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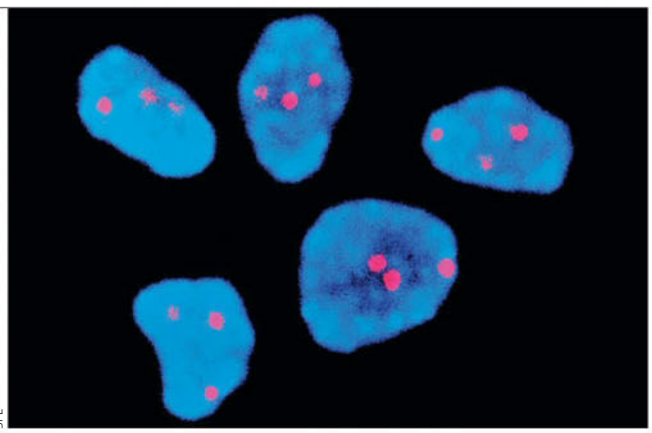

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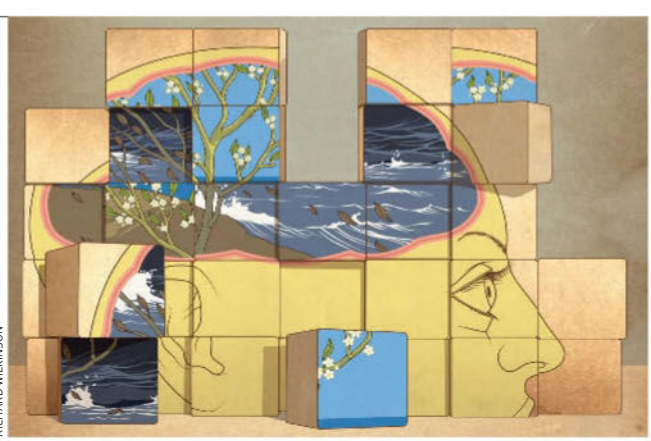

RICHARD WILKINSON

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JULIE DERMANSKY

Speak out if you can

Resistance to oppression of science must not become divided

WERNER HEISENBERG did not like the Nazis, but he worked on their project to build a nuclear bomb. The English physicist Paul Dirac came to his defence. "It is easy to be a hero in a democracy," he said.

Science does not exist in a vacuum. Rather, it inhabits "a world of money and votes, a world of media enquiry and lobbyists, of pharmaceutical manufacturing and environmental activism and religions and political ideologies and all the other complexities of human life," as UK epidemiologist Elizabeth Pisani has written.

Some scientists face this reality every day – if, for example, they work on sexually transmitted diseases, as Pisani does, or if they speak truth to power on drug policy, as former government adviser David Nutt did. Now the number facing it has soared.

The Trump administration has put almost every environmental scientist squarely in its sights, whether they model climate change or study endangered species. Having failed to purge their ranks, it has silenced those on the government payroll, preventing them from talking to the public or press.

Resistance, in the form of rogue Twitter accounts, came swiftly – but their defiance is no substitute for the dialogue on which decent research, public understanding and decision-making depend. Experience from Canada's own "war on science" suggests such tactics, even if they go no further, can have a profoundly chilling effect (see page 25).

How to respond? Resign, resist, or keep researching? Many scientists will be struggling with choices that go beyond their training and experience. Not everyone will be able to quit or speak up, with careers on the line: it is not easy to find a job in specialist fields. Those working in some other areas – big physics, say – may be free to carry on pretty much as before, if they keep their mouths shut. And some will agree with the Trump team that science-based regulation has become overly obstructive to US business.

"Disagreements between scientists and supporters must be tolerated, as they are in science"

The question of how to respond is not just for federal employees. We can expect scientists from other disciplines and, for that matter, from other countries, to stand with their colleagues. In a fortnight, Boston will host one of the world's biggest scientific meetings. Its programme is sure to be affected by the drastic border controls imposed last week; its break-time discussions will be dominated by talk of resistance. Some will express solidarity with the excluded by refusing to take the platform. Others will suggest that carrying on as normal is the best riposte.

Is there a correct approach? Tensions are emerging between those who see science as part of a broader struggle for diversity and human rights, and those who believe the argument should be more narrowly about preserving the integrity of research: witness the kerfuffle over the objectives of the planned "March for Science".

Infighting and division will prove fatal to either agenda. While scientists and supporters will have different ideas about the actions that should be taken, it's vital that disagreements are tolerated – just as they are in the practice of science itself.

It is more important to express unity about the need to turn back repression than it is to agree an ideologically pure form of protest. Faced with the undemocratic suppression of speech, not everyone can be a hero. That makes it all the more important that those who can speak out do so for those who cannot – with many voices, if not one. ■

CHRISTOPHER ALUKA BERRY/REUTERS

US travel ban hits scientists

ON 27 JANUARY, Donald Trump signed an executive order denying Syrian refugees entry to the US, suspending all refugee admissions for 120 days and blocking citizens of seven nations from entering the US for at least 90 days. Scientists are among those affected, with some speaking out about its impact.

"While one can understand security imperatives, a broad ban that restricts movement of widely defined groups can hold back important scientific progress; progress that can solve some of our most urgent problems," says one professor at a leading US university. A dual citizen of one of the countries on the list, he says he will probably have to cancel research trips, as well as a visit to see his mother.

The countries targeted by the ban are Iran, Iraq, Libya, Somalia, Sudan, Syria and Yemen, all of which have majority Muslim populations.

Scientists from these countries who are not currently in the US are cancelling plans to attend conferences there. "I am a Muslim, a Syrian, and a Scientist who wants to present his work in the top conference in Artificial Intelligence (AAAI). Thanks to the #TrumpBan, I just cancelled my trip," wrote Talal Rahwan at the Masdar Institute of Science and Technology in Abu Dhabi in a Facebook post.

But the effects on the scientific community may be more far reaching than disrupting travel for individuals.

"Freedom of communication is absolutely essential for science to function," says Rush Holt, CEO of the American Association for the Advancement of Science (AAAS). "It's not just nice for people to attend conferences and communicate in person, it's part of the practice of science."

An open letter from academics opposing the executive order has received more than 12,000 signatures so far, including those of 44 Nobel laureates. Some are also planning a "March for Science" protest in Washington DC.

Ultimately, the US may lose its scientific standing by restricting travel as it could lose its capacity to attract "the best and the brightest", says Marga Soler of the AAAS Center for Science Diplomacy.

"Brain drain is a real possibility because other countries, like Canada, are offering to take in the people affected by this policy. It's a loss for the US," she says.

Yellow fever alert

MONKEYS in the forests of Brazil are being devastated by yellow fever.

The outbreak began in late 2016 and has since spread to humans, killing around 50 this year. Vaccines have been rushed to hospitals, where long queues of people await inoculation.

