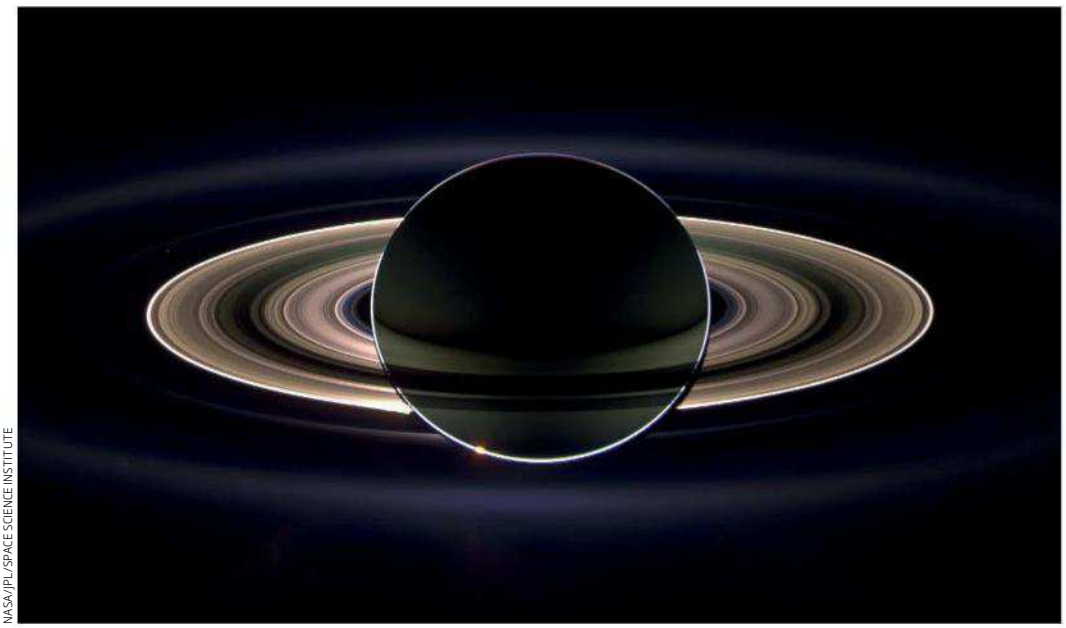
Four of the products had no significant effect, the team found in a report published by the government of New South Wales. But a device made by an Australian company called Ocean Guardian halved the number of shark attacks on the bait.

The device attaches to the tail of a surfboard and is designed to create a strong electric field. The aim is to overwhelm the sensory receptors that sharks use to detect weak electric signals from prey, says Huveneers.

"The aim is to overwhelm the sensory receptors that sharks use to detect weak electric signals from prey"

Although it didn't eliminate shark attacks in the trials, the device may actually work better in real-life contexts, says Huveneers. That's because the tuna was probably more enticing to sharks than human flesh, given that tuna is part of their natural diet, he says.

"I think that overall, there's probably never going to be one silver bullet that stops all shark attacks," says Huveneers. "That's why we need to keep doing research on all possible mitigation strategies." Alice Klein ■



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Saturn, photographed by the Cassini spacecraft in 2006

Saturn's rings clock its rotation

Adam Mann

WHEN the Cassini spacecraft visited Saturn, its measurements of the planet's magnetic field clocked its rotation as taking 7 minutes longer than the last time we checked – suggesting there's something awry with our methods. But clues to the giant planet's true rotation rate could lie in another part of Cassini's data haul: a deluge of images of Saturn's rings.

In the early 1980s, the Voyager probes flew past Saturn, giving us the first close-ups of its rings, with some unexpected features that looked like record grooves. Researchers realised that Saturn's moons gravitationally tugged on rock and ice particles in the rings. When the moons and ring particles have orbital periods that are simple ratios of one another, the moons give the particles periodic kicks – known as orbital resonance.

"With resonances you can launch waves that propagate through the rings, kind of like dropping a rock in a pond," says Christopher Mankovich at the University of California, Santa Cruz. But while the moon-generated undulations moved away from the planet, there were a handful of weird waves headed in the direction of Saturn itself.

One explanation for the "backwards" waves is that earthquake-like events inside the gas giant could be moving huge amounts of mass around, tugging ring debris towards the planet. "It turns out that Saturn's rings are an extraordinarily sensitive way of detecting disturbances inside the planet," says David Stevenson at the California Institute of Technology.

"Tugs from a moon can launch waves that spread through the rings, like a rock dropped in a pond"

The Voyager probes also recorded data on Saturn's magnetic field, finding that it was whipping around on its axis every 10 hours and 40 minutes, a figure that was taken as the rotation rate of the entire planet.

But when the Cassini spacecraft arrived at Saturn in the mid-2000s, it measured the magnetic field's rotation period as greater than 10 hours and 47 minutes. It was impossible that massive Saturn had slowed down that much in a few short decades.

To get a clearer idea of Saturn's rotation, Mankovich and his team looked to its rings. Cassini found many more inward-moving waves than the Voyager probes. Using data from Saturn's second-innermost C ring, the team made computer models that account for the patterns and positions of the inward-moving perturbations.

These suggested Saturn is rotating about every 10 hours and 35 minutes, a finding that agrees with recent estimates using Cassini's measurements of the planet's gravitational field (arxiv.org/abs/1805.10286). The models also hint that Saturn's interior may rotate at different rates at different depths. ■

You really can make yourself pitch perfect

MOZART and Beethoven are both said to have had it. The same is said of Mariah Carey. Now a study suggests that some adults may be able to learn perfect pitch in just a few weeks of training.

Many musicians can identify notes in relation to a reference note. For instance, if they hear the note C and are told it is C, they will be able to identify G. But only a few have absolute pitch – also known as perfect pitch – which is the ability to identify any note without a reference note.

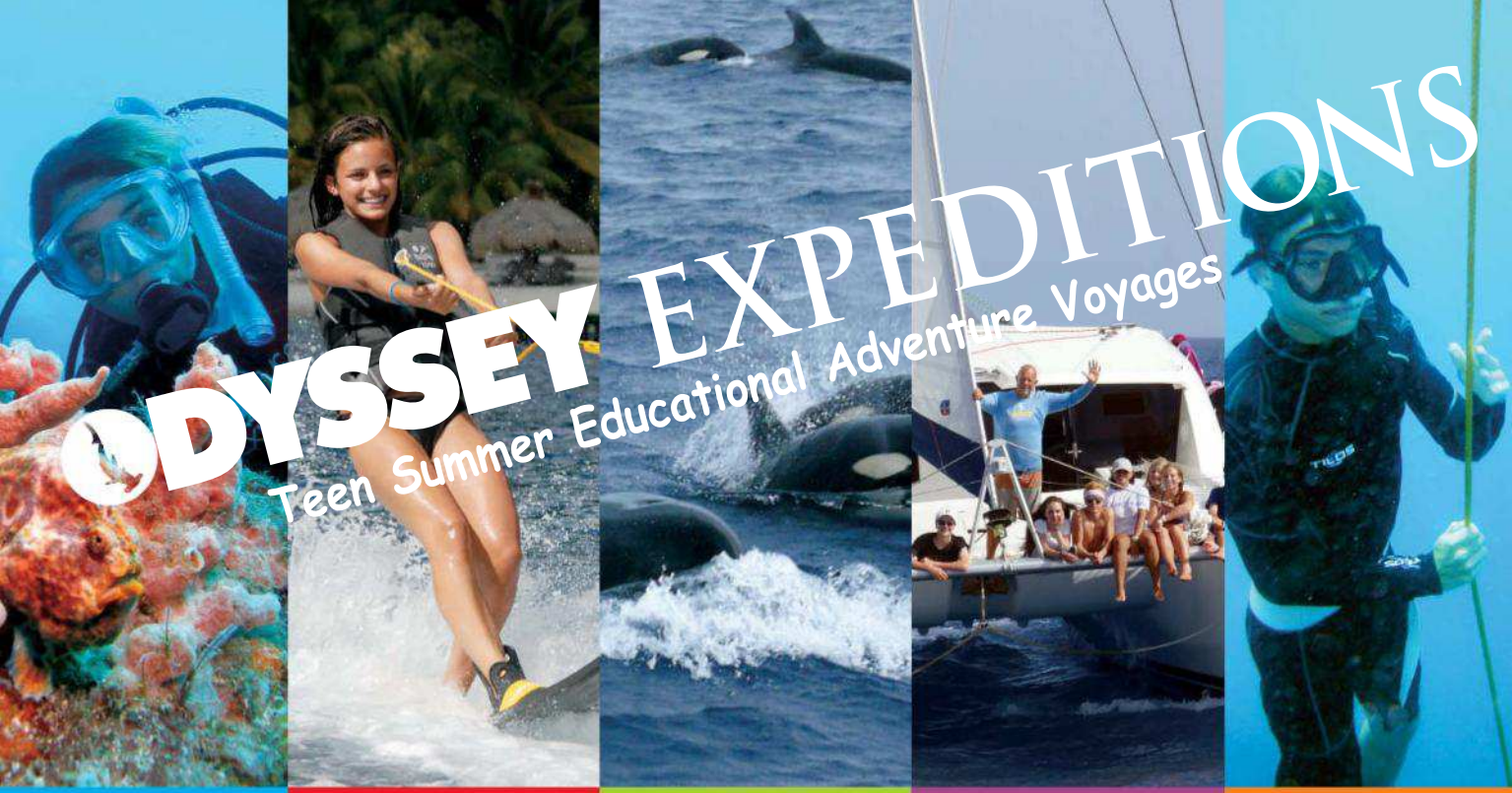
"It is a tremendous advantage," says musician Rick Beato. People with absolute pitch can play or write down any tune they hear, or just sit down and compose music without needing an instrument.

It is thought that only around 1 in 10,000 people have this ability, and that if a person doesn't learn perfect pitch before the age of around 8, they never will. However, when Stephen Van Hedger of the University of Chicago and his colleagues attempted to train six people in absolute pitch, two of them improved considerably (*bioRxiv*, doi.org/cqjn).

The training – which took four hours a week, for eight weeks – involved listening to notes, trying to identify them and finding out if the guesses were correct. At the start, the two people who showed most improvement scored under 40 per cent on tests of absolute pitch. By the end they scored 98 per cent or more. One of them scored 100 per cent. "He passed the strongest test we could throw at him," says Van Hedger.

But some are sceptical. The two volunteers who improved had music lessons in childhood, notes Seung-Goo Kim at the University of Cambridge. "In other words, this study shows that absolute pitch can be refined in some adults by training if they already have 'latent' absolute pitch."

"There are a lot of people who don't know they have perfect pitch," says Beato. Michael Le Page ■



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The downside of unlimited food at rubbish dumps

BIRDS that feast on all-you-can-eat buffets at rubbish dumps could be making themselves sick.

Many scavenger birds, like vultures and storks, supplement their diets by stopping off at large landfill sites and rubbish dumps. But a new study looking at the health of these birds suggests that they may be paying a heavy price for those easy calories.

Pablo Ignacio Plaza at the National University of Comahue in Argentina and colleagues took blood samples from 48 adult black vultures who ate from a rubbish dump in Patagonia and 46 adult black vultures from the Patagonian steppe whose source of food was in the wild.

The vultures that ate at the dump were not only heavier, but their blood also showed higher levels of uric acid caused by eating too much protein, and excessive sugar levels due to the processed carbohydrates such as sweets and cereals they had consumed (*PeerJ*, doi.org/gdd9h3). In the long term, such high levels of both could lead to kidney and metabolic diseases, says Plaza.

The birds also had higher levels of immune proteins in their blood, perhaps due to the higher levels of pathogens in the dump.

The finding suggests that other bird species that regularly feed at rubbish dumps, such as the critically endangered California condor in the US, might also be affected.

Cellular recycling extends life

BOOSTING cells' "disposal system" can stave off age-related organ damage and increase lifespan by 10 per cent in mice.

Our body's "autophagy" system breaks down damaged DNA and cells that no longer serve their purpose, but, as we age, this process appears to slow down and our tissues start to accumulate damage.

Beth Levine at the University of Texas Southwestern Medical Center and her colleagues have been studying mice with a genetic mutation that increases autophagy in some organs. They found that these animals live three months longer. "It might not sound like a lot, but in the mice it's a 10 per cent increase," says Levine.

The team found that the hearts and livers of the mice showed less scarring – a sign of ageing – and they developed fewer age-related cancers (*Nature*, doi.org/cqg6).

The researchers hope to develop a drug that safely boosts autophagy in humans. Levine says her team has identified some compounds that might be suitable for this. The first trials are likely to include people at a high genetic risk of developing age-related disorders like Huntington's, Alzheimer's and liver diseases, she says.

Meet the scorpions that hiss at you

YOU would think a nimble stinger and powerful pincers would be enough. But some scorpions have another defence strategy: hissing.

Lauren Esposito at the California Academy of Sciences in San Francisco and her colleagues used DNA sequencing to work out the evolutionary history of hissing in a subfamily of scorpions called Centruroidinae.

The group includes the club-tailed scorpions, which make noise by rubbing comb-like structures on their bodies against plates of exoskeleton on their bellies that are covered in fine granules, like sandpaper.

The ability to hiss seems to have evolved once. Later, most toxic scorpions lost it (*Arthropod Systematics and Phylogeny*, vol 76, p87). This means the scariest-sounding scorpions may be harmless, and their venomous cousins are so secure in their toxicity they don't need to boast.

AI could mind online Ps and Qs

F-BOMBS are out, and pleases and thank yous are in. An AI created by IBM translates offensive chatter into more polite language, while keeping the core message intact.

The team trained the AI on millions of posts from Reddit and Twitter, before giving it offensive posts it had not previously seen to make more palatable.

In almost every case, offensive text was successfully converted into less-offensive language, with the intended meaning remaining (arxiv.org/abs/1805.07685).

In the future, the system could be used on social media and it will be able to handle "posts containing hate speech, racism and sexism", says Cicero Nogueira dos Santos, one of the IBM team.

Big brains are different too

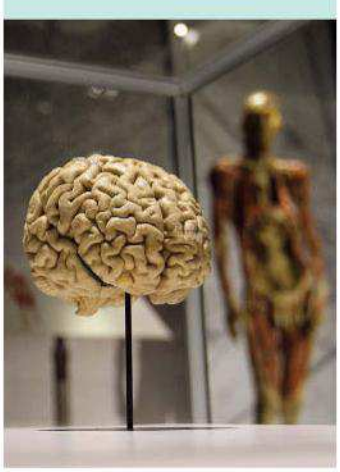
PEOPLE who have big brains don't just have scaled-up versions of more average-sized brains. Instead, certain regions – particularly those involved in bringing together information from across the brain – are hyperexpanded.

Armin Raznahan at the US National Institute of Mental Health in Maryland and his colleagues discovered this by comparing images of around 3000 people's brains. They compared the area of 80,000 regions across the cortex – the large part of our brain that is involved in functions like thinking.

Their analysis showed that some areas expanded more than others in people who had an overall larger brain size (*Science*, doi.org/cqhb). These regions seem to be involved in integrating information from across the brain, says Raznahan.