But there is no vaccine for monkeys, who are dying in vast numbers in Espírito Santo and Minas Gerais, the two worst-hit states. "Some 80 to 90 per cent of the brown howler monkeys are infected or have already died," says Sérgio Mendes at the Federal University of Espírito Santo. "This is a true catastrophe. These outbreaks happen periodically, but this is the worst I've ever seen."

"Some 80 to 90 per cent of brown howler monkeys are infected or have already died. This is a catastrophe"

Mendes knows of 400 howler monkey deaths in the state, but he believes these may be only 10 per cent of the total, with most losses happening largely unseen in remote forests.

The fear is that the fever will spread to other monkeys, such as the critically endangered northern muriqui, of which only some 1000 are left in the wild.

School shootings

GUN violence at US schools and universities peaks during periods of high unemployment, according to a study of 381 shootings.

The root causes of gun violence in the US are difficult to unpick. Federal funding for research in this area has effectively been banned since 1996, and there's a lack of comprehensive data.

For this study, the researchers drew on six data sets to compile their list of shootings between 1990 and 2013. The highest rates

of school shootings occurred in two periods: 1992 to 1994 and 2007 to 2013, and coincided with periods of higher unemployment. Gun violence was also correlated with low consumer confidence and a higher frequency of homeowners failing to keep up their mortgage payments (*Nature Human Behaviour*, doi.org/bx3h).

"Our study indicates that increases in gun violence in our schools can result from disappointment and despair during periods of increased unemployment," says John Hagan at Northwestern University in Chicago.

AI poker victory

AN AI has beaten top professional poker players in a tournament for the first time.

Called Libratus, the AI took on four of the world's best Heads-Up No-Limit Texas Hold 'Em poker players in a 20-day match at a Pennsylvania casino. After 120,000 hands, Libratus won, amassing $1.7 million more in chips than the humans combined.

"I'm feeling great," says Tuomas Sandholm at Carnegie Mellon University and part of the team behind Libratus. "This is a David versus Goliath story, and Libratus was able to throw a pebble."

The win is remarkable because poker is a game of imperfect information: players don't know what cards their opponents have, so never have a full view of the state of play. The AI wasn't taught any strategies and instead had to work out its own way to play based on the information it received. Its algorithms aren't specific to poker and could have applications in everything from cybersecurity to fighting disease.

It's an important milestone for AI, says Georgios Yannakakis at the University of Malta: "The real world is a game of imperfect information, so by solving poker we become one step closer to general artificial intelligence."

Plagued antelopes

MONGOLIA'S iconic antelopes are dying en masse from a virus that normally hits livestock – peste des petits ruminants, or goat plague.

Hunting and disease have already cut saiga antelope numbers from 1.25 million to 50,000 over the past four decades. Now, a further 2000 saiga – about a fifth of the endangered Mongolian subspecies – have perished in the country's Khovd province, and thousands more are at risk.

Although the disease is not dangerous to humans, it kills up to 90 per cent of infected animals. Vaccinating livestock usually keeps it in check.

Ibex and goitered gazelle have also been infected. "If these prey species are devastated, then the food source for the endangered snow leopard will be affected and this will raise conflict with people," says Richard Kock of the Royal Veterinary College in London. "A real catastrophe."

"If these prey species are devastated, then the food source for the endangered snow leopard will be cut"

Antibiotic resistance spreads

RESISTANCE is spreading from the farm to the hospital. The first large-scale survey of resistance to colistin, a crucial antibiotic of last resort, has detected it in around 1 per cent of hospital patients in two large cities in China.

That's surprising as in China colistin isn't used in people. While it is a vital drug for treating infections resistant to other antibiotics in the US and UK, in China it is fed to livestock to promote their growth. This means the resistance gene must have spread from bacteria in livestock to bacteria in people.

This is the strongest evidence yet that the use of antibiotics on farms affects resistance in people. "We can now say unequivocally that feeding antibiotics to animals negatively affects humans," says Tim Walsh at Cardiff University, UK, who worked on the study.

The colistin resistance gene was first discovered in China in 2015, and has since spread to other countries. The study also identified the first known case of the resistance gene being carried by the most globally widespread, disease-causing strain of the human gut bacterium *Escherichia coli*, called ST-131 (*The Lancet*, doi.org/bx3f).

On 1 April, China is set to make it illegal to use colistin as a growth promoter in livestock, and the drug will instead start being used to treat people. But some infections will already be able to resist it.

SHENG LI/REUTERS

No more colistin for you

60 SECONDS

Ions in lunar landing

Earth may have been leaking oxygen on to the moon for billions of years. Our planet's magnetic field not only protects the moon from the solar wind, it also creates a sheet of ions that stream between the two, carrying hydrogen as well as oxygen (*Nature Astronomy*, doi.org/bx3g).

Smoking's extra costs

Smoking accounts for almost 6 per cent of global healthcare spending, and its economic impact equals 1.8 per cent of global GDP. In 2012, that impact amounted to £1.15 trillion, with nearly 40 per cent of it borne by less-developed nations, according to data from 152 countries (*Tobacco Control*, doi.org/bx25).

Practice makes perfect

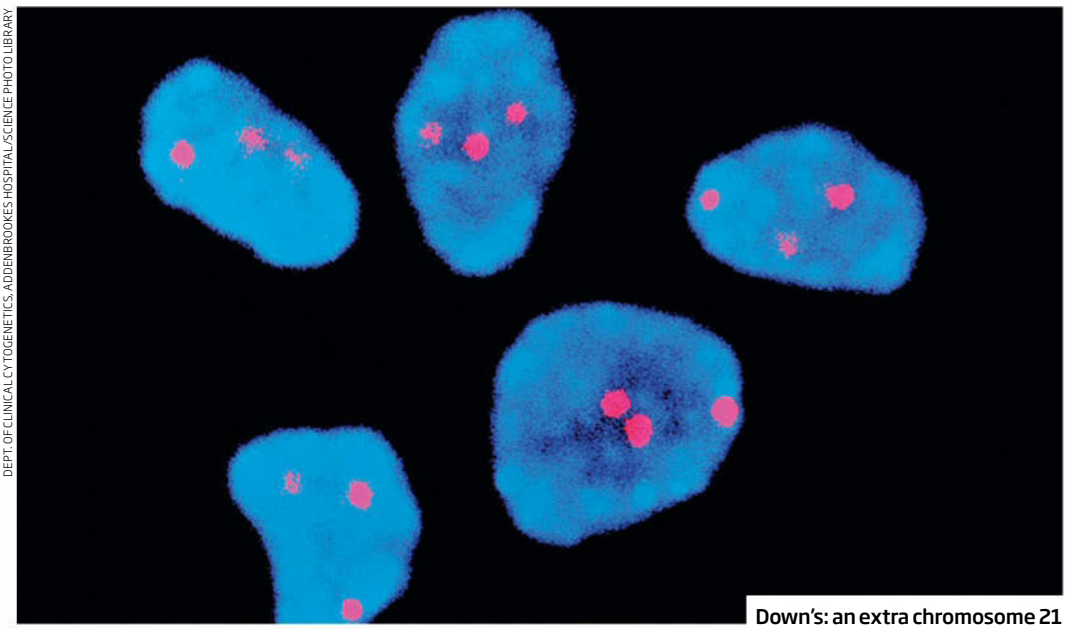
Don't stop just yet. A study involving 183 people learning a new task finds that to really master something, we should keep practising even when we no longer think we can get any better. Such "overlearning" may help cement improvements in performance (*Nature Neuroscience*, doi.org/bx3m).

Sunken continent find

A long-lost continent has been found submerged deep in the Indian Ocean. Plate tectonics that drew India and Madagascar apart stretched it like plasticine, causing it to sink some 85 million years ago. Ancient zircon crystals brought up in lava on Mauritius have now revealed it (*Nature Communications*, DOI: 10.1038/ncomms14086).

Fish use wee-mails

Urinating at rivals is all part of one cichlid fish's territorial display. When fish separated by a transparent barrier couldn't detect their opponent's urine, they showed more hostile behaviour and urinated more often, presumably to get their message across. The barrier also made fish more likely to attack larger opponents (*Behavioral Ecology and Sociobiology*, doi.org/bx3b).



DEPT. OF CLINICAL CYTOGENETICS, ADDENBROOKES HOSPITAL/SCIENCE PHOTO LIBRARY

Down's: an extra chromosome 21

Clinic claims stem cells treat Down's syndrome

But jury is out over a new treatment for babies, says **Andy Coghlan**

A CLINIC claims it has used stem cells to treat Down's syndrome in up to 14 people. "As far as we know, it's the first time that stem cells have been used to treat Down's syndrome," says Jyoti Titus, manager at Nutech Mediworld clinic in New Delhi, India.

The announcement has set alarm bells ringing. It's not clear to independent stem cell or Down's experts how stem cells – which can form many types of tissue – might treat Down's, a genetic disorder caused by having an extra chromosome. "The use of these cells does not make biological sense and may place the babies at considerable risk of side effects,"says John Rasko of the International Society for Cellular Therapy.

Clinically proven stem cell therapies are only just starting to become available. The first off-the-shelf stem cell treatment to gain regulatory approval was launched in Japan last year, and prevents transplanted organs from attacking their recipients. A number of research teams are putting other experimental stem cell therapies through stringent clinical trials.

But hundreds of clinics worldwide already offer stem cell treatments unvetted by regulatory authorities. A patent held by the clinic's medical director, Geeta Shroff, from 2007 suggests that the cells offered by Nutech Mediworld could be helpful for over 70 types of conditions, from Down's syndrome to Alzheimer's disease, and even vegetative states.

Most treatments for children with Down's syndrome centre on support – including speech and behavioural therapies. But in a study published last year, Shroff reported that a baby with Down's syndrome developed better understanding, improved limb muscle tone, and the ability to recognise his relatives after receiving stem cells (*Journal of Medical Cases*, doi.org/bx3v).

No controls

"There's no comparison to similar individuals with Down's syndrome, and no indication this therapy had any effect whatsoever, so the author has no basis at all for saying the injections were beneficial," says Elizabeth Fisher at University College London.

But since no other treatment was given, it is evident that the child's improvements were due to stem cell treatment, says Titus. "He started babbling and crawling, and his facial features underwent a change." The boy, who lives in Singapore, is now 3 years old. "He continues to develop age-appropriate skills," says Titus.

Shroff's study says she injected the cells, developed from a donated embryo, into his blood, back muscles and under his skin, as well as giving them as a nasal spray. "Stem cells have an innate ability to repair and regenerate, and that is how the baby's condition improved," says Titus.

"The use of stem cells doesn't make sense and may place the babies at considerable risk"

"There's no obvious way in which this treatment would have worked," says Victor Tybulewicz at the Francis Crick Institute in London. To have any effect, neural stem cells would need to be injected into the brain, he says.

"The author appears to have no idea of where [the cells] are going, or what they're doing," says Fisher. "It's even worse now we know they've treated 14 patients, not just one."

Titus says that the way the cells were developed means recipients don't need immunosuppressants. But Tybulewicz disagrees. "I expect the most likely outcome of the injections would have been that they were recognised as foreign and eliminated by the immune system," he says. More details of the biological impact of the stem cells will be revealed in a study that has been submitted for publication, says Titus.

Nutech Mediworld isn't the only clinic offering stem cells. An analysis led by Rasko last year identified 417 unique websites advertising stem cell treatments directly to patients. Of these, 187 were linked to 215 clinics in the US. Thirty-five websites were linked to organisations in India.

Although India introduced national guidelines on clinical stem cell research and treatments a decade ago, these are not legally binding. ■

'Forbidden' time crystals created from new recipe

IT'S no longer just a wild theory. Two independent teams of physicists have followed a recipe to build the world's first versions of an enigmatic form of matter – time crystals.

MIT physicist and Nobel laureate Frank Wilczek first speculated about the existence of time crystals in 2012, while teaching a class on ordinary crystals, such as salt or snowflakes. In a typical crystal, the atoms or molecules are tightly arranged in regularly repeating patterns in three-dimensional space, resembling a lattice.

Wilczek thought that it might be possible to create a similar crystal-like structure in time, which is treated as a fourth dimension under general relativity. Instead of regularly repeating rows of atoms, a time crystal would exhibit regularly repeating motion.

Many physicists were sceptical, arguing that a time crystal whose atoms could loop forever, with no need for extra energy, would be tantamount to a perpetual motion machine – forbidden by the laws of physics.

Wilczek countered that a time crystal was more akin to a superconductor, in which electrons flow with no resistance, and in theory could do so forever without the need to add energy to the system. In a time crystal, electrons would travel in a loop rather than a line and occasionally bunch up rather than flow smoothly, repeating in time the way atoms in ordinary crystals repeat in space.

Now Norman Yao at the University of California, Berkeley, and his colleagues have revealed a blueprint for making a time crystal (*Physical Review Letters*, doi.org/bxxr). And the recipe has already been followed by two teams.

For Yao's time crystal, the interactions between quantum particles are key. An external force – like the pulse of a laser – flips the magnetic spin of one ion in a crystal, which then flips the spin of the next, and so forth, setting the system into a repeating pattern of periodic motion.