These expanded areas are the same regions that have grown relatively larger throughout our evolution, and they continue to grow in our early lives, becoming relatively larger in adult brains than they are in children's brains.

It isn't clear if this confers any benefits though. Past research has found that people with larger brains do tend to have a higher IQ, but the relationship is subtle – brain size only accounts for around 5 per cent of the variation in IQ, says Raznahan.



DANNY CASEY/AAP/PA

Pluto has dunes made of methane ice

ICY Pluto doesn't seem like it would resemble a beach, but it turns out to have dunes tens of metres high.

Matt Telfer at the University of Plymouth in the UK and his colleagues used data from NASA's New Horizons spacecraft to study ridges near a Plutonian mountain range. They wanted to know whether these could be dunes of ice particles, akin to Earth's sand dunes.

The team found several signs that support the idea. They are regularly spaced – set apart by about 400 metres to a kilometre – and the angles between them depend on the mountains they border. That suggests they are formed by winds flowing down the sides of the peaks.

Evidence for wind itself is found in dark streaks among the dunes. These are caused by the wind passing over spots of dark material, and dragging it along (*Science*, doi.org/cqjv).

The team says the dunes are most probably made of methane ice. There is an excess of methane in the area and it is less dense than other ices on Pluto, so it is easier for the feeble wind to pick up.

The wind may be too weak to blow the methane grains away on its own, but they might be lofted into the air when sunlight causes the surrounding nitrogen ice to sublimate. As the nitrogen turns into gas and floats away, it carries with it particles of harder-to-melt methane that the wind picks up and piles into dunes.

Some of the particles may get welded together to form a firmer surface, like ice cubes left in the freezer too long.

Bird baths can fix broken feathers

SPLASHING around in water doesn't just get a bird clean – it can also repair feathers.

Marc Meyers at the University of California, San Diego, and his colleagues assessed how resilient vulture feathers are by repeatedly bending them nearly in half, then soaking them in water. They tested the calamus, the hollow base of a feather's spine that sits under the skin, and the rachis, the rest of the central shaft.

The walls of the shaft are made of keratin fibres, with layers of a spongy matrix sandwiched between them. The researchers found that the fibres did not absorb water but the spongy material did, swelling like a balloon and unbending the fibres.

After two cycles of soaking and drying, the rachis recovered about 82 per cent of its original strength, the calamus about 78 per cent. After three more cycles, the calamus maintained its strength, while the rachis degraded to 56 per cent (*Advanced Functional Materials*, doi.org/cqgp).

Meyers says that materials that mimic feathers could be used in self-healing structures, like radio antennas that repair themselves in the rain.

ALL CANADA PHOTOS/ALAMY STOCK PHOTO

Insect head count based on splatter

THE way car windscreens get wallpapered with insects on country drives has inspired an odd census.

Amanda Martin at Environment and Climate Change Canada wanted to know what effect insect collisions with cars on increasingly busy roads were having on their populations nearby. That meant sampling thousands of flying insects along a roadway to make comparisons.

"We thought, wouldn't it be great if we could collect insects as they were hitting the car?" she says. So Martin and her colleagues turned their vehicle into a big mobile piece of flypaper, fitting it with large sticky trap panels on the grille and roof.

They then drove the vehicle on 10 high and 10 low-traffic rural roads in Ontario, counting and categorising the insects stuck to the traps. There were 23.5 per cent fewer insects on high-traffic roads than low-traffic ones (*Insect Conservation and Diversity*, doi.org/cqhd).

This doesn't necessarily show that more insects are killed on busy roads, says Martin. Higher emissions could be killing nearby insects, or busy roads may help spread non-native plants that insects can't exploit.

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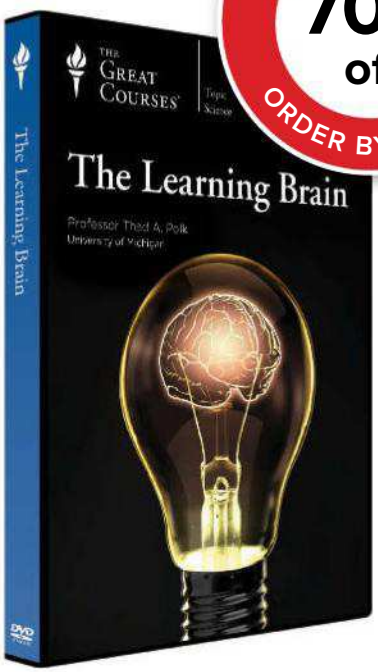

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A dose of reality

Attempts to crack down on psychedelic substances are failing to protect people from harm. Drug safety testing could be a better way, says **Jesse Klein**

THE war on drugs has become an arms race. In an effort to outpace the law, unregulated laboratories are creating thousands of modified versions of psychedelic substances and selling them to unknowing partygoers.

These chemistry experiments have consequences. Last month, two people died at the Mutiny Festival in Portsmouth, UK, seemingly as a result of taking drugs – festival organisers warned of "a dangerous high-strength or bad-batch substance on site".

Following the deaths, there have been renewed calls to have drug safety tests on-site at festivals and similar locations, to identify and inform people about the substances they have bought.

"Roughly one in five drug users are being mis-sold drugs in the UK," says Fiona Measham, a criminologist at Durham University, UK. Her drug-testing organisation, The Loop, will be operating at 10 UK festivals this year, and recently set up a facility in Bristol city centre. "The only reason that we are able to estimate this figure is because of our drug safety testing," she says.

Novel psychoactive substances are a growing problem. In 2005, there were only 16 of these substances reported in Europe, but by 2016 that had risen to 560.

In response, the UK government decided to go on the offensive to tackle these "legal highs". Instead of playing catch-up by retroactively banning drugs as they cropped up, the UK passed the Psychoactive Substances Act in 2016, to make all such substances illegal.

It didn't make much difference. This blanket ban on almost any psychoactive drug – the likes of caffeine and alcohol are excluded – was widely criticised for its poor science. The act defines the word "psychoactive" so loosely that it could apply to things like nutmeg and flowers.

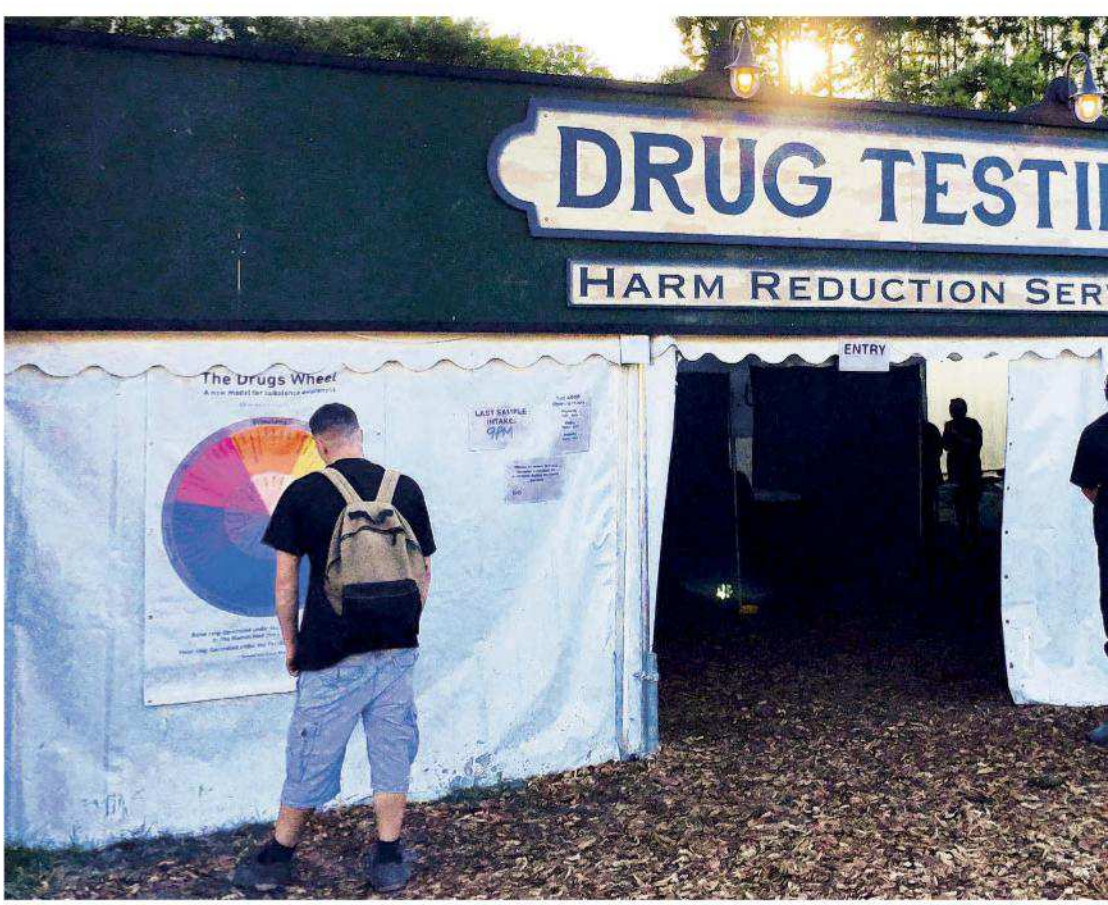
"The courts still don't know what is or is not covered by the act," says Alex Stevens, who researches criminal justice at the University of Kent, UK. "And in many cases nor do the police."

In the two years since the law was passed, the market for traditional street drugs and the former legal highs has merged. Dealers are now selling these cheaper designer drugs disguised as traditional recreational substances in an effort to cut costs. Unlike traditional street drugs, these designer drugs have not been formally studied in the lab. Their effects are dangerously unknown.

"You can literally go on the internet, hire a Chinese laboratory to take a known scheduled drug and tweak it into a new substance, then sell it in the US as MDMA or LSD," says Madalyn McElwain of DanceSafe, a US-based non-profit dedicated to reducing drug harm at raves, nightclubs and festivals.

Organisations like The Loop or DanceSafe say people will take drugs, prohibition or no, so they want to reduce any unintended impact. They set up at festivals or nightclubs and invite people to drop off a sample of their drugs to be analysed, identifying the substances within and their strength. An hour later, the person returns to receive the results, along with a brief intervention to explain the risks and identify safe dosages.

Testing services aim to steer people away from fake drugs



THE LOOP

Through these tests, DanceSafe has found that pills sold as MDMA, or ecstasy, are often something else entirely. The organisation collected 529 samples between 2010 and 2015, and found that only 60 per cent of the drugs that people believed were MDMA actually contained the compound. The fakes include bath salts, methamphetamine and a dangerous amphetamine known as PMA. "There are more chemicals in play," says McElwain.

Dangerous highs

In Portugal, where drugs are decriminalised, a non-profit called Kosmicare provides on-site drug checking at the Boom music festival. In 2015, Kosmicare found that many samples of LSD its team tested there were actually N-BOMe, a dangerous synthetic hallucinogen that reportedly killed 17 people in the US that year. But even when the sample is pure, Kosmicare can help people decide on a dosage based on the strength of their sample.

"The idea is that we have a chance to talk to them, understand their drug use patterns and give them tailored information based on their results," says Helena Valente, director of Kosmicare. People who use the service welcome the information, she says – almost everyone returns for their results.

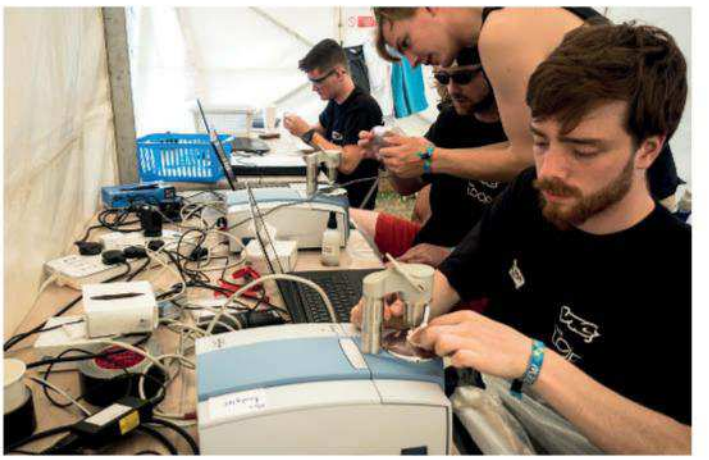
According to the latest annual *Global Drug Survey*, published last month, two-thirds of people said they would use such a service if it were available. But the survey also found that drug checking doesn't seem to alter many people's behaviour. Only around 11 per cent of respondents said testing changed the way they use drugs, while around 43 per cent said it simply reinforced what they already knew.

Testing alone isn't enough, says Adam Winstock, who runs the survey. "Both drug checking and drug-law reform are needed to help people adopt safer drug-taking behaviours."

Measham's work suggests that safety testing does at least help some people. When The Loop set up at the Boomtown festival (pictured, left) in Hampshire, UK, last year, medical staff saw a 25 per cent decrease in drug-related incidents.

The Loop found that N-ethylpentylone was being sold as MDMA. The substance looks like MDMA, but instead of creating euphoric feelings for 3 to 6 hours, the drug produces anxiety and paranoia for 24 to 36 hours. The Loop also found malaria tablets, boric acid and plaster of Paris masquerading as party drugs.

When people at the festival were told about the results, 18 per cent actually handed the drugs over to the testing centre for destruction. Kosmicare found an even stronger result: when festivalgoers were told their LSD was N-BOMe, around 74 per cent of people said they did not intend to take the drug anymore – though whether they followed through with this is unknown.



THE LOOP

Tests can identify substances and determine their strength

"The police were really happy because we were taking harmful drugs out of circulation," says Measham. "The paramedics were happy because we were reducing drug-related harm, and the users were happy because we identified potentially harmful drugs."

An incident in 2014 shows what happens when such services aren't in place. That year, a red pill in the shape of the Superman logo was sold as ecstasy in many European countries. The Trimbos Institute, a drug-checking group in the Netherlands, sent out alerts through health centres and an app to inform people that the pills contained a deadly amount of PMMA, an MDMA substitute. No one in the Netherlands died, but in the UK, where alerts were not widely spread, four festivalgoers were killed by the dangerous pill.

"When people found out their drugs were fake, 18 per cent handed them over for destruction"

"One of the problems in countries without drug safety testing is you are waiting for someone to die or be hospitalised before you put out a warning," says Measham.

But safety testing can only work properly in countries with a relatively liberal attitude towards drugs. The Loop only operate at festivals with support from the police, a stark difference when compared with the US. There, DanceSafe must work in secret because of the 2003 RAVE Act, a law designed to crack down on underground dance venues where organisers were promoting the use of illicit drugs.

The language of the law is so broad that it effectively bans drug checking: organisers can be prosecuted if they knowingly operate or profit from any place where drugs are being consumed. Festivals worry that organisations like DanceSafe could be seen as encouraging illegal drug use, although no one has yet been prosecuted in this way. As such, DanceSafe must take participants away from public view to do the testing, and does not state publicly which festivals it operates at.