There are two key elements. First, it must be a closed system, unable to interact with and lose energy to the environment. Second, interactions are the driving force behind the time crystal's stability. "It's an emergent phenomenon," says Yao. "It requires many particles and many spins to talk to each other and collectively synchronise."

Using Yao's recipe as guidance, two groups have now created time crystals in the lab. Last September, a group headed by Chris Monroe of the University of Maryland in College Park built a time crystal out of a string of trapped ytterbium ions.

One month later, a team led by Harvard University's Mikhail Lukin built a time crystal by exploiting defects formed in diamond. Both teams have submitted papers for publication.

Both approaches yielded the telltale signature of a time crystal: the repeating pattern is out of step with the laser pulse used as the driver. But how do you tell whether this is just because you are pushing it periodically with the laser pulse? The evidence is that the period the crystal settles into is different from that of the driving pulse that pushes it.

That means time crystals are more than just a curious oddity: they represent the simplest form of a new state of non-equilibrium matter that physicists have only begun to explore.

Spyridon Michalakis, a physicist at the California Institute of Technology, says Yao's work "bridges the gap between theory and experiment by making concrete suggestions for experimental platforms". **Jennifer Ouellette** ■

EQUINOX GRAPHICS/SCIENCE PHOTO LIBRARY

Time crystals are caught in a loop

Chimps in gang 'murder' of an ex-tyrant

BEATEN with rocks and sticks, stomped on, then eaten: it was a violent demise for the chimpanzee known as Foudouko. Worse still, he died at the hands of his own community in south-east Senegal.

This is one of just nine known cases of chimpanzees killing one of their own adult males, as opposed to a member of another group. Such rare intra-group killings can give insights into chimp behaviour, such as male coalition building, says Michael Wilson at the University of Minnesota in Minneapolis, who was not part of the team that studied Foudouko's death. "Why do these coalitions sometimes succeed, but not very often? It's at the heart of this tension between conflict and cooperation, which is central to the lives of chimpanzees and even to our own," he says.

Chimp groupings usually have more adult females than males, but not so in Foudouko's group. "When you reverse that and have almost two males per every female – that really intensifies the competition for reproduction," says Wilson. "That seems to be a key factor here."

Human influence may have skewed the sex ratio, says Jill Pruetz at Iowa State University in Ames, who has since 2001 been studying the group Foudouko was a member of. In Senegal, female chimps are poached to provide infants for the pet trade.

"Tension between conflict and cooperation is central to the lives of chimpanzees and even to our own"

So, why was Foudouko targeted by his peers? Thirteen years ago, he reigned over the chimp clan at the Fongoli Savanna Chimpanzee Project. As alpha male, he was "somewhat of a tyrant", Pruetz says.

Later ousted, he lived alone on the edge of chimp society for years before returning and trying to resume a leadership role – even as several younger males were jostling for power (*International Journal of Primatology*, doi.org/bxx2). "He was trying to come back in at a high rank, which was ultimately a foolish thing to do on his part," says Pruetz. Chelsea Whyte ■

Fussy ants act as nest's imagination

Chris Simms

THE power to imagine a better world has helped transform human societies, and it may be doing the same to ant societies.

Individual ants have differences in behaviour – something almost akin to a personality – that affect colony decisions. And some ants are so different in their personal preferences that they may act as the imagination of the colony, driving it on to a better future.

Rock ants (*Temnothorax albipennis*), found in coastal areas of the UK, make their homes in crevices. If a nest is wrecked, or if scouts find better digs, it often makes sense to relocate.

But not just any crevice will do. When looking for a new home, ants have a high-maintenance list of requirements, says Thomas O'Shea-Wheller at the Ant Lab of the University of Bristol, UK. They seek low light levels, an entrance gap of 1 to 1.5 millimetres, a ceiling height of roughly 2 millimetres and an internal area of about 20 square centimetres. To test how individuals' opinions of potential nests affect a group decision to relocate, O'Shea-Wheller's team showed artificial nests that were excellent, good or poor to 160 individual ants from 10 colonies.

In general, the better the nest, the more time the ants spent in it laying down pheromones. These pheromones make other ants more likely to join them.

But the team found a lot of variability between the amount of time individuals spent in a nest of a certain quality. "Some ants are picky, others are more liberal and will accept almost anything," says O'Shea-Wheller. "Much like humans, not everyone wants to live in a mansion."

And some ants never seem happy, however nice a nest is.

NORASMAH BASARI

Well, I beg to differ...

They live there, but seem restless, and are more likely to scout. It means they are always searching for new things. "They are the imagination of the colony," says O'Shea-Wheller.

"The ability of the colony to find new nest sites depends on there being some wanting to search," says Anna Dornhaus at the University of Arizona in Tucson. "It's useful to the colony to have some ants that are fussy."

The team modelled this behaviour and found that if the colony was choosing between two poor nests, the ants with more extreme behaviour – in this case the ones that would settle for almost anything – helped make the collective decision-making process faster and more flexible (*Proceedings of the Royal Society B*, DOI: 10.1098/rspb.2016.2237).

"This adds to the evidence that individuality is important," says Nathalie Stroeymeyt at the University of Lausanne in Switzerland.

However, we still don't know what's behind this individuality. "We'd like to know what drives personality differences, what the evolutionary benefits are," says Dornhaus. "At least this gives us a suggestion about why personality differences could be useful – and could benefit a colony." ■

Workplace AI tells your boss if you're slacking

THINK government surveillance is excessive? Wait until you hear what your employer might be up to.

Artificial intelligence is making it possible for companies to monitor workers' behaviour in great detail and in real-time. Start to slack off, or show signs of going rogue, and an algorithm could tattle to your boss.

One company offering such services is London-based start-up StatusToday. Its AI platform relies on a regular supply of employee metadata, including everything from the files you access to when you use a key card.

From this, it builds a picture of how departments and individuals normally function and flags any anomalies. The idea is to spot when someone might pose a security risk by deviating from their usual behavioural patterns. "All of this gives us a fingerprint of a user, so if we think the fingerprint doesn't match, we raise an alert," says Mircea Dumitrescu, the company's chief technology officer.

The system also aims to catch employee actions that could accidentally cause a security breach, like responding to a phishing email or opening malware. "We're not monitoring if your computer has a virus," says Dumitrescu. "We're monitoring human behaviour."

But catching the odd security breach means monitoring everyone, and the AI can also be used to track employee productivity. "It seems like they're just using the aura around AI to give an air of legitimacy to good old-fashioned workplace surveillance," says Javier Ruiz Diaz of digital campaigning organisation the Open Rights Group. "You have a right to privacy and you shouldn't be expected to give that up at work."

"But catching the odd security breach means monitoring all of your employees"

Exactly how companies use the system will be up to them, but it's hard to shake the image of an AI constantly peering over employees' shoulders. "The general creepiness will bother people, and that could be counterproductive if it affects their behaviour," says Paul Bernal at the University of East Anglia.

Phil Legg at the University of the West of England says it will never catch every security risk. "If people know they're being monitored, they can change their behaviour to game the system," he says. Timothy Revell ■

How to stop Alexa talking to strangers

DOES your digital assistant know who it's talking to? A wearable device prototype could let voice-controlled assistants like Apple's Siri or Amazon's Alexa recognise their owner and stop them taking orders from anyone else.

The VAuth device, developed at the University of Michigan in Ann Arbor, uses an accelerometer that can be hidden in a pair of glasses or worn around the neck. This measures the vibrations created as you speak. An algorithm then compares those vibrations with the received audio command. If they match, the message is received as normal. If not, the assistant is blocked from responding.

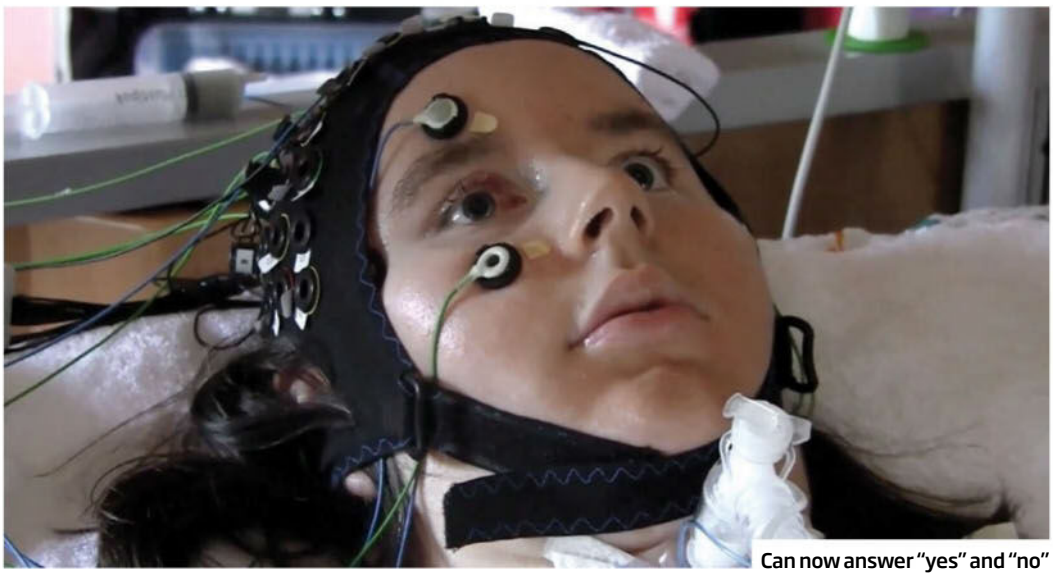
Computer scientists Huan Feng and Kassem Fawaz tested VAuth with 18 people saying 30 different commands to Android assistant Google Now. It matched speech vibrations with audio signals 97 per cent of the time, and didn't act on commands issued by others (arxiv.org/abs/1701.04507). Feng and Fawaz say it would work with other voice assistants.

The technology comes too late for some Amazon Echo owners in California, whose devices overheard a newsreader on TV say "Alexa ordered me a dollhouse", and tried to order the toy online via the Alexa assistant.

Authenticating commands would prevent such problems and stop some methods of "hacking" voice-controlled devices, says Feng. Matt Reynolds ■

AMAZON

Alexa, order more tea



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Can now answer "yes" and "no"

Fully paralysed people reveal they are happy

PARALYSED people have communicated with their families by thought alone, thanks to a technique that learns to recognise brain activity associated with "yes" or "no". The method is non-invasive and has enabled completely "locked-in" people to describe their lives as "wonderful".

The four people involved in the study all have amyotrophic lateral sclerosis (ALS) – a degenerative disorder that causes people to stop being able to control their muscles, until they are unable even to move their eyes.

It has been impossible to know what such completely locked-in people are thinking. "It is assumed that being cut off from communication is one of the worst states a human can be in," says Niels Birbaumer at the Wyss Center in Geneva.

To find out, Birbaumer and his colleagues have combined two devices that record brain activity. The first, called NIRS, measures blood in active brain regions by passing a beam of light through the head. Alongside this, the team used EEG electrode caps to record brainwave activity, to tell if a person was awake or asleep.

The group trained their device to recognise the brain activity associated with "yes" and "no" by posing simple statements. "We might say, 'your name is this, you did that in your past'," says team member Ujwal Chaudhary at the University of Tübingen. It took up to three weeks to train the device to detect "yes" and "no" with 70 per cent accuracy (*Plos Biology*, DOI: 10.1371/journal.pbio.1002593).

"They only have positive emotions – they're basically happy all the time. We don't know why"

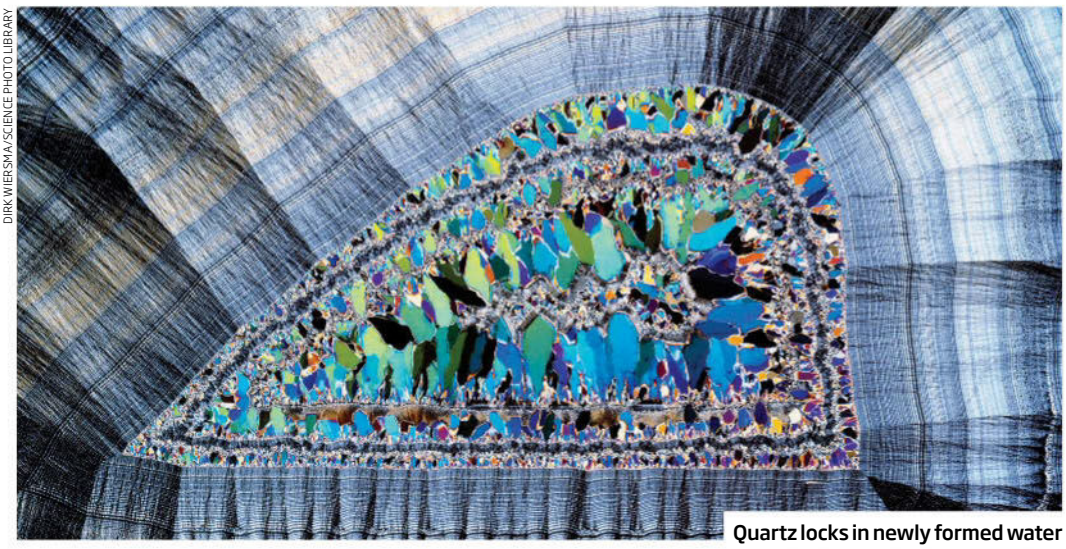
At that point, they started asking the four patients questions the team didn't know the answer to. "We might ask them if they were in pain, or if they wanted to visit a certain place or meet a certain person," says Chaudhary. Each question was asked 10 times. If the team's device recorded a "yes" seven or more times, then they took that as the person's answer. "One of our patients is a young woman, only 23 years old," says Birbaumer. "She told us that she wanted to see New York, so now her family is making preparations to take her there. Another woman wanted to visit her brother in Spain."