McElwain hopes the success of drug safety checking elsewhere will lead to a change in US law. "People don't want to die. People don't want to have a bad experience," she says. "People want to prepare before ingesting the chemical, and they will take the necessary steps. We are here to provide the tools." ■

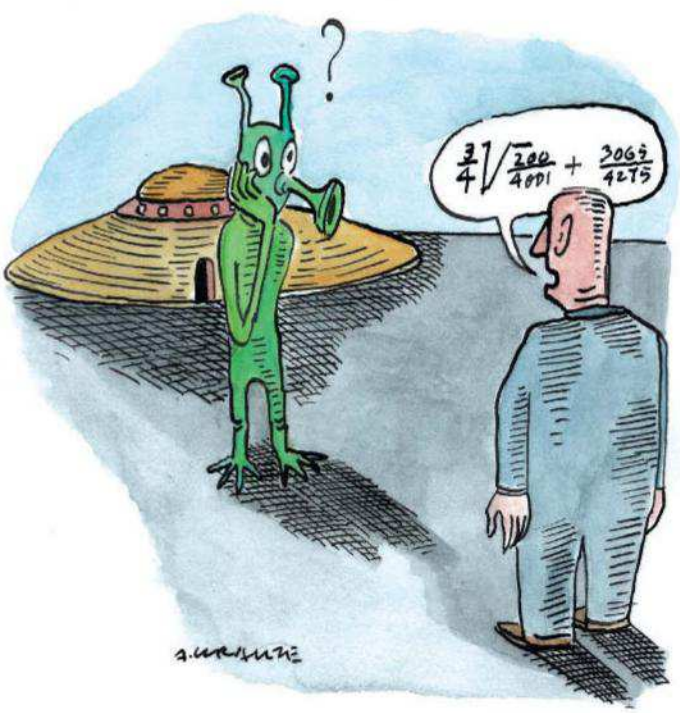
Can we speak alien?

It's time to find a new way to talk to possible extraterrestrial civilisations, says **Douglas Vakoch**

ASTRONOMERS seeking contact with ET have typically relied on messages based on maths and science. They reason that alien civilisations with transmitters and receivers to allow interstellar communication will know some fairly sophisticated physics.

But the messages humankind has sent have sometimes included quite different content. The 1977 Voyager Golden Record had an audio greeting: "Hello from the children of planet Earth". No one thought this would be meaningful to anyone other than those who sent it. But maybe our language would not be totally alien.

METI International, which I head, began its namesake activity of messaging extraterrestrial intelligence in late 2017, targeting an exoplanet orbiting Luyten's star, 12.4 light years away. It sent a mathematical and scientific primer. To prepare for further



missives, we held a workshop – "Language in the cosmos" – at the International Space Development Conference last month in Los Angeles. Its goal: to create more-intelligible messages by studying how humans talk to one another.

Noam Chomsky, the father of modern linguistics, has said that if a Martian visited, it would think we all speak the same language. The differences would seem like dialects of one tongue because human languages are so similar. Chomsky argues that a universal grammar underpins them all.

Might this hold throughout the galaxy? At METI's workshop, University of Cambridge linguist Ian Roberts, with colleague Jeffrey Watumull and Chomsky, argued that alien languages may share some of this common ground. For instance, all our languages combine individual words through a process linguists call "merge",

No need to detox

The idea that some foods or drinks can rid us of toxins is bunk, says **Anthony Warner**

FOR those who rail against overinflated health claims on the things we consume or use, the term detox has long been a bugbear. The implication that foods, drinks, diet plans, spa treatments or even hair straighteners can somehow fast-track poisons out of your body has no basis in science, yet has been made real in the public's mind by constant repetition.

Thankfully, anyone with a functioning liver, kidneys and digestive system doesn't need any help removing toxins – most are broken down or excreted in hours. There is no firm evidence that juices or electrical appliances make any difference to this.

So, three cheers for a decision that will see "detox" used a little less. The Unilever-owned Pukka Herbs was told by the UK Advertising Standards Authority not to use the term to advertise one of its teas. Given that there is no scientific evidence that it can remove toxins, this is sensible.

Highlighting this case may seem trivial, seeing as Pukka's tea is no doubt as refreshing as any herbal brew and is just one of many that use the word. But the

"If, in theory, I would be allowed to promote a range of detox sausage rolls then something is wrong"

ruling illustrates a more complex problem. The ASA considers "detox" to be a general health claim, along the lines of "better for you" or "healthier choice". The tea fell foul of the rules due to a lack of any relevant proven general health benefits, rather than specific proof of an ability to remove bodily toxins.

For example, a product fortified with selenium, a mineral that has allowable health benefit claims regarding immune function and antioxidant properties, could be advertised using the word detox. This means that, in theory, I would be allowed to promote a new range of detox sausage rolls,

which is repeated, over and over, to form complex sentences. The steps of "combine and repeat" might be found in alien languages as well, Roberts and his colleagues suggest.

As we plan more transmissions, do we need a new way to construct messages? Should we replace numbers with the works of Shakespeare? Probably not. It might make more sense to focus on what maths and language have in common. The linguistic process of merge has a striking similarity to basic arithmetic. The structure of addition is eerily reminiscent of the simplest sentences, in which we combine nouns like "aliens" and verbs like "reply" to describe the hoped outcome of our own transmissions: "Aliens reply".

In our next messages, METI will draw on some of the cognitive processes that undergird such seemingly different human creations as maths and language. Aliens may not know about partial derivatives or the past perfect subjunctive – at least not in the forms we are familiar with. But if we start by incorporating principles like merge and repeat into our messages, then build to more complex forms, ET may just be able to follow us. ■

Douglas Vakoch is president of METI International

so long as I was able to fortify them in this way. It is hard not to think that something is wrong. The obvious solution is for detox to no longer be allowed as a general health claim; it should be viewed as specific, referring to removal of toxins and judged on that basis.

It is sad that herbal teas cannot be sold for their taste alone, rather than dragging up vague notions of detoxification. But it is an even greater shame that there is so little restriction on the way this word is now used. ■

Anthony Warner is a food industry development chef, blogger and the author of *The Angry Chef* (OneWorld)

ANALYSIS Experimental treatments

NICHOLAS KAMM/AFP/GETTY IMAGES

US 'right to try' drug law could harm patients

Andy Coghlan

TO PEOPLE with incurable illnesses, Donald Trump must seem like their saviour. Last week he signed into federal law the Right to Try Act, which will give terminally ill people greater access to experimental medical treatments. That might sound good – but experimental means they haven't been fully tested to make sure they are safe, or that they work.

People in the US with serious illnesses who want to try experimental medicines were already able to do so, but only with the permission of their doctor, the US Food and Drug Administration and the company testing the treatment. Around 1000 apply each year to the FDA, and it approves 99 per cent of the requests.

Now, people can apply for untested fixes without the FDA's say-so. "Federal law now protects the right of dying patients to obtain and use cutting-edge medicines without asking first for government permission," said Victor Riches, president of the Goldwater Institute, in a statement. The institute has led a nationwide campaign to get the law passed.

Beguiling as that may sound, we know untested treatments can cause harm. Take thalidomide, which was given to pregnant women during the 1950s without proper testing, leading to severe birth defects.

Since then, almost all countries have set up strong regulatory regimes to prevent something similar happening again. In the US, policing this is the job of the FDA. But backers of the new law see the FDA as an obstacle to access and free choice.

Yet what campaigners for the right to try don't talk about is what happens when untested treatments go wrong.

"There are lots of snake-oil salesmen just waiting for the opportunity to sell fraudulent therapies"

There is a clear risk of people being charged exorbitant sums for treatments that don't work, and uncertainty over whether people will qualify for compensation if a treatment fails or causes serious harm.

This issue has arisen in recent months following the proliferation of clinics offering potentially untested treatments based on stem cells, especially in Florida and California. Some people have been blinded by treatments in which they received injections of their own fatty tissue into their eyes. Since the turn of the year, the FDA has stepped up efforts to curb the activities of stem cell clinics, and in early May sought permanent injunctions through the US Department of Justice to stop two major clinics from operating.

The FDA's powers to crack down on purveyors of untested treatments may be weakened by Trump's new law. Scott Gottlieb, head of the FDA, voiced concerns about the draft act in evidence to a House of Representatives subcommittee last October. Key among them was a fear that the act would weaken the FDA's ability to prosecute companies or clinics violating the rules and ethical norms that govern its existing scheme allowing access to experimental treatments.

All of this could see people denied legal redress and the backing of the FDA when things go wrong. "The impact of the bill will be to undermine patient welfare by undermining FDA regulation," says Sean Morrison of the University of Texas Southwestern Medical Center, who monitors the growth of stem cell clinics. "It provides a path around FDA regulation, and there are lots of snake-oil salesmen out there just waiting for the opportunity to sell fraudulent therapies to desperate patients." ■

Star spinner

ARACHNOPHOBES, look away now. Pictured here in all its glory is the Tarantula Nebula – indeed this is the sharpest ever image of this vast cloud of hydrogen gas.

Around 160,000 light years away and more than 1000 light years across, the nebula dwells within the Large Magellanic Cloud, a dwarf galaxy that is a satellite of our own Milky Way.

Of course, the cosmic spider suspended at the top of the image is not weaving webs. Instead, the nebula's churning gas is slowly being spun into brand new stars. Its huge size makes it the brightest star-forming region in our galactic neighbourhood – so luminous that you can actually see it with just a pair of binoculars.

The picture was taken using the VLT Survey Telescope at the Paranal Observatory in Chile, with the aid of a filter designed to pick up the red glow of ionised hydrogen. This is created when radiation from new stars strips the electrons from hydrogen atoms.

Studying the distribution of ionised hydrogen will help astronomers understand the physics taking place within the Tarantula Nebula as stars form. Jacob Aron

Image
European Southern Observatory

ROBERTO CIGNA

How to keep the lights on without blowing the planet

Can we really get all our electricity from wind, sun and water by 2050, asks Peter Fairley

TO STAND any chance of halting runaway climate change, we need to squelch carbon emissions down to near zero by mid-century. That means getting off filthy fossil fuels – and fast. Few scientists would disagree with that, but there is precious little consensus on how to do it. Nuclear fission power is expensive and mired in controversy. Nuclear fusion, directly harnessing the kind of reactions that power the sun, remains a distant dream. Meanwhile, renewable energy is too unreliable to meet all our power demands.

Or is it? Clean energy technologies have come on leaps and bounds in the past decade or so. More recently, an impassioned debate has broken out among energy experts as to whether "100 per cent renewables" is now within our grasp and, if so, how we get there. "We can really mess this up," says Dan Kammen, an energy researcher at the University of California, Berkeley. "Just because we can make the shift doesn't mean we will." But the path we need to take – and the hurdles we face – are increasingly clear.

The renewables revolution has gathered momentum in recent years thanks to free-falling prices. And as clean becomes cheap, installation is surging. The world added 98 gigawatts (GW) of solar energy last year – more than any other energy source. Over half of that, 53 GW, was in China, which has long been the world's biggest consumer of dirty coal.

In California, the world's fifth-largest economy, renewables already provide over a third of electricity and will surpass 50 per cent well before 2030. Germany is aiming to get at least 80 per cent of its power renewably by 2050. Even oil and gas nations are setting ambitious renewables goals – the United Arab Emirates, for instance, plans to shift 44 per cent of its power to renewables by 2050.

That's great, but not enough. Tackling climate change requires more than just revamping the power grid. Converting services that currently run on fossil fuels, from transportation and heating to heavy industry, is also crucial. After increasing energy efficiency across the board, electrifying as many fuel-guzzlers as possible is the cheapest way to limit global warming to the target of 2°C above pre-industrial levels, according to the International Energy Agency.

That is a huge undertaking, and it is only just getting started (see "Electrifying!", page 28). Even if you just bring a few of the sectors that rely on burning fossil fuels onto the grid, the figures are daunting. Right now the world gets just a quarter of its electricity from renewables. In Europe, grid experts estimate that renewable generation must quadruple by 2050 (see "New generation", page 28).

Such a transition brings economic challenges. Renewables cost many times more to install than fossil generators, and workers will be dislocated as fossil industry jobs disappear. Low operating costs and reduced wholesale prices will also undercut the business case for flexible power sources, which means the way electricity is traded on the wholesale market will have to change. Ultimately, however, renewables deliver economically by slashing spending on fossil ›

fuel and avoiding environmental catastrophe, which hurts economic growth.

In 2015, Mark Jacobson of Stanford University took the bull by the horns, publishing a blueprint for shifting the US exclusively to wind, solar and hydro power by 2050 – not just for electricity, but for all of the country's energy needs. He and his colleagues calculated that it would require a 25-fold increase in renewable capacity over the next 35 years. They subsequently extended the award-winning roadmap to 139 countries, accounting for 99 per cent of global emissions.

Not everyone was convinced. Last summer, a group of researchers led by Christopher Clack, founder of a company called Vibrant Clean Energy, published a stinging riposte, arguing that Jacobson's plan rested on "implausible and inadequately supported assumptions". Jacobson sued Clack and the *Proceedings of the National Academy of Sciences*, which published the original paper and the rebuttal, for libel. He argued that the Clack pack's attack mischaracterised his modelling assumptions as errors, and that the journal had violated its own publishing rules. It didn't go down well. After taking flak for what many saw as an effort to stifle debate, Jacobson dropped the lawsuit in February.

What that spat and the whole 100-per-cent renewables argument really revolves around is one inescapable fact: the most abundant sources of renewable energy, namely wind and the sun, are capricious. The sun goes down, the wind drops, and seasons vary every year. The supply of renewable energy can plummet inconveniently just when local demand is peaking.

24.5 %

of global electricity production came from renewable sources in 2016

Source: Renewables 2017 Global Status Report, Renewable Energy Policy Network for the 21st Century

We can cope with that up to a point by tweaking today's grid. But the variability challenge really starts to bite when renewables exceed about 70 to 80 per cent, according to modelling by the Hawaiian Electric Company. Hawaii is the only US state that's already mandated to get to 100 per cent renewable power by mid-century (see "Success stories", page 30) – an ambition the company's vice president Colton Ching calls "big, hairy and audacious".

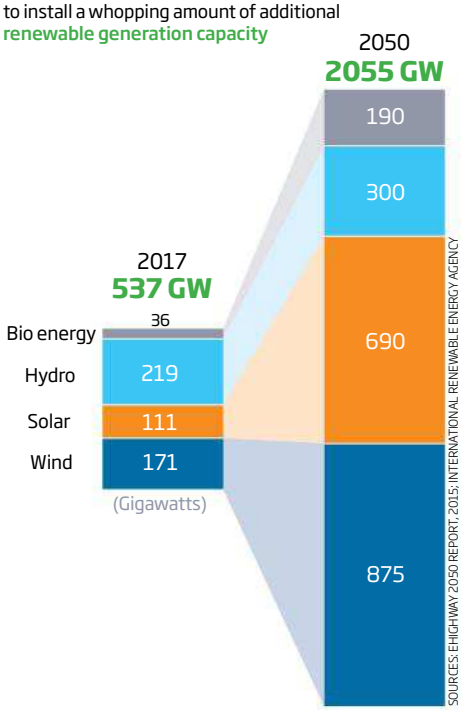
That's why Clack and some of his colleagues prefer not to rule out other low-carbon sources designed to produce power on demand: nuclear reactors and coal or gas generators that capture the CO_2 they produce. But both are punishingly expensive to build and operate and nuclear in particular enjoys precious little public support. "I was a nuclear-trained officer in the US Navy," says Doug Houseman, a smart grid expert who has consulted for more than 100 major energy companies. "I'm a big fan. But the political climate is such that the chances that we're going to be able to build sufficient nuclear [plants] are negligible."