"I believe this is very useful," says Nick Ramsey at University Medical Center Utrecht in the Netherlands.

The team used the device to ask the four people if they were happy. "They say that life is wonderful," says Birbaumer.

Many people, including some medical professionals, assume that paralysed people have a low quality of life. Birbaumer says that in his experience, this isn't true. Some research suggests locked-in people are unable to process negative emotions, says Chaudhary. "They're only processing positive emotions, and if that happens, you're basically happy all the time," he says. "We don't know why that is, but it seems as though the brain is trying to protect itself."

The people also gave opinions, for better or worse. One man was asked by his granddaughter if he would give her his blessing to marry a younger man. "Eight times, his answer was no," says Chaudhary. **Jessica Hamzelou** ■



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Quartz locks in newly formed water

Our planet makes water from scratch

Andy Coghlan

EARTH may have an inbuilt water factory. Deep inside the hot mantle, the conditions are right for chemical reactions to turn hydrogen and rock into water.

This might mean our planet's water originated from within, rather than arriving from space through collisions with ice-rich comets – the leading theory at the moment. And this newly formed water is under such high pressure that it could be triggering deep earthquakes whose origins have so far remained unexplained.

That's the upshot of a computer simulation of reactions in the upper mantle between hydrogen and quartz, the most common form of silica in this region.

"This is one way water can form on Earth," says team member John Tse at the University of Saskatchewan in Canada. "We show it's possible to have water forming in Earth's natural environment, rather than being of extraterrestrial origin."

The simple reaction takes place at about 1400 °C and pressures 20,000 times higher than atmospheric pressure as silica, or silicon dioxide, reacts with liquid hydrogen to form liquid water and silicon hydride.

The study simulates this reaction at various temperatures and pressures typical of the upper mantle between 40 and 400 kilometres down. It backs up work by Japanese researchers who performed this reaction in 2014.

"We set up a computer simulation very close to their experimental conditions and simulated the trajectory of the reaction," says Tse.

"This shows it's possible to have new water forming on Earth naturally, rather than it coming from space"

But in a surprise twist, the simulation showed that the water forms within quartz but then can't escape, causing the pressure to soar to as high as 200,000 atmospheres.

"The hydrogen fluid diffuses through the quartz layer, but ends up forming water not at the surface, but in the bulk of the mineral," says Tse. "We analysed the density and structure of the trapped water and found that it is highly pressurised."

Water finally escaping from the crystals could cause earthquakes (*Earth and Planetary Science Letters*, doi.org/bxwx).

"The formation and release of overpressured water may be a significant trigger in the deep lithosphere for ultra-deep earthquakes, sometimes located well below the crust and in the more rigid parts of deep continental plates," says John Ludden, executive director of the British Geological Survey.

The findings also suggest that at least some of Earth's surface water may have come from within. "Water formed in the mantle can reach the surface via multiple ways, for example, carried by magma in the form of volcanic activities," says Tse.

It is possible that water is still being made this way deep inside Earth, and this process could also be occurring inside other planets.

"The study highlights how the minerals that make up Earth's mantle can incorporate large amounts of water and how Earth is probably 'wet' in some sense all the way down to its core," says Lydia Hallis at the University of Glasgow, UK. ■

AI agony aunt gives love advice online

AN ARTIFICIAL intelligence has been trained to give love advice.

NTT Resonant, which operates the Goo web portal, created a system called Oshi-el to answer people's relationship questions on its forums.

"Most chatbots today are only able to give you very short answers, and mainly just for factual questions," says Makoto Nakatsuji at NTT Resonant. But questions about love, he says, are often long and complicated. "They include a lot of context like family or school, which makes it hard to generate long and satisfying answers."

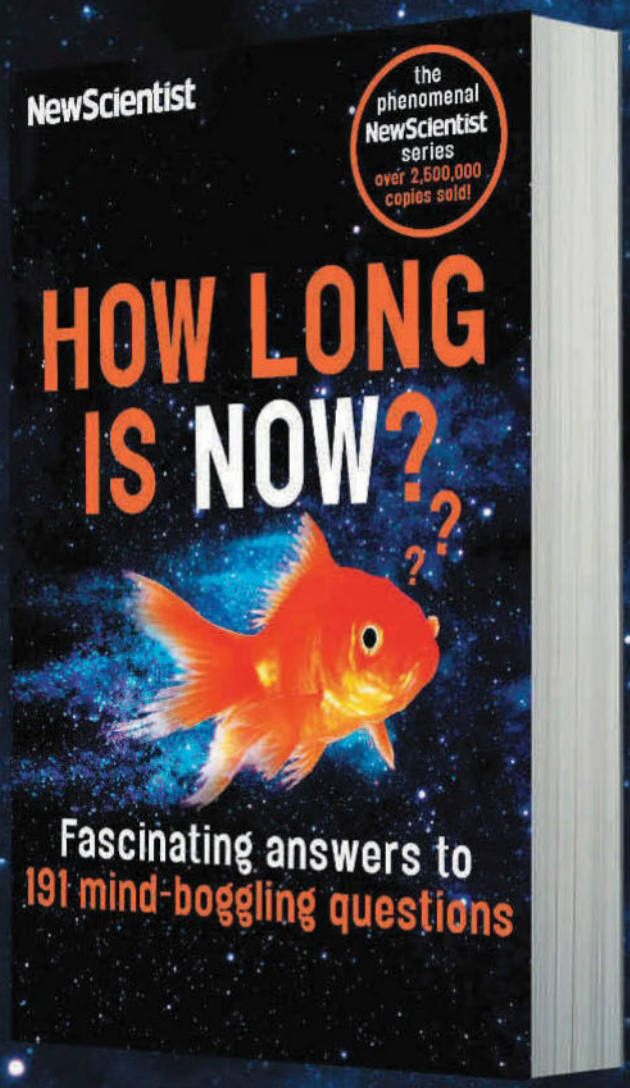
Nakatsuji and his team trained their algorithm using almost 190,000 questions and 770,000 answers from the Oshiete goo forum. They came up with a generic structure for answers that includes a sentence showing sympathy, a suggested solution to the problem, an additional comment and a note of encouragement.

The Oshi-el AI then selects and combines appropriate sentences based on the words in the question and additional context from the title.