For a growing number of energy companies, then, there is no option but to aggressively pursue 100 per cent renewables. "There is no future for anything that isn't renewable," says Ernesto Ciorra, the chief innovation officer at power and gas giant Enel. Everyone admits that it will be challenging. So how do we do it?

One way to deal with daily fluctuations in renewable energy supply is by finding clever ways to shift demand to take up surplus wind and solar when supply is running hot, and to defer consumption when it is not

New generation

To get 100 per cent of its electricity from renewable sources by mid-century, Europe is going to have to install a whopping amount of additional **renewable generation capacity**



SOURCES: EHIGHWAY 2050 REPORT, 2015; INTERNATIONAL RENEWABLE ENERGY AGENCY

ELECTRIFYING!

Getting 100 per cent of our electricity from renewable sources is a massive challenge (see main story), but it also creates an even larger carbon-cutting opportunity. The stuff we plug in today accounts for a measly one-fifth of global carbon emissions from energy. So if we're serious about deep decarbonisation, we need to plug a lot more into the grid.

Electrification looks relatively straightforward for cars. Electric motors move cars more efficiently than gas engines, and lithium batteries are becoming sufficiently cheap and durable. Sales of electric cars are already on an exponential upward curve, with China leading the way. Meanwhile, major economies such as France and the UK are doing their bit by banning petrol and diesel-fuelled cars from 2040.

Freight trucks, which produce over 7.5 per cent of US carbon emissions, are harder to plug in. Industrial processes that rely on burning gas are trickier still, since gas is a convenient way to deliver a lot of heat. But there's a solution: convert electricity to hydrogen gas and synthetic methane fuel.

For trucking in Europe, for example, subsidies a fraction the size of those that drove the ascent of wind and solar would make these "electrofuels" competitive with diesel by 2020, according to Jerry Murphy at University College Cork in Ireland. Heavy industry, including the steel plants that spew out 7 per cent of global carbon emissions, could run on hydrogen, too. In fact, Swedish steelmaker and energy company Vattenfall is designing the world's first steel plant powered by renewable hydrogen.

Electrification is a mammoth task. But recent progress in China, the world's biggest carbon polluter, is encouraging. Between 2000 and 2016, electricity's share of total energy there doubled from 11 to 22 per cent, and it will exceed 50 per cent by 2050, according to Shu Yinbiao, chairman of the State Grid Corporation of China.

(see "Managing expectations", page 31). The other way to cope, of course, is simply to stockpile the surplus so we can use it when demand peaks.

Supercharged batteries such as the sprawling lithium-ion facility Tesla recently installed in Jamestown, Australia, are the most obvious option. Boasting a capacity of 100-megawatts, this is the world's most powerful battery, for now at least. It can power up to 30,000 homes – albeit just for an hour.

In fairness, the Tesla battery was built as backup for South Australia, which has suffered a series of recent blackouts. Even so, its limitations go to show that although batteries could plausibly hold enough juice to cope with day-to-day peaks in demand, their cost makes them a prohibitively expensive answer to monthly and seasonal fluctuations, which are by far the biggest block in the road to 100 per cent renewables.

Pumped up

We don't yet have devices capable of storing several months' worth of renewable energy at a reasonable price, which is what we will need. But some well-tested solutions can take us a long way, and we have a raft of more innovative options that could be scaled up.

One trusty storage technology capable of doing a lot more is hydropower. Hydro reservoirs are giant reserves that store rain and meltwater, ready to be released through energy-generating turbines when demand peaks. Some hydropower plants can also use excess off-peak energy to pump water back uphill, where it recharges the reservoir, ready for another run through the power turbines. This pumped hydro technology accounts for the vast majority of global electricity storage and yet there is plenty of room to grow.

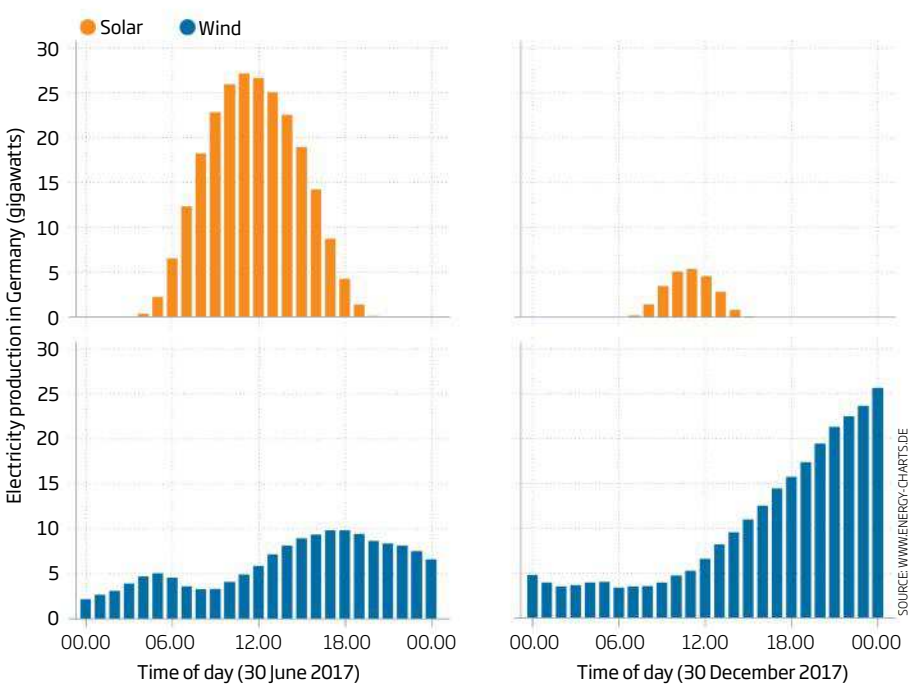
No wonder it's back in fashion big time in some parts of the world. China more than doubled its pumped hydro capacity over the last decade and is in the process of more than doubling this again. Technology upgrades, meanwhile, are letting places that lack hilly geography or plentiful fresh water get in on the act. Australia, for instance, is evaluating a massive coastal plant to store power by raising seawater from Spencer Gulf to a reservoir 260-meters above sea level on the adjacent plateau.

But tapping hydropower for storage is complicated by other environmental concerns. Most of the water that drives the power-generating turbines must also sustain river ecosystems, irrigate crops and ›

ISTOCK / GETTY IMAGES PLUS

Intermittent power

Solar and wind are the most abundant sources of renewable electricity, but they are also the most variable, as 2017 data from Germany shows



PETRAS MALUKAS/AFP/GETTY IMAGES

SUCCESS STORIES

While more and more places are setting ambitious clean energy targets, some countries are already operating power grids with close to 100 per cent renewables. Typically, their success is down to geography. But other factors are at work too.

Costa Rica and Norway owe their successes to a rich supply of hydropower, the result of mountains and plentiful rain. Volcanic Iceland is doubly blessed with hydropower and geothermal energy. The real renewable growth leaders to watch, however, are the less geographically well-endowed countries that are nevertheless speeding forward. The cultural and political factors driving their energy transitions offer important lessons.

Denmark has boosted its wind power supply from under 5 per cent of electricity in 1990 to over 40 per cent today, and is heading for all-renewable power and heating by 2035. Much of the credit for their accelerated transition belongs to a strong "communitarian" ethic that encompasses environmental protection, says Benjamin Sovacool at the University of Sussex, UK. He says that a long-held consensus on climate change underpins stable long-term energy policy to address it.

Hawaii is the only US state with a mandate to reach 100 per cent renewables. The high cost of imported petroleum moved things along. But so has the fact that Hawaii, like Denmark, has a relatively small and cohesive population. "We tend to all know each other," says Colton Ching of the Hawaiian Electric Company. "That smallness allows us to make decisions, be nimble, and agree to things that would be much more difficult in a larger state." And maybe there is a lesson in that for larger and more diverse jurisdictions: work harder to forge consensus.

slake the thirst of cities. Then there's the need to flood tracts of land for reservoirs, often displacing settled communities.

Perhaps the most promising alternatives are rapidly improving techniques that convert surplus electricity into combustible hydrogen, methane or even synthetic diesel – fuels that, unlike electricity, lend themselves to bulk storage. Power to Gas (PtG), as it is known, begins by using electricity to split water into hydrogen and oxygen. The energetic hydrogen gas can then cleanly fuel cars and trucks or fire-up industrial boilers.

A limited amount of hydrogen can also be compressed and fed into gas pipeline networks and their large storage sites, ready for delivery when demand peaks. The hydrogen can even be reacted with CO_2 to produce renewable methane, which could replace fossilised natural gas altogether.

Unlimited storage

In a world brimming with depleted gas fields, the storage potential is essentially unlimited. Ireland's gas distributors already keep several weeks' supply on hand by injecting natural gas into the depleted Kinsale gas field off shore from Cork, says Jerry Murphy, a bioenergy researcher at University College Cork. There is no reason we can't take advantage of similar sites to store renewable gas.

PtG remains an emerging technology, and some experts dismiss it because hydrogen electrolysers – the devices that use electricity to split water – are less energy efficient and several times more expensive than batteries. Then again, others think this may be misreading the economics of long-term power storage. Battery costs explode as you multiply the amount of energy to be stored, says Ken Dragoon, who runs Flink Energy Consulting in Portland, Oregon. You have to buy twice as much battery capacity to store twice as much energy, whereas with electrolysers, doubling the gas produced from surplus power simply means operating the same equipment for twice as long. "At some point it becomes cheaper to use the electrolyser," says Dragoon. The amount of storage needed for a 100 per cent renewable energy system is way beyond that economic crossover.

These sorts of solutions could overcome short-term variations in renewables' generating capacity over hours or days, and even take some of the strain from inter-seasonal variability. The rest will require a different approach: rather than hoarding electricity locally, share it widely. After all, the wind is always blowing somewhere, and where it's not there may be sunshine. If you can zap enough wind and solar power from one place to another, you need less on reserve. That will require continental supergrids that move power more efficiently than we do today.

The technology exists: unlike conventional AC power lines, where electricity flows near the surface of a power line, high-voltage direct current (HVDC) transmission uses its full cross-section and thus encounters less resistance along the way. It can transmit big power without big losses over thousands of

High-voltage power lines, like these linking Poland and Lithuania, counter renewables' reliability problem

kilometres, and it can do so whenever we are ready. Continental supergrids can be built as soon as the power companies give the green light, says Rajendra Iyer, at General Electric's HVDC business unit. "The DC grid solutions are there. They can be deployed any time."

They already are in China, which has built a series of massive lines to supply its coastal megacities. This year, the State Grid Corporation of China expects to deploy its first 1,100,000-volt DC technology: a 3324-kilometre line capable of carrying 12 GW, roughly half of Spain's average consumption, that will put idled wind and solar farms in China's north-west back in operation. This "ultra-high voltage" tech also underpins its proposal to create a global supergrid that would make renewable energy relatively steady, cheap and bountiful. Imagine solar power from the Sahara available across Asia and Europe and you get an idea of China's ambition.

It sounds like a no-brainer. For inter-continental supergrids, however, the challenges are geopolitical and cultural. Nations must be willing to place their trust in imported energy – not so different from today's dependence on oil and gas produced in only a few parts of the world, but also not a minor complication at a time of increasing international tension. The discord that delayed the Nord Stream gas pipeline from Russia to Germany, and which now plagues its sequel, foreshadows the geopolitical hurdles facing supergrids.

The other barrier is public resistance. Opposition from communities that new DC power lines would traverse is one of the main reasons why Europe's transmission operators have, to date, stopped short of planning a continental supergrid.

Europe can probably get by without one. A technical study called the eHighways 2050 project, completed in 2015, suggests that Europe could shift to 100 per cent renewable power by expanding links between neighbouring countries rather than sending long lines across them. But foregoing a supergrid may raise energy costs, and even the smaller links Europe is planning face concerted local opposition. In 2013, Germany's grid regulator approved a trio of HVDC links to balance North Sea wind power against solar energy from southern Germany. Grid operators vowed they would be ready before the last nuclear power plants in the country shut down, planned for 2022. But under public pressure the German government dictated the power cables should run underground, delaying the project until at least 2025.

71 %

of energy experts surveyed in 2017 agreed that getting all of our electricity from renewables is realistic

Source: Renewables Global Futures Report, Renewable Energy Policy Network for the 21st Century

That sort of conflict, together with the technical and economic challenges for both super-charged storage and supergrids, makes the shift to 100 per cent renewable power seem daunting in the extreme. Yet many scientists are more optimistic than ever. Jacobson remains bullish, and others see change in the wind too. "This is no longer just people like me who have been arguing for a renewable future for a long time, but also sceptics and more real-world focused engineers who thought it was a fiction," says Kammen, who was among the authors on the paper criticising Jacobson's blueprint.

The real question, they say, is not whether we can get to 100 per cent renewable energy, but whether we will do it in time. Moving fast means saying no to new fossil fuel generators, accelerating renewable installations, sustaining innovation to continue cutting storage and transmission costs and rethinking power markets.

As Jean-Baptiste Paquel, senior advisor for ENTSO-e, the Brussels-based consortium of European grid operators, says: "If you want to make this change and make it affordable, you need to push for all of these solutions." ■

Peter Fairley is a freelance energy and environment writer based in Victoria, Canada

MANAGING EXPECTATIONS

The inherent fickleness of weather-driven energy poses a big challenge for electricity grid operators, which must continuously balance supply and consumption. This will only get harder as more of our electricity comes from renewables. How will we manage steep drops in supply without today's go-to source of flexibility, the carbon-belching natural gas turbines that ramp up and down at will?

The cheapest bet is a strategy known as demand management – manipulating energy demand at certain times to keep the grid in balance. Operators such as the National Grid in the UK already incentivise businesses to trim their usage at times of peak demand or ramp it up when supply is surging. But the process is growing increasingly sophisticated. These days, smart meters and machine learning techniques are enabling grid operators to deftly tweak the growing number of residential devices linked to the web. In future, myriad appliances will be automatically activated when renewables are running hot and dialled-down when they are not.

The trick is to make demand management work for consumers, says Lindsay Anderson at Cornell University in Ithaca, New York. That means not only tweaking loads intelligently to avoid inconvenience, but also crafting rates that reward the use of renewable energy. "A lot of it can actually be invisible to the consumer while being a huge benefit to the grid," she says. "We have the technologies that we need. We just have to use them in creative ways."

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ON THE ORIGINS OF WHITE NATIONALISM

What motivates far-right extremism? Sociological studies are giving new insights and ways to tackle the phenomenon. Peter Byrne investigates

TIM ZAAL hurt a lot of people in his time: blacks, Mexicans, gays. Strung out on drugs and propaganda, he fitted the toes of his engineer boots with razor blades, all the better to kick the scum and save the white race.

Zaal has since recanted, but others continue to follow in his bootsteps. After decades largely under the radar, race-based violence and extremism is back in the news. In June 2015, white supremacist Dylann Roof killed nine black worshippers at a Methodist church in Charleston, South Carolina. In August 2017, the Unite the Right rally in Charlottesville, Virginia, saw youths on the streets giving Nazi salutes, and one counter-protestor killed,

SAMUEL CORUM/ANADOLU AGENCY/GETTY

deliberately mown down by a car.

It's not just in the US. In June 2016, British politician Jo Cox was murdered by a white nationalist. Last November, tens of thousands rallied by torchlight in Warsaw, Poland, waving banners that advocated deporting refugees and making Europe white again, while chanting "Sieg Heil" – in the once-Nazi-occupied land where Auschwitz was built.

For most, the motivations of such hate seem unimaginable. But pioneering work in the US is beginning to reveal its roots. What it is uncovering turns a conventional view of terrorist motivations on its head – with implications for how all societies should deal with the phenomenon.

The Unite the Right rally in Charlottesville, Virginia, in August 2017 brought together groups from across the far-right political spectrum

IT IS a cold night in January, and I'm eating hamburgers with Zaal in a mall restaurant at the border of Orange County and Los Angeles. A big, affable man in his early 50s, he talks easily about his life as a violent white supremacist during the 1980s and 1990s. Also at the table is Pete Simi, a sociologist at Chapman University in the city of Orange who researches white supremacist extremism.

Simi first met Zaal when he disengaged from organised racism at the turn of the millennium. Since then, Simi has interviewed Zaal about his life history, as he has done scores of active and former far-right extremists. The two have common acquaintances, and casually drop names. "Did you know that so-and-so is dead?"

White supremacism has a long tradition in the US. From the 1860s, after the southern Confederate states lost the US civil war, white workers found themselves competing with freed slaves for economic resources and social status. The backlash was often murderous: thousands of black men, women and children were lynched, shot, stabbed, tortured and burned alive, and their property often expropriated with impunity. Racial segregation was the law of the land, not just in the agrarian south, but also in the industrial north as millions of black people fled the cotton fields for factory ghettos. By 1925, membership of the Ku Klux Klan approached 6 million, ›

about 5 per cent of the US population.

Orange County is best known as the home of the Disneyland theme park. Its affluent suburbs were long a bastion of old-school Republican conservatism. Richard Nixon was born there and it is where Ronald Reagan kick-started his political career. Until the 1970s, the county was almost exclusively white, before African-American, Hispanic and Asian incomers changed its complexion.

Like similar places nationwide, Orange County became a centre of a small but hardcore white supremacist backlash. Zaal viewed himself as a patriot fighting against a Jewish-orchestrated plot to commit genocide on the white race. "We saw it as doing what police wouldn't do," he says. "We were cleaning up our neighbourhoods of the scum."

Just days before I met Zaal, white supremacist Samuel Woodward was charged with stabbing to death a Jewish gay man called Blaze Bernstein, whose body was found buried in an Orange County park. Woodward has pleaded not guilty to the charge. The murder was cheered online by Woodward's comrades in the neo-Nazi group Atomwaffen Division.

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IN THE wake of the Unite the Right rally in Charlottesville, counter-terrorism expert Erroll Southers at the University of Southern California wrote an opinion article for *USA Today*, which linked the violence to Donald Trump's racialised rhetoric. The next day, someone shot out his front door.

JASON ANDREW/GETTY

Members of the Rise Above Movement join the rally in Charlottesville

Bottom right: A rally in Shelbyville, Tennessee, in October 2017

Southers is black. A retired FBI agent, he teaches courses on homegrown terrorism to law enforcers. "White nationalists are a greater threat to Americans than jihadists," he says.

The Anti Defamation League reports that in the US, white supremacists were responsible for 18 of 34 terrorist murders in 2017. Seven of the remaining 16 were anti-government extremists, leaving nine tied to Islamist terrorism. Since 2002, there have been three times as many deadly far-right terrorist attacks than jihadist attacks in the US, although the jihadist attacks have claimed more victims overall, reports the New America Foundation.

In the UK in the year to March 2017, right-wing extremists made up around one in six of over 6000 referrals to the country's counter-extremism programme, Prevent, and almost 40 per cent of 332 people entering Prevent's "Channel" process, which supports individuals considered vulnerable to be drawn into terrorism. In February this year, police said that they had foiled four far-right terrorist plots in the UK in the previous 12 months.

In the US, the Southern Poverty Law Center, which monitors hate groups, has catalogued more than 600 active neo-Nazi and white supremacist groups and hundreds of anti-government militias that either have a stated intention to overthrow liberal democracy or historically engaged in armed struggle.

Southers sees similarities between the white extremist and Islamist terrorists: both fit the prevailing notion among researchers that most terrorists are not psychopaths, but relatively typical people motivated by circumstance to protect their "in-group" from dangers, real or imagined. "Given their belief systems, both types of terrorists are acting rationally," he says. "Most terrorists are 'altruists' who view themselves as soldiers fighting for a noble cause." The calling to enact political change precedes the calling to violence: the ends justify the means.

Simi's research suggests that is not the whole story.

• • •

SIMI and I are hiking with "Chuck" (not his real name) on a rocky beach north of San Diego. Chuck is a 50-year-old electrician who used to advocate Christian Identity, the idea that white Europeans are the lost tribe of Israel.

As an adolescent, Chuck listened to white power punk, hung out with swastika-tattooed neo-Nazi bikers and was into weed, amphetamines, LSD, magic mushrooms and alcohol. He was discharged from the US Navy after he was sentenced for assaulting a Mexican man – for being Mexican, he adds.

On release from prison, Chuck joined the San Diego branch of the Hammerskin Nation, an ultra-violent neo-Nazi group with international branches. He ran in the same head-

WHAT MAKES A RACIST?

Pete Simi's research among former white supremacists has shown that many experienced childhood emotional trauma and are predisposed to crime. Of the 103 people he studied

- Half report witnessing serious acts of violence growing up
- Half report experiencing physical abuse during childhood
- One-quarter report being sexually abused during childhood
- Half report being expelled or dropping out of school
- Three-quarters report a history of physical aggression before they got involved in far-right politics
- Half report exposure to parental racism
- More than three-quarters report parental divorce
- Half ran away from home during childhood or adolescence
- Half were shoplifters or petty criminals
- Slightly less than half report a family history of mental health problems
- Two-thirds report substance abuse issues
- Two-thirds report attempting suicide

slamming circles as Zaal, but he was more enamoured of the cross than the swastika. "I did not consider myself to be a national socialist, but a Christian patriot ready to start a race war and take the country back from the Jewish communists."

As Chuck grew older, raising a family, he began distancing himself from violent extremism. There was no blinding light, just a fading of interest until one day he no longer believed in a world conspiracy. He has been active with Life After Hate, a group that offers "off-ramps" and counselling to far-right extremists who want to heal.

Simi has a professional background in mental health assessment. His interviewees start by talking about themselves in an unstructured way, to uncover their life priorities and emotional impulses. This is followed by more structured, factual questioning about past events, which probes subjects' emotional motivations. It is rare to get such an insight into the minds of those who hold these kinds of extreme views. When terrorist suspects are interviewed about their pasts it is usually by intelligence and police agencies, often in prison and with a focus on ideology and operational methods.

Simi and his team record the emotions associated with events the subjects mention such as family traumas, hurting people, or joining or leaving a violent group. They can then determine the intensity of pleasure or pain the events evoked, as revealed in the language used. The results are digitised for statistical analysis to uncover the extent of shared motivations between the people he interviews. The aim is to avoid fitting the data to pre-existing theories of causes and effects.

The first results from this programme were laid out in 2016, in a 260-page paper from the National Consortium for the Study of Terrorism and Responses to Terrorism (START), principally authored by Simi, with the title "Recruitment and Radicalization among US Far-Right Terrorists". The analysis revealed that white extremists, while not necessarily psychopathic, are often violent before they join extremist groups. Only after joining are they generally schooled in ideologies that justify channelling pre-existing urges into violence towards Jewish people, non-white people and anti-racist groups. The ideology is the excuse for ultra-violence, not the reason. "Far-right ideologies channel a pre-existing need to express violence by narrowing the selection of victims," says Simi.

That insight challenges thinking on the origins of extremism, says ethnographer Kathleen Blee at the University of Pittsburgh, Pennsylvania, whose research focuses on female white supremacists (see "Women of the right", page 39). "It shows that the embrace of those really terrible ideas could be a consequence of an immersion in the culture, rather than the cause of an attraction to the culture," she says.

Simi's analyses tease out the possible driving factors. About 80 per cent of his interviewees have experienced childhood traumas: violence, sexual abuse and broken homes (see "What makes a racist?", left). Many had horrible, shame-filled childhoods that morphed into lonely, self-hating adulthoods. White power groups can provide angry loners with a sense of pride in community and conveniently dehumanised targets to blame. White supremacist propaganda is filled with references to collective shame related to feelings of cultural, racial and economic dispossession, from the Confederacy's defeat in the civil war to the election of Barack Obama as the first non-white US president. ›

SCOTT OLSON/GETTY

Verbatim quotes from Pete Simi's interviews with current and former white supremacists

"I believed I was doing something noble, altruistic, that I was dedicating my life to my people, to my race… It wasn't like, 'Hey, I'm a hater and I'm proud of it'."

(Donald, White Aryan Resistance)

• • •

"We're here to defend God and defend the people… not oppressing or taking over."

(Callie, American Front)

• • •

"Fighting is a lot like a hug. It makes you feel good… It's always been that way. Ever since I got the s* beat out of me as a teenager."**

(Stanley, United Society of Aryan Skinheads)

"It wasn't about the racism… I knew the whole time that it wasn't right… But to be accepted, to feel like I belonged…"

(Kevin, Blood and Honor)

• • •

"It was more fashion than politics by a huge factor."

(Jacqueline, Society Skin Nation)

• • •

"You're running by yourself in the streets. It's the camaraderie that draws you in, at first. And then once you see what's really going on in the world politically… you're like, well, now, I've got something to believe in, something to defend, the white race! You feel invincible even when you are getting all beat to s* by cops or anti-racist skins."**

(Logan, Public Enemy No 1)

"The behavioural problems represent lives spinning out of control," says Simi. "Resorting to violent extremism can be a coping mechanism for these people. They are drawn toward violent extremist groups for non-ideological reasons, for shelter, protection, a sense of family."

As happened with Chuck. His parents, he says, were pot-smoking hippies who failed to recognise that the male babysitter was sexually molesting him on a regular basis. "I just kind of buried that, and it turned into shame and then anger and then self-hatred that got projected onto the world."

The sun sets and he rides away on his motorcycle. "Most of these guys are not crazed lunatics," says Simi. "But neither are they socially or psychologically healthy. They carry invisible scars."

JASON ANDREW/GETTY

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SOCIOLOGICAL research on extremists is difficult to design. Researchers cannot advertise for "Nazis" or "violent white supremacists" to join a scientific study. Simi developed his volunteer cohorts of active and former extremists by gaining the trust of his often-paranoid subjects one interview at a time. Interviewees then suggested others for him to contact in a method called "snowballing".

This is not a randomised process. It is subject to ethical review by institutional boards, and Simi's studies are required not to cause harm to his subjects. His studies of individual life histories differ in method and level of detail from his previous real-time, ethnographic observations of active white supremacists.

Starting in the mid-1990s, Simi was a guest in the noose-draped homes of white extremists for days and sometimes weeks. He attended white power music festivals in the wilds of Idaho and birthday parties in honour of Adolf Hitler, encounters detailed in a 2010 book, *American Swastika*, co-authored with sociologist Robert Futrell. Simi's entry ticket was an easygoing demeanour, an ability to drink lots of beer and the colour of his skin.

White power families can seem like any other from the outside. They live in suburban homes, mow the lawn, do run-of-the-mill jobs. But the Christmas tree is often topped with a swastika, not a star. They give their kids racist colouring books. They rally around burning crosses, an ancient Scottish war signal. Armed with automatic weapons, they train to exterminate non-white people.

Some of Simi's field subjects had been convicted of attempted lynchings, aggravated assaults and murder. They would happily have stomped him if they had smelled a rat, he recalls. He made a point of identifying himself upfront as a scientist studying their culture, appealing to vanity, perhaps. Not everyone was thrilled by his presence; he did not pretend to agree with racist politics. But he didn't argue with his hosts either, or ask the wrong kind of questions about weapons or criminal acts. He kept conversations tracked on cultural and ideological issues, while observing the interplay of relationships in the environment.

In the late 1990s, Simi spent time with an itinerant Hammerskin musician named Wade Michael Page. He had been recruited into organised racism while in the US Army after the first Persian Gulf war. Years later, in 2012, Page gunned six Sikhs to death at a temple in Oak Creek, Wisconsin, before being killed by police.

Simi didn't see it coming specifically, he says, but he was not shocked. The bass guitarist had many risk factors for violent behaviour, including chronic depression, alcoholism and suicidal ideation. Adding in white supremacy proved to be a recipe for terrorism.

Anti-fascist campaigners in Charlottesville

But not every white supremacist with these risk factors opens fire on a minority church congregation, or points their car at an anti-fascist protester and accelerates. "The idea of predicting something as complicated and as rare as terrorism is just not realistic," says Simi. Terrorism is primed when an emotionally damaged person meets the wrong people in the wrong place at the wrong time.

• • •

ZAAL did jail time for his violent deeds, and now regularly tells the story of how he deradicalised at the Los Angeles Museum of Tolerance.

But the Charlottesville march triggered something deep inside him. The chant "Jews will not replace us" horrified most people. For a moment, Zaal thrilled at the prospect that the revolution might finally be on. "Such momentary relapses are not uncommon," says Simi.

In 2017, Simi and Blee, together with colleagues Matthew DeMichele and Steven Windisch, presented a study of 89 former white supremacists in *American Sociological Review*. They wrote that "the habitual and unwanted thoughts, feelings, physiological responses, and behavior that can follow exit" from active status mirrors the effects of withdrawing from opiate addiction. It may be no coincidence that, as Simi's earlier studies showed, many white supremacists are also substance abusers: the reward of hate may be dopamine, too.

In an unpublished pilot for a future study, Simi and collaborators at the University of Nebraska and the National Institutes of Health have taken fMRI and EEG scans of the brains of five repentant white supremacists and a control group of five mixed martial arts fighters whose brains were likely to show similar signs of trauma.

The volunteers were shown symbols and images designed to be neutral or to activate the former white supremacists' previous identity and ideological orientation. The experiment found significant activation in the emotion processing regions of the brains of the former white supremacists in response to racially charged images, such as of an interracial couple. No such regions were activated for the control group. The researchers conclude that "the inherent racial bias in former white supremacists happens before more active cognitive processing".

In her 2002 book *Inside Organized Racism*, Blee observes that, "The mainstay of any substantial racist movement is not the pathological individual but rather a pathological vein of racism, intolerance, and bigotry in the larger population that the movement successfully mines". Unconscious bias towards protecting our in-groups is a natural, evolutionarily adaptive feature of the human psyche, and the wellspring of racism. Shortly after the violence in Charlottesville, an ABC News/*Washington Post* poll reported that 9 per cent of adults in the US surveyed, equivalent to about 22 million people, said it is acceptable to hold neo-Nazi or white supremacist views.