For now, the answers still come across as scripted, but they make sense. "I can see this is a difficult time for you. I understand your feelings," says Oshi-el in response to a woman who finds herself stuck in a love triangle (the response has been translated from Japanese). "I think the younger one has some feelings for you. He opened up himself to you and it sounds like the situation is not bad. If he doesn't want to have a relationship with you, he would turn down your approach. I support your happiness. Keep it going!"

It might work for love advice, but this approach is limited. In order to write a more comprehensive answer, an AI would need to "understand" the question, says Di Wang at Carnegie Mellon University in Pennsylvania. "But I think in this case people don't care whether the advice is correct. You can say whatever as long as it sounds good." Kata Karáth ■

WHY ARE DOGS' NOSES WET?



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How to disconnect linked memories

Anil Ananthaswamy

A SIMPLE smell or sound can be enough to bring back memories of a place or person. Now it's possible to link unrelated memories, and separate them again – in mice at least.

Individual memories are stored in groups of neurons, an idea first proposed in 1949. But only now do we have sophisticated ways to examine these ensembles of brain cells.

To see whether two separate memories could be linked, Kaoru Inokuchi at the University of Toyama in Japan and colleagues taught mice to associate certain stimuli with pain.

The team trained mice to form two separate fear memories. First, the mice learned to avoid the taste of saccharine. Whenever they licked a bottle filled with saccharine solution, they were injected with lithium chloride, which induces nausea.

A few days later, the same mice were taught to associate a tone with a mild electric shock. This caused the mice to freeze whenever they heard it, even if no shock followed. They remembered the tone as a traumatic experience.

The team then linked these two memories. Whenever the mice licked saccharine, they were played the tone that scared them, so eventually the mice froze at the taste of the liquid alone.

To unlink these memories, the team turned to optogenetics, a technique that uses light to control specific neurons. The team selectively silenced neurons so that the memories no longer overlapped, and the mice didn't freeze when they tasted saccharine. When the tone was played, however, they were still afraid, proving that this memory had not been erased, just decoupled from the taste of saccharine (*Science*, doi.org/bxxs).

"The fact that you can parcel out these memories and manipulate them in a predictable fashion is remarkable," says Sumantra Chattarji, at the National Centre for Biological Sciences in Bangalore, India. "This was impossible a few years ago."

Inokuchi says similar techniques may one day help people with post-traumatic stress disorder decouple traumatic memories from memories of more mundane events, preventing flashbacks (see page 36). But he warns that the benefits of this – which could involve surgery and gene therapy – will need to be weighed against the risks. "If the psychiatric disease is very serious, then we may be able to apply this approach," he says.

However, Chattarji says PTSD might also involve a different fear mechanism, which may not respond to this technique. The brain's medial prefrontal cortex normally helps suppress fear memories in the amygdala, but this might be impaired in people with PTSD. Strengthening the connections between the medial prefrontal cortex and the amygdala may be an alternative way to suppress such memories, he says. ■

GETTY

Unrelated memories can overlap

Water seen on planet 50 light years away

A FARAWAY world is steaming. Astronomers have found water vapour in the atmosphere of an exoplanet called 51 Pegasi b – and achieved the feat using a brand new technique.

Detected over 20 years ago, 51 Pegasi b was the first known "hot Jupiter" – a Jupiter-like world orbiting close to its star. It isn't the first such planet to have water spotted in its atmosphere, but it is the first non-transiting one.

All previous water detections relied on planets transiting – slipping in front of – their host star as seen from Earth. That's a slight problem, in that most exoplanets never make transits.

In 2015, astronomers estimated that there could be as many as 200 small stars with planetary systems that are closer to us than the nearest star with a transiting Earth-size planet. "If we really want to understand our local neighborhood of stars and their potentially habitable planets, then we need a technique that works on non-transiting systems," says Jayne Birkby at the Harvard-Smithsonian Center for Astrophysics.

That's the beauty of what Birkby and her colleagues have done using the Very Large Telescope in Chile. They observed 51 Pegasi b and its host star side by side, which doesn't typically allow light from the two bodies to be disentangled.

But the team didn't just take a single snapshot. Instead, they watched the system for 4 hours, capturing part of the planet's orbit. As the planet shifted away from and then towards Earth, its light shifted towards redder and then bluer wavelengths, thanks to the Doppler effect (arxiv.org/abs/1701.07257).

"If we want to understand our local neighbourhood of stars and their planets, we need this technique"

Analysing its spectrum allowed the team to pick out its atmosphere from that of the star as well as Earth's, and spot a watery signature.

"The detection is pretty rock solid," says team member Matteo Brogi, at the University of Colorado, Boulder. It's also an important step towards detecting water molecules in smaller, more habitable worlds.

Birkby is particularly keen to use this method with the Extremely Large Telescope, now under construction in Chile. "We think that's probably going to be our best chance for looking at the atmosphere of Proxima b," she says – referring to the Earth-like planet spotted a mere 4.2 light years away last year. Shannon Hall ■

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Tidal wave to test black hole paradox

Jennifer Ouellette

A LASER-driven tidal wave could test a question that has long baffled physicists: is information inside a black hole lost forever or somehow preserved through the mysterious machinations of quantum mechanics?

The defining feature of a black hole is thought to be that anything that crosses the event horizon – the proverbial point of no return – can never escape and is lost forever.

So what happens to everything that has fallen into the black hole? Logic dictates that it, too, should be lost. But quantum mechanics holds that information must be conserved and cannot be lost, hence the paradox.

Unfortunately, there's no good way to study a black hole up close to test what's really going on. So physicists have been exploring "analogue" black holes that mathematically mimic their celestial counterparts.

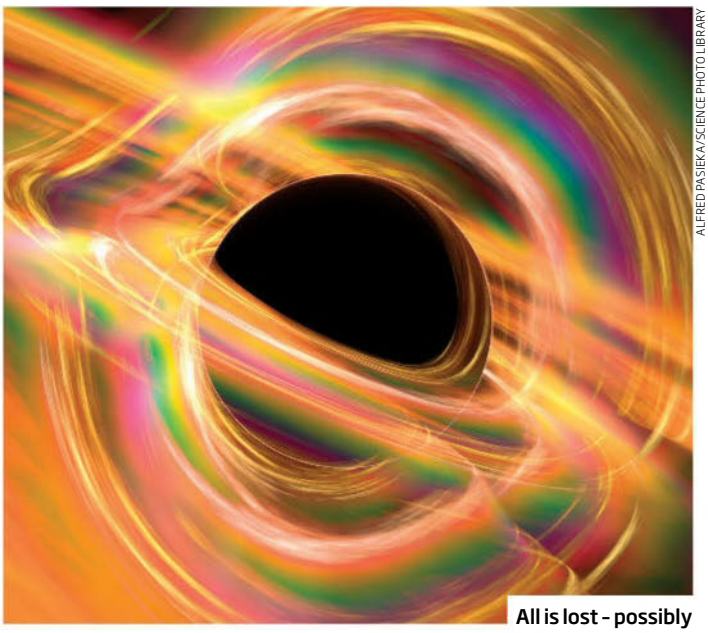
Researchers have suggested that an accelerated mirror could mimic a black hole's event horizon, providing a way to look for these correlations in the lab.