In a roundabout way, that answers the question why only very few people with horrible childhoods and other risk factors for violence end up kicking people with razor-blade-tipped boots: they are the extreme values in a Bell curve that covers all forms of social racism. That provides at least some handle on how to counter the problem, both through tackling childhood trauma and rooting out racism in society as a whole.

For Zaal, the path out of his addiction to hatred opened up unexpectedly after he became a parent. "I was with my 3-year-old son at a grocery store. And he says, 'Look, Daddy, there's a big – and he dropped the 'n' bomb in the store. The black guy just walks away, shaking his head. But all of these little white ladies are screaming and hollering at me, I mean old ladies. 'Oh, how dare you! How dare you teach your child these things!' And my son looks up at me and says: 'Aren't you going to beat them up, Daddy?'. That was my moment of clarity." ■

Peter Byrne is a journalist based in northern California

WOMEN OF THE RIGHT

White nationalism is often portrayed as a male affair. But while most white supremacist organisations hold that God created women to cook, clean the house and make babies, that doesn't mean they are wall flowers, says Kathleen Blee of the University of Pittsburgh. Male leadership in white nationalist organisations is often dependent on the adoration of followers. Female influence is more informal, indirect and personal – and so potentially more effective, she says.

Researching her 1991 book *Women of the Klan: Racism and gender in the 1920s*, Blee found that millions of middle-class white women, including suffragettes, joined the Ku Klux Klan. The Klan supported voting rights for white women to diminish the electoral power of non-white people.

It is a pattern repeated among women Blee has interviewed who are involved with today's white power skinhead, Christian Identity, neo-Nazi and Ku Klux Klan groups. Most of them are educated, middle class and were raised in relatively typical families. Ideology is not the primary attraction for joining what many initially view as a social club, a place to have fun.

Some women find the violent images of racist culture to be personally empowering. "It gives them a feeling of mastery and of female potency, however illusory, that they rarely find in other social settings," says Blee. Once inside an organisation, women are socialised to adopt the idea that white people are at risk of extermination and must fight back (and produce more babies) before it is too late.

"The racist movement can construct an ideology of extraordinary racism by using dystopian themes from everyday discourse," says Blee. Take a seemingly race-free slogan such as "family values are under attack". What distinguishes this sentiment in the mouths of extremist women is not the belief that the family is dying, but who they believe are responsible for its downfall: Jewish people, black people, Mexicans, gay men, lesbians and liberals.

Buzz off

Bees are not only remarkably smart, but are capable of emotions similar to our own, finds **Richard Schiffman**

AS YOU watch a bee bumbling about on a summer's day, you might assume nothing special is going on. We have come to accept that these humble insects are little more than mindless drones buzzing around on the autopilot program of biological instinct. We presumed that they lacked individuality and simply slaved mindlessly for the larger purposes of the hive.

But, under the close scrutiny of imaginative scientists, we are now learning that bees actually have unique personalities that enable them to solve problems, make choices and react in ways that look suspiciously like human emotions. "Bees are capable of behaviour that rivals in complexity that of some simple mammals," says Andrew Barron at Macquarie University in Sydney, Australia. All with a brain the size of a mustard seed.

We have known for decades that bees working collectively are capable of great things – not least symbolic language in the form of their waggle dance, which they use to share information about the location of food sources.

Then findings started trickling in that showed individual bees deserved more credit. They can follow intricate rules, distinguish between patterns in nature, sort sensory stimuli by shape and colour, and even have a rudimental ability for mathematics. But in the past few years apian skills have been shown to have truly mind-boggling complexity.

To test the limits of bee abilities, Olli Loukola and his colleagues at Queen Mary University of London recently taught bumblebees to roll small plastic balls into holes to win slurps of sugary water. Soon, the bees were devotedly operating the miniature vending machines, frequently finding shortcuts to the sweet prize – some even walked backwards, a behaviour that isn't natural to them. In another experiment, bees were trained to pull strings to release tasty rewards.

The string study, published in 2016, was arguably the first evidence of tool use in invertebrates, an ability previously reserved for birds and mammals, particularly primates. Other research has found that bees in the lab will only attempt a certain task if they have all the requisite information, implying a rudimentary form of metacognition.

They are also expert navigators, according to Joseph Woodgate, a behavioural ecologist also at Queen Mary University. "Like travelling salesmen, bees need to move between a large number of flower patches in the most efficient route possible," he says. By attaching miniature transmitters to bees and tracking them with radar, he recently found that his subjects not only remembered where they had previously been, but also flew shorter, straighter paths as time went on. This demonstrates that they are constantly learning from the environment and innovating, rather than simply mechanically repeating themselves.

Findings like these have astounded biologists, who once assumed that bees resembled genetically programmed bots

Angry? Perhaps, if the latest findings are anything to go by

driven by instinct and incapable of solving problems or learning new skills.

Still, perhaps the biggest surprise regarding apian intelligence was the finding that the inner lives of bees are governed by complex feelings – mental states that are in some ways similar to human emotions like discouragement and contentment.

Feeling brave

In humans, feeling happy makes us respond more positively to ambiguous situations. To see if this happens in bumblebees, researchers gave sugar water to some bees but not others before they were set free to forage. Those that received the syrup were more likely to seek out unknown sources of food.

Further tests confirmed the bees weren't simply feeling more adventurous thanks to a sugar high. Instead, the unexpected reward appeared to trigger a hit of the neurotransmitter dopamine, which – as it does in humans – left the bees in a more positive state of mind. Those that supped on sugar were also braver, venturing out sooner after scientists simulated a predator attack.

Lead author Clint Perry of Queen Mary University won't go so far as to assert that the adventurous bees were "happy" – a state that is hard enough to define in ourselves. But other research backs up the idea that bees have feelings too. Melissa Bateson and her colleagues at Newcastle University, UK, showed that vigorously shaking bees to mimic a predatory attack made them – in her words – "more pessimistic" and less likely to risk trying novel nectars, whose odours they didn't recognise.

The question of whether animals have human-like emotions is extremely controversial, making some scientists reluctant to state that bees have similar feelings to us. But even though bees can't fill out surveys to report on their levels of contentment, it would be surprising if they lacked at least equivalents of emotional states, says Perry. "The reason why emotions likely evolved is to help organisms make better decisions," he says. An animal that couldn't feel something like fear when confronted with danger, or go-getter enthusiasm when food is plentiful, would have poor long-term prospects for survival.

And while it is unlikely that bees need to unburden themselves to their mates after a long day's slog in the meadows, Perry thinks there may be other ways in which, just like in human society, apian emotions prove themselves useful for the social cohesion of the group. "Each species evolved emotions for its own specific purposes," he says.

"Bees may help us with the most intractable problems of the human mind"

Together these findings suggest that bees are at the forefront of insect cognition. Even more remarkable, the feats they have pulled off are normally associated with the largest and most recently evolved part of the human brain, the neocortex, which the minuscule bee brain lacks. This has left some neurologists scratching their heads about how insects solve problems we once thought required our own "higher" centres to crack.

"When it comes to brains, there is clearly more than one way to do things," says Barron. For instance, animals like bees that lack a prefrontal cortex, the part of the neocortex involved in planning, aren't restricted to the grey stuff in the head, Barron points out: they can process information in bundles of nerve cells in other parts of their body.

As we learn more about bee brains and how they work, Barron thinks we will gain fresh insight into our own cognitive and emotional processes. Bees may even help with some of the most intractable problems of the mind, such as how thoughts get processed in the brain.

"There are so many things going on at once within our central nervous system at any given moment that it can be tough to trace out what precisely is happening," says Barron. But with bees' stripped-down nervous system, the pathways are much clearer and easier to chart. "By studying their far simpler system, we will learn a lot about how our own more complex brain works as well as how it evolved," he predicts. That's something to make a buzz about. ■

Richard Schiffman is a freelance writer based in New York City

Time to say goodbye?

The backlash against social media is dissected in a series of new books. But do they provide any answers, asks **Nina Jankowicz**

JIM WEST / ALAMY STOCK PHOTO

Antisocial Media: How Facebook disconnects us and undermines democracy by Siva Vaidhyanathan, Oxford University Press
The People vs Tech: How the internet is killing democracy (and how we save it) by Jamie Bartlett, Ebury Press
Ten Arguments For Deleting Your Social Media Accounts Right Now by Jaron Lanier, Bodley Head
How Democracy Ends by David Runciman, Profile Books
How Behavior Spreads: The science of complex contagions by Damon Centola, Princeton University Press

THE past two years have resembled an especially bad hangover for the social media industry. For so long, it threw the most popular parties, and was showered with praise for its many contributions to society. But in late 2016, the party ended. Rumpled and groggy, social media awoke to a flat strewn with the remnants of revelries past. Guests accused their host of crimes it didn't remember committing, and, worse still, of violating their trust. They threatened not to attend future parties if things didn't change.

Gone are the halcyon days of the early 2010s, when Facebook and Twitter took credit for the activism of the Arab Spring. The industry's collective problems – from foreign interference in elections to privacy scandals – seem to balloon by the minute, to the point where Silicon Valley is implicated in the downfall of democracy itself.

Siva Vaidhyanathan, professor of media studies at the University of Virginia and author of *The Googlization of Everything*, argues in his latest book *Antisocial Media* that Facebook has made its users less deliberative. Jamie Bartlett, director of the Centre for the Analysis of Social Media at the think tank Demos, concurs. Writing in *The People vs Tech*, Bartlett argues that social media is destroying our free will, encouraging tribal politics, bolstering support for populists and interest groups, siphoning capital from the middle class and expanding monopolies.

AMESY/GETTY

In a scholarly work that could have done with a little more signposting, Vaidhyanathan concludes that without significant and sweeping reform, including coordinated international pressure, Facebook's problems are unsolvable. Its failings are in its ubiquity and its size, and therefore its lack of control over user-generated content. In short, Facebook's problem is itself.

Bartlett discusses the use of technology by Donald Trump's presidential campaign (though Barack Obama's campaign pioneered many of these techniques), then presents an exhaustive menu of policy prescriptions to rebuild the crumbling pillars of democracy. Considering the reticence of social media companies to reform and the fraught state of governance across the West, it reads like a wish list for a techno-political utopia.

More doable, perhaps, is the simple solution presented by Silicon Valley insider and virtual reality innovator Jaron Lanier in *Ten Arguments for Deleting Your Social Media Accounts Right Now*. Lanier labels social media platforms "BUMMERs", on which "Behaviors of Users [are] Modified and Made into an Empire for Rent". Because the BUMMERs are so entrapped by their business model, which depends on them using everything they know about us to serve up highly targeted advertisements, he argues that the companies are unlikely to change without an outside push – namely decreased engagement on their platforms.

His most convincing case for account deletion is that social media deprives discussions of context and limits our capability to connect to others. It brings out the worst in human nature, privileging the snackable and sensational and demoting the nuanced and empathic.

"Facebook's failings are in its ubiquity and its size, and thus its lack of control over user-created content"

Ten Arguments is more compelling than the many similar treatises on social media published since 2016 because of

Lanier's intimate knowledge of the sector. It is refreshing to read an alternative to the well-trodden tropes excusing Silicon Valley's missteps. Instead, Lanier gives the reader agency in deciding how much of our lives we should give over to entities that are only interested in extracting profit from our data.

Though Lanier's prose is at times sententious in the choppy, instructive style of a self-help book, his lecturing is permissible; perhaps a strong dose of self-help is what we need as we seek to divorce ourselves from the unseen influence social media exerts over our lives.

He cares little, however, that social media's prevalence and convenience have made it genuinely difficult for people to quit. Outside of the ease it presents, social networking is no longer singularly social. Business communications happen on Facebook Messenger and WhatsApp, and absence from Twitter is career suicide in some professions. Lanier merely instructs readers to find a balance of engagement that works for them, a piece of advice that leaves them far too open to future manipulation.

Reforming social media may require us to abandon it, at least for a while

While many believe that tech may have irreparably damaged democracy, others have ideas to rewire the tech world for good. In *How Democracy Ends,* David Runciman, professor of politics at the University of Cambridge, suggests that while representative democracy has seen better days, we need not mourn it quite yet. Though he acknowledges the damage done by social media, he is rather more forgiving (a bit too forgiving for my taste) of the tech companies involved, and suggests that with a firm dose of regulation technology may help democracy through its midlife crisis rather than bring about its early demise.

Once we attain control over social networks, Damon Centola, associate professor at the University of Pennsylvania's Annenberg School for Communication, has ideas for how we might rewire them. In *How Behavior Spreads*, Centola explains that our general understanding of contagions and their behaviour is misguided. Although simple contagions, such as disease, spread easily over weak ties and thin networks, complex ones, such as vaccination programmes and other behaviours that stem the transmission of disease, benefit from strong ties and close social networks.

His online experiments use health communities to show how network structure and social relations affect the diffusion of positive health behaviours, such as dieting and regular exercise. Centola describes networks in which users have a greater degree of empathy towards others, as well as the means to compare themselves to each other. These networks can increase the adoption of complex contagions.

His ideas have exciting implications for social engineering, whether related to vaccination adoption in the developing world or a reduction of energy use in the West. But they could also be applied to the problem of fake news.

The interventions that governments and civil society organisations across the West have deployed to fight fake news largely centre on fact-checking and awareness-raising. Centola categorises the spread of information as a simple contagion, while these correctives are complex and nuanced, and therefore unlikely to spread as far or as quickly as the information they seek to correct.

Although Centola's research suggests it would be nearly impossible to seed corrective information online, planting behaviours within well-wrought networks might be possible. Facebook and Twitter could work with researchers to identify and map online communities that could take the lead in building research skills and media literacy among their networks. This targeted approach would be more likely to change behaviour than simply broadcasting public service messages about the ills of fake news to the entirety of the internet.

"Social media brings out the worst in human nature, privileging the sensational and snackable"

Centola's ideas present an appealing possibility to meet one of the challenges of democracy in the internet age, but they and the other solutions presented here rely on the active participation, or at least acquiescence, of users and social media companies. Neither inclination yet exists. Even at the height of the Cambridge Analytica scandal in April, Facebook enjoyed user growth. And though the social media industry is abuzz with fixes meant to restrict malign actors and increase advertising transparency, these changes are mostly cosmetic and don't consider the biggest danger their platforms present: their business model. Only governments can force them to reconsider those.

The social media party may not be over, but it needs more than new decorations. It needs a doorman, a more responsible host and attendees that actively hold both of them to account. ■

Nina Jankowicz studies disinformation at the Wilson Center in Washington DC

Britain's season of science

For a summer of smart thinking, try *New Scientist*'s festival picks

THE 2018 festival scene is gearing up across the UK and it contains some real science gems. So dig out your tent or borrow your mate's van, pack your waterproof and set out on a festival crawl.

Hurry to the Times Cheltenham Science Festival (until 10 June), which will explore the connections and divisions that give our world its shape, from our love of pets and the horror of loneliness, to the spread of diseases and the epidemiology of ideas. There is a fair amount of future gazing too, the lesson being that the biggest influences on our lives are often the ones hardest to spot. (One session asks how the detection of dark matter might change our world view.)

At London's Tobacco Dock, FutureFest (6 to 7 July) will "occupy the future", maintaining its edgy relationship with tech, and the hopes we have for it, through immersive installations, debates and talks. Headliners include former deputy prime minister Nick Clegg, journalist Paul Mason, musician Imogen Heap and rapper Akala. AI and the future of work will feature strongly, though there is relief to be had from our immediate concerns through conversations with aliens and designing public services for Mars.

All very grown up. By contrast, Latitude (12 to 15 July) focuses on the kids. They get to build a rocket with Rocketude, delve into herbology with the Chelsea Physic Garden and probe life's building blocks with the DNA Explorers.

Set in the spectacular grounds of the Jodrell Bank Observatory, Bluedot (19 to 22 July) opens with the Hallé Orchestra, conducted by George Fenton, performing his original *Blue Planet* soundtrack against an HD screening of footage from the 2001 series. Richard Dawkins, Jim Al-Khalili and Alice Roberts are among the speakers, and to unwind there will be musical offerings from the likes of Roni Size, Gary Numan and The Chemical Brothers.

Kew has its own science festival (21 to 22 July) at its idyllic country home site in Wakehurst, Sussex. The venue contains the Millennium Seed Bank, so this is a rare chance to peek at Kew scientists as they develop techniques to conserve plants and seeds.

For the third year running, WOMAD (26 to 29 July) boasts a Physics Pavilion. There may be elegiac moments to be had in *Earthling*, comedian and writer Gemma Arrowsmith's one-woman show about the future of humankind. Much of the programme focuses on the science of everyday life. Anne Pawsey will talk visitors through "The Physics of Gin", while Peter Barham (author of *The Science Of Cooking*), chef John Watson and chef/scientist Andy Chapman help soak up any excess spirits with their "Physics of Food".

If you need a real getaway, head for the Brecon Beacons, home to Green Man (16 to 19 August), where Einstein's Garden will be on top form for its 10th birthday. Among the highlights is a chance to take part in an artwork called *One Thousand Mindreaders*, where artist and magician Stuart Nolan will teach you how to spot the smallest movement of someone else's hands as they draw – and then recreate that drawing. There is real science here: Nolan worked with University of Bristol researchers to develop tech that can sense subconscious muscle movements.

"There's future gazing too, the lesson being that the biggest changes are often the hardest to spot"

For a season finale, *New Scientist*'s own festival, New Scientist Live (20 to 23 September) returns to London's ExCeL. There will be researchers reporting on everything from antibiotics to xenobiology. You might even learn how to spot the algorithms that run the world.

Sarah-Jayne Blakemore will reveal how the physical changes that happen in our brains during adolescence manifest themselves in teenage behaviour, while Carlo Rovelli, the Italian theoretical physicist whose *Seven Brief Lessons on Physics* sold in the kind of numbers usually reserved for bestseller fiction, will discuss his latest idea: that time doesn't exist as we know it.

That is the magic of taking science out of the lab: you go home buzzing with heretical new ideas. ■

Music meets science under Jodrell Bank's telescope at Bluedot festival

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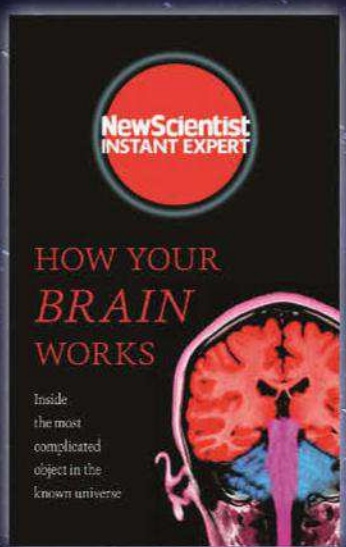

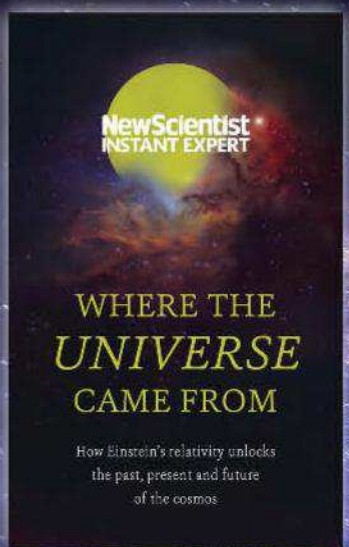

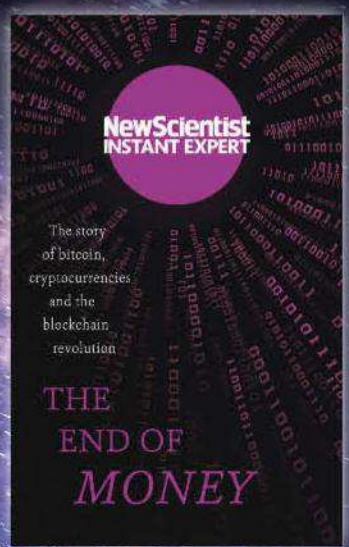

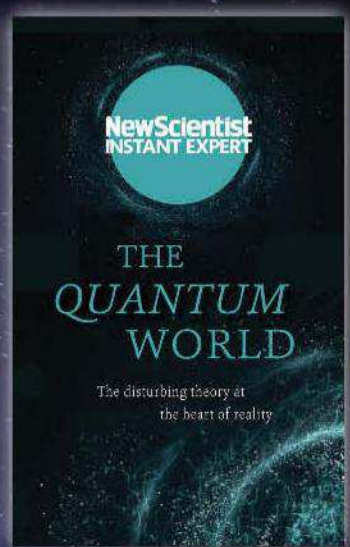

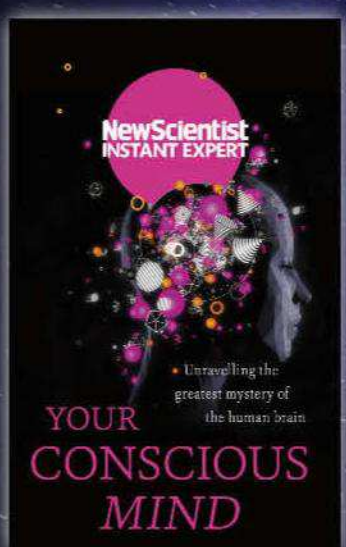

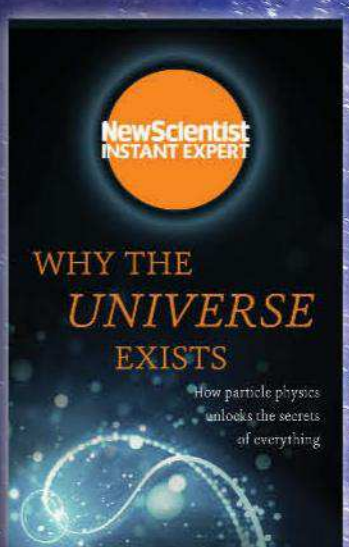

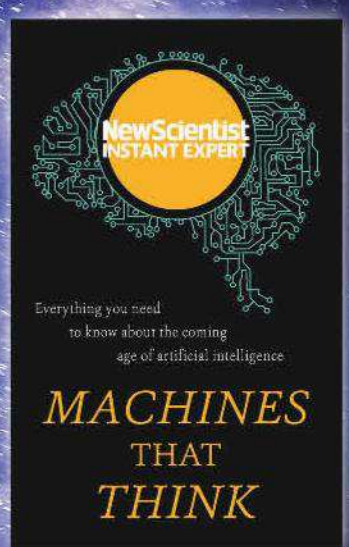

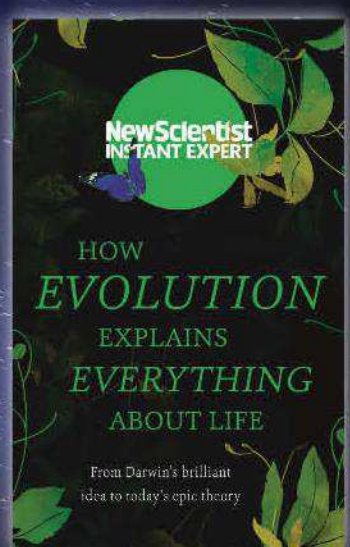

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EDITOR'S PICK

Fears and hopes over disposing of plastic

From Ann Wills, London, UK
Aisling Irwin reports on trying to solve the problem of plastic waste by getting it to dissolve (19 May, p 25). However, a plastic-eating enzyme could be disastrous if it cannot tell the difference between what is meant to be degraded and material that we need to be permanent. Plastic is used in many medical, optical and dental devices. An enzyme to tackle waste could cause people's contact lenses, medical implants or dental appliances to dissolve.

It wouldn't be the first time that an invention meant to help humans had the opposite effect. If a throwaway single-use plastic product cannot be readily recycled, we shouldn't allow it to be manufactured.

From David Copsey, Brighton, East Sussex, UK
I have come across a practical solution to plastic disposal that is obvious when you think about it. Across Colombia, the Conceptos Plásticos enterprise is transforming plastic and rubber waste into a construction material and using it to build houses for those who need them.

The trouble with the trolley problem

From Brian Horton, West Launceston, Tasmania, Australia
Clare Wilson reports a "real life" test of the "trolley problem", in which subjects could allow five mice to receive a painful electric shock, or press a button to shock just one mouse (19 May, p 14).

As in all cases of the trolley problem, the situation is so artificial that people try to think of ways of avoiding the dilemma without actively harming anyone (or any mouse).

In the published study we see that the subjects found the test hard to turn down because they received course credits for it. One out of 198 people refused to take part but was still given credits.

Nearly half did not really believe that any shocks would be given – and no mice were harmed in this study. The only conclusion I can reach is that some people would behave differently in a real situation from what they say they would do hypothetically.

This will not help artificially intelligent cars decide how many people to kill (and which) when an accident is inevitable.

Remember vasectomy for birth control equality

From David Holdsworth, Settle, North Yorkshire, UK
Lara Williams comments that a male pill will be a breakthrough for science but not for women (12 May, p 22). She does not mention vasectomy.

In my experience this allows a man to assume full responsibility for contraception without any need for interference with his body chemistry. Numerous jokes reveal, however, that vasectomy

"Asteroids squished can form a planet. Pluto is comets squished and has a comet's eccentric orbit"

Brinda Thomas responds to people demanding that Pluto, found to be comets squished together, be called a planet (2 June, p 8)

might interfere with men's self-esteem. Could it be that for some men, part of the thrill of sex is the risk of unplanned pregnancy?

From Guy Cox, St Albans, New South Wales, Australia
Vasectomy is the commonest form of contraception worldwide. True, those who take it up are not teenagers but men wanting "end of family" contraception. Still, it prevents more pregnancies than any other contraceptive method.

I can understand the appeal of a male pill to men who want to avoid condoms, though it might be counterproductive if it lowers testosterone levels. Most women in my life have preferred a diaphragm, saying it does not reduce the enjoyment of sex and has no side effects.

A rational strategy would be for women to use a diaphragm until their family is complete and thereafter for men to get a vasectomy. Messing with hormones is just unnecessary.

And all shall be, in fact, above average

From Trevor Magnusson, Hobart, Tasmania, Australia
Like everyone else, I consider myself a better than average driver (12 May, p 42). More accurately: when I am alert and concentrating, my performance is better than the average of other drivers' total performance, including their performance in inattentive moments.

And so is yours. Stated that way, we are not delusional at all. When I am not concentrating I suffer very few mishaps, because they require two things to happen simultaneously: a lack of alertness, and a chance situation in which that lapse is significant.

From Garry Trethewey, Cherryville, South Australia
So "good mental health" dictates that we all overestimate our abilities. I wonder about the relationship between that and the effect reported by Justin Kruger and David Dunning in "Unskilled and unaware of it: how difficulties in recognizing one's own incompetence lead to inflated self-assessments" (doi.org/dks). In other words, those that know least think they know most.

There is an international trade in deforestation

From Perry Bebbington, Kimberley, Nottinghamshire, UK
Fred Pearce reports that developed nations expand their forests, while poorer nations lose them (19 May, p 6). Developed countries might well use less firewood, but surely that is because they have replaced firewood with fossil fuels, hardly much of an improvement. In any case, developed countries are beginning to use firewood on an industrial scale as power station fuel – a dubious form of so-called green energy.

When dinosaurs really got reinstated as a group

From Gregory Paul Baltimore, Maryland, US
Colin Barras writes that dinosaurs were "reinstated as a scientific fact" in the 1980s (5 May, p 38). But in 1974 Robert Bakker and Peter Galton published "Dinosaur monophyly and a new class of vertebrates" (doi.org/ftw3f9).

This led to dinosaurs being widely accepted as a single distinct group. Almost all phylogenetic studies since have come to similar findings. As Bakker and I later noted, the ›

subdivision of dinosaurs into ornithischians and saurischians has always been weak because the latter may not be a real group. Whether we currently have enough data to settle that issue is problematic.

The editor writes:

■ Bakker and Galton's 1974 paper was, in retrospect, the beginning of the turning point, but it was apparently greeted at the time with a "firestorm" of controversy.

Basalt has another talent we may be able to exploit

From Michel Daubizit, Sansac de Marmiesse, France

Olive Heffernan says coating farms with basalt could cool Earth by absorbing carbon dioxide (3 March, p 26). It could have another use: making hydrogen.

Basalt contains a similar amount of iron to peridotite, an igneous rock common in Earth's mantle but rare in the upper crust. In peridotite, a reaction named serpentinisation produces hydrogen as iron reacts with water under pressure. The upper crust contains lots of basalt, but mining it would not be necessary. I propose fracturing it to increase its surface area, and injecting alkaline water.

This would solve the problem that basalt is much less reactive than peridotite. Once hydrogen production has ended, the rock could be used to sequester CO_2 – experimental drilling to test this is under way (18 June 2016, p 16).

The doubts of a researcher I have discussed this with are mostly to do with profitability, considering the price of hydrogen.

Is going dry just a disguised way of dieting?

From Jackie Jones, Brighton, East Sussex, UK

In your article about the effects of not drinking alcohol for a month (19 May, p 7), you noted a drop in blood pressure and a 1.5 per cent decline in weight. I am not sure that all the benefits were the result of abstaining.

Participants had previously been drinking three bottles of wine a week, containing about 1700 kilocalories. Since the team did not see any (other) changes in their diet during the study, the participants were in effect dieting.

Not just virtual training but fully simulated war

From John Phillips, Hughenden Valley, Buckinghamshire, UK

Chris Baraniuk reports virtual training environments for troops (28 April, p 8). The obvious next step is to fight the war itself entirely within the virtual world.

The future may not be part of the universe

From Ben Dallimore, Isle of Luing, Argyll and Bute, UK

Your letters about the nature of time have been interesting. Rod Munday suggests that the future consists of events of which there are as yet no memories (Letters, 19 May). But consider the future from the perspective of an observer just prior to the big bang.

There was undoubtedly a future as a number of interesting things have since happened, but there was no universe. Thus the future is "outside" the universe as we normally think of it, so we can forget about ever travelling into it.

And we must somehow be prevented from travelling into the past because of the well-explored paradoxes that would result.

I wonder whether this means that there is no space in the past. If there were, then we could simply walk to the past, because space is what we move around in. So space, in which our bodies and our consciousness exist, is a thing of the present and the passage of time is the transition from… er…

That iconic polar bear may just have been old

From Tillmann Benfey, Fredericton, New Brunswick, Canada

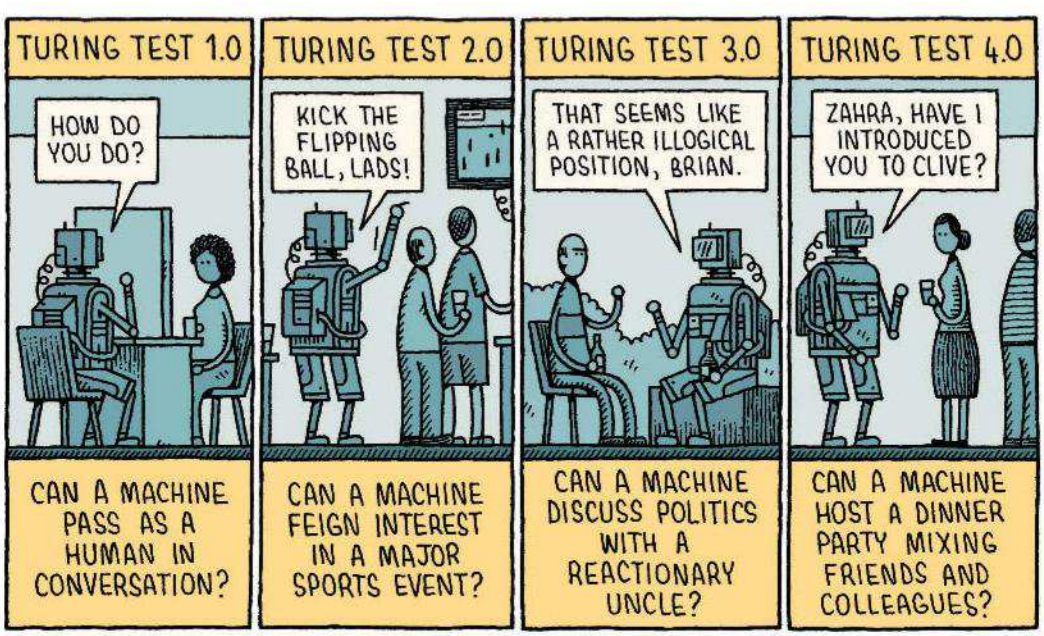
You reproduce a widely circulated image of an emaciated polar bear limping across a barren landscape (10 February, p 35). I often wonder whether it simply shows an old animal near the end of its natural life. This by no means detracts from the importance of understanding and mitigating the effects of climate change, but large animals with few predators, such as adult bears, presumably often die from old age even if we rarely witness this in nature.

An old saying can teach a dog new tricks

From Brian King, Barton On Sea, Hampshire, UK

Danny Chambers quotes William Hutchinson, an advocate of positive training for dogs: "Be to his virtues ever kind. Be to his faults a little blind" (10 March, p 24). Is this epigram the ultimate in doggerel?

TOM GAULD



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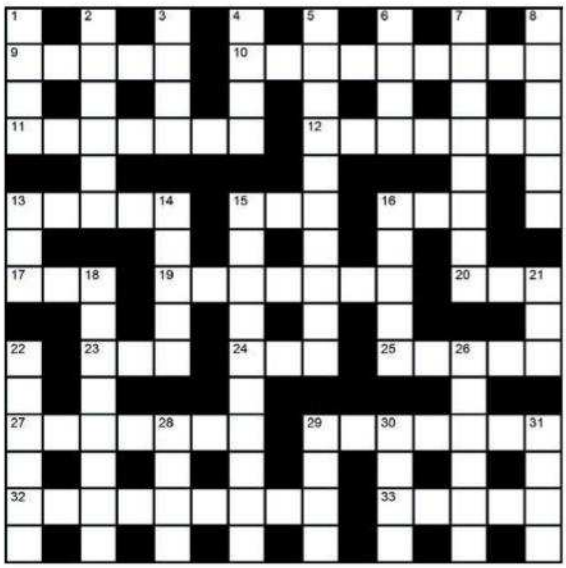
CROSSWORD

Compiled by Richard Smyth



Crossword No19

ACROSS

9 Savoury taste, associated with monosodium glutamate (5)
10 Viral respiratory tract infection (9)
11 Surgical stitches (7)
12 Green variety of beryl (7)
13 See 1 Down
15 Abbreviated name for a trigonometric function (3)
16 The Greek letter ψ (3)
17 1 + 1, for example (3)
19 Concept arising from the second law of thermodynamics (7)
20 Unit of energy and work equal to 10^{-7} joules (3)
23 See 2 Down
24 Substance released by most cephalopods (3)
25 Type of synthetic polyester resin (5)
27 Woody shrub widely cultivated for its starchy root (7)
29 Researcher who has done a PhD (7)
32 Nd (9)
33 Asian tree, or the oleoresion harvested from it (5)

DOWN

1/13A/14 ___, ___ and ___, 1997 work by Jared Diamond (4,5,5)
2/23 A Triglyceride pressed from the seeds of the plant *Ricinus communis* (6,3)
3 ___ paradox, logical conundrum concerning truth and falsity (4)
4 Basic input/output system (4)
5 Tremor following an earthquake (10)
6 ___ cupboard, a laboratory ventilation device (4)
7 Term describing alien species such as a grey squirrel or zebra mussel (8)
8 The Chemical History Of A ___, lecture series given by Michael Faraday in 1848 (6)
13 Fundamental state of matter (3)
14 See 1 Down
15 $C_6H_8O_7$ (6,4)
16 Chordata, Arthopoda and Mollusca, for example (5)
18 Name given to the Apollo space programme (8)
21 "___ does not play dice" – statement on uncertainty attributed to Albert Einstein (3)
22 Prefix that might go before -phobe, -logical or -babble (6)
26 Vertebrate organ fed by the renal artery (6)
28 ___ nitrite, $C_5H_{11}ONO$ (4)
29 Device that might be impulse, gravity or positive displacement (4)
30 Science, technology, engineering and mathematics (4)
31 Tesla ___, invention of 1891 used to produce high-voltage alternating current (4)

Answers to crossword No18

ACROSS: **1** WARBLE, **4** DIAGONAL, **9** RADAR, **10** BUCKYBALL, **11** HAHN, **12** MAXI, **13** OXIDE, **15** LIFTOFF, **16** ECHO, **19** HOUR, **20** PETRIFY, **23** BENCH, **24** SOAP, **25** ICBM, **27** OSTEOWARE, **28** EXACT, **29** BERKELEY, **30** BLURAY. **DOWN:** **1** WORMHOLE, **2** REDSHIFT, **3** LYRA, **5** INCLINED PLANE, **6** GLYCOPHYTE, **7** NIACIN, **8** LILIES, **10** BEAUFORT SCALE, **14** MONOCHROME, **17** SINCLAIR, **18** SYMMETRY, **21** ABSORB, **22** INSTAR, **26** BELL.

PAUL MCDEVITT

WHAT'S the collective term for 40-centimetre-long hammerhead flatworms? Feedback's guess is that it's a sort of raw adenoidal scream that opens a portal to the black abyss and brings down everlasting night.

Whatever it is, it's probably prettier in French. That is just as well, because France has recently seen hordes of hammerhead flatworms, native to Asia, slither out of the depths of its collective unconscious to feast on earthworms, clone themselves en masse, and quote Proust at one another down Montmartre byways.

English folklore reminds us that the situation is not without historical parallel, though. Back in the day, the Lambton Worm terrorised County Durham until a knight who was clad in spiked armour gave it a fatal tenderising.

The French, having dispatched their aristocracy, must find another solution. No strangers to culinary bravery – *les escargots au beurre* come to mind – perhaps French chefs could be persuaded to add a flatworm tatin to the pages of *Larousse Gastronomique*.

MORE monsters: the residents of Lake Worth, Florida, received an emergency alert on 20 May warning them of "extreme zombie activity". Local news channel WPBF reported that a power failure around 2 am triggered the automated message, which was sent to thousands of mobile phones in the area.

The message informed the bucolic seafront community of a "power outage and zombie alert for residents of Lake Worth and Terminus", citing a fictional settlement featured in horror series *The Walking Dead*. "Restoration time uncertain."

In a statement, a city spokesperson said the message was the result of someone tampering with the alert system. "I want to reiterate that Lake Worth does not have any zombie activity currently and apologize for the system message."

IT'S like an episode of *CSI: Miami*, but with more midges and less sunshine. Forensic scientists are combing Loch Ness in Scotland for traces of DNA – which they note could reveal its most famous resident.

Stepping into David Caruso's weathered loafers is Neil Gemmell at the University of Otago, New Zealand. His team is performing a year-long trawl of the loch, sampling the water for traces of genetic material. As animals go about their lives, they leave tiny fragments of skin, scales, and other sources of DNA in their surroundings. These can be used to identify the inhabitants of the loch, answering important questions about the spread of invasive species such as Pacific pink salmon.

Of course, without a reference plesiosaur to compare Nessie's DNA with, confirming the existence of the mythical monster might prove tricky. But not to worry: "if an exact match can't be found, we can generally figure out where on the tree of life that sequence fits," says Gemmell.

The odds of Nessie making a guest appearance are slim, but the expertly baited hook did prove irresistible to that other elusive creature scientists like to seek out: friendly journalists.

THE eminently pragmatic Bernie Harper writes: "Has anyone ever asked an actual signal operator how they would solve the seemingly intractable 'trolley problem' in reality?" This ethical dilemma, involving a runaway tram, onrushing points, various people tied to the tracks, and a hapless signalman forced to play god, is a favourite of philosophy textbooks.

If the operator can see the carriage directly, notes Bernie, they could wait for the first axle to pass over the points before diverting the second axle onto the other line. This will derail the carriage, creating lots of warning noise and presumably triggering some sort of investigation. At low speeds, he adds, this is a life-saving strategy.

Never mind those fusty professors of philosophy in their ivory towers: if you want a practical answer, turn to the thinker on the Clapham trolley. We are sure readers can offer similarly simple solutions to other issues vexing top minds today.

MEETING in the middle: Richard VandeWetering spies a mysterious headline in Canada's *Globe and Mail*: "U.S. labour market tightening; mid-Atlantic factory activity picks up".

Feedback is reminded of the suggestion that trading nodes be built midway between major stock exchanges, such as London and New York, to minimise the time needed to issue orders. What sort of fees would stockbrokers based in Atlantis charge, asks Richard. Answer: we don't know, but liquid assets are no doubt preferred.

VISITING the outpatient department of Bassetlaw hospital in Worksop, UK, Richard Davis notes that the entrance is labelled "automatic door" and does indeed open when approached. But on egress, "the same doors are marked 'Automatic door. Press button to open'".

Richard says this probably stops the doors opening every time a patient is wheeled past, but how to parse the contradiction? Feedback's instinct is to suppose the internal mechanism must be in some way buggy. Otherwise, why would it in be a hospital?

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An ad in Leeds, UK, promises buses "up to every ten minutes, or better". Bryn Glover wonders: how are those two alternatives?

Shape up

People seem to come in all shapes and sizes. Do any other animals display the same amount of variation in size as humans among healthy adults? Why is there this variety, and what are its consequences for the future?

■ Yes – the dog, for one. *Canis familiaris* has had an extremely secure niche for a long time, and it has human breeders and carers. This disrupts adaptive evolutionary strategies which would normally enable some individuals to do better than others in the wild. The species does not have its non-adaptive (and arguably useless) variations weeded out by challenges to its survival, so they have room to proliferate.

But of course any old "useless" feature could one day prove to be an advantage. This can happen either directly, as with peppered moths evolving in industrial England (darker ones survived better when their world turned black and dirty, a phenomenon called "industrial melanism") or indirectly, for example if a gene variant that results in bright pink eyes also gives rise to more flexible blood vessels, protecting against atherosclerosis.

"In domesticated animals, breeders can produce unusual traits that would be eliminated in the wild"

Trischa Mann
Ballarat West, Victoria, Australia

■ Individual variation in traits like body shape and size is partly to do with differences in lifestyle and environment, but genetics also plays an important role.

In all living things – including humans – genetic variants are constantly being introduced through mutations, with a mistake in copying DNA resulting in offspring carrying a modified gene that was not present in the parent(s). In species that reproduce sexually, genes are reshuffled into new combinations with each generation. Because many genes interact in determining traits like body shape, this widens the variations between individuals.

In wild animals, the amount of variation between individuals is likely to depend on how important a particular trait is for survival. If an animal needs to be within a narrow size range to survive, natural selection will weed out any variants outside this range; if not, a greater range of sizes will be seen. Species are likely to have more variation in some traits than others, for example colour over size.

If an animal is domesticated, breeders can produce a far greater variety of unusual traits, such as with dogs. Most of these traits would be eliminated by natural selection in the wild.

In humans, there is clearly variation in body size and shape as well as a range of other features, and we are more likely to notice these because they are in our own species. Relative to animals, the amount of variation in the human species is not considered unusual, and may in fact be a little on the low side. The peoples of Africa are the most genetically diverse compared to those from other continents, which were founded by small migratory populations. These lost some of the variations that had built up in Africa, where our species originated.

In today's developed world, it could be argued that humans are no longer subject to natural selection as our ancestors were. Women with body shapes that would once have made childbirth dangerous can now opt for a caesarean, and this increases the range of body shapes that can persist in the population. If this state of affairs continues into the long term, the amount of variation in body size and various other traits will probably gradually increase.

"With the advent of tools that allow editing of genes, future variation in humans may be of our own making"

However, with the development of molecular tools like CRISPR that allow editing of genes, it may be that future levels of variation in humans will be of our own making.

Lachlan Jones
Brisbane, Queensland, Australia

■ That humans vary in size is surely a tool of evolution. If a species did not vary, then it would become extinct at the first change in the environment. Size – both height and body shape – is just one trait that can be selected for. It has been suggested, for example, that the Inuit are short and stocky because this minimises body surface area and thus heat loss in cold climates.

Individual variation, enforced by sexual reproduction and the mingling of parental genes, ensures that people are all different. But we are not that different compared with domesticated animals. For them, human rather than natural selection has driven change, producing dog breeds that range from Great Danes to tiny chihuahuas. We have also bred small Shetland ponies and shire horses, the latter standing anything up to 2 metres tall from ground to withers.

John Davies
Lancaster, UK

This week's question

WATERY TRAILS

Ferries and other craft crossing Sydney Harbour naturally leave a distinct wake, signified by trails of a lighter colour than the surrounding water. These sometimes persist for more than 30 minutes after the craft has passed through, and the surface takes on an appearance reminiscent of ski trails through virgin snow. How can this be so on a body of water that is in constant, albeit gentle, motion?

Barry Clendinning
Manly, New South Wales, Australia

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