Photons reflected back from the mirror would represent Hawking radiation – the observable effect when one half of a virtual particle pair falls into an event horizon and the other escapes.

The photons trapped at the moving mirror boundary would be the abandoned partners. When the mirror stops moving, it should create a sudden burst of energy, similar to the death throes of a black hole.

Pisin Chen of National Taiwan University and Gerard Mourou of the École Polytechnique in France realised that a next-generation particle accelerator called a plasma wakefield accelerator could act like such a mirror.

These accelerators work by shooting pulses of intense laser light into plasma to create a wave rippling through the cloud of ionised gas, leaving a wake of electrons akin to those that form behind a speedboat in water. As more electrons are pumped into the system, they draw energy from surfing that wake and accelerate, building in intensity like a tsunami.



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All is lost – possibly

"In order to create such plasma 'wakefields', the laser must dump its energy into the plasma," says Chen. "By the law of conservation of energy, the laser pulse as well as its wakefield must therefore slow down."

To counter this tendency, Chen and Mourou devised a way to accelerate the plasma wakefield itself, which can be thought of as a plasma mirror. This can be done, they demonstrate, by tailoring plasma in such a way that its density increases gradually (*Physical Review Letters*, doi.org/bxxt).

Chen and Mourou have yet to build such an experiment, but they believe it can be done with existing technology. The setup could also be used to model other properties of a black hole, such as how it distorts space-time.

The idea is interesting but hard to perform, says William Unruh at the University of British Columbia, Canada. "It is very, very easy to lose entanglement into the environment." ■

LSD could treat depression by altering focus

UNDERSTANDING LSD's mind-expanding effects may help us find new treatments for disorders like schizophrenia and depression.

LSD acts on a range of receptors in the brain, including ones for serotonin and dopamine. What isn't known is exactly which receptors are responsible for its various effects.

To probe the role of a receptor called serotonin 2A, Katrin Preller and her colleagues at the University of Zurich, Switzerland, gave 22 volunteers 100 micrograms of LSD each. In some tests, people also took ketanserin, which blocks this receptor. The team found that hallucinations, feeling separate from the body and a sense of bliss were absent in these tests, suggesting this receptor is responsible for these effects of LSD.

Another test involved volunteers listening to songs, some of which they had chosen as having meaning to them. While on LSD, they rated what had been non-meaningful songs as highly meaningful – an effect also blocked by ketanserin (*Current Biology*, doi.org/bxxv).

Preller thinks this suggests that the serotonin 2A receptor is involved in day-to-day decisions of which stimuli have meaning and deserve attention. "This is incredibly important," she says. "We do it constantly, for example if you see a familiar face."

In psychiatric conditions such as schizophrenia and phobias, too much attention is given to unimportant stimuli. Preller speculates that LSD might help people refocus. "If you have a depressed patient ruminating about negative thoughts, LSD might facilitate a process where you attribute meaning to other things," she says. Alternatively, people with these conditions might benefit from drugs like ketanserin that reduce the action of the serotonin 2A receptor.

"LSD might help a depressed person with negative thoughts attribute meaning to other things"

A second team has examined how LSD binds to another receptor, called serotonin 2B. The group found that a part of the receptor acts as a lid, trapping the LSD molecule – which might explain why LSD trips can last up to 15 hours (*Cell*, doi.org/bxxw). "It takes LSD very long to get into the receptor, and once it's stuck it doesn't go away," says team member Daniel Wacker at the University of North Carolina, Chapel Hill. Sam Wong ■

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ELLEN MULLER

Hermit crab has candy cane legs with a scoop for claw

HOW about a little eye candy? A new species of nocturnal hermit crab, discovered in the Caribbean, fits the bill.

It's called the candy striped hermit crab, after the bright red stripes that run up its white claws and legs. It also sports a large scoop-like claw, which it might use for feeding – though no one knows for sure yet.

Ellen Muller, a photographer and naturalist on the island of Bonaire off the coast of Venezuela, inadvertently snapped a night-time photo of one of these little critters while photographing lobsters. "I saw a strange crab that I'd never seen before, and I do a lot of night diving, so I'd seen all the normal things," she says. "This wasn't normal."

So Muller sent the picture to Rafael Lemaitre, the curator of decapod crustaceans at the National Museum of Natural History, Washington DC. He confirmed that this was indeed a new species (*ZooKeys*, doi.org/bxvr).

Muller found the crabs living nearly 14 metres below the surface in crevices that were occupied by other, larger marine animals. In one, a moray eel loomed in the darkness. After spotting one crab crawling on the body of an eel in photographs, Lemaitre suggests that these crabs could be acting as cleaners, eating mucus or other bits on the eel's body. Their distinctive markings are typical of tropical cleaner fish that use their bright colours and patterns to advertise their services.

Gene editing saves two children

TWO girls given gene-edited cells to kill their cancers are both doing well more than a year later.

An 11-month-old girl called Layla was the first to get the treatment, in June 2015, followed by a 16-month-old girl who was given cells in December 2015.

The treatment is a form of CAR T-cell therapy. This involves using a virus to add a gene to immune cells to make them target specific cancers. The approach normally requires people to be treated with their own modified immune cells. If other cells are used, they can attack the patient's body. However, it can be difficult to extract enough immune cells from very young or ill patients.

So Waseem Qasim at University College London created UCART19 cells with help from Paris-based biopharmaceutical company Cellectis instead. These cells were developed using gene editing to disable the gene that causes donor immune cells to attack their host.

When the team first revealed details about the treatment of Layla, the group stressed that it was too soon to say whether she was cured. But 18 months on, Layla is doing well with no sign of leukaemia returning, and the second child is also healthy (*Science Translational Medicine*, doi.org/bxwj).

Wrinkly cortex? You are a creative type

WHAT are you like? A look at your brain can tell. Scanning the brains of 500 volunteers and assessing their personalities has found a link between brain structure and certain character traits.

The researchers focused on the outer layer of the brain. They found that people who are more neurotic and prone to mood changes tend to have a thicker, less wrinkly cortex. People who seem more curious and creative, say, show the opposite pattern (*Social Cognition and Affective Neuroscience*, doi.org/bxwm).

The link may help explain how we mature. The cortex changes into adulthood, becoming thinner and folding more. As we age, we also tend to become less neurotic. "Our work supports the notion that personality is, to some degree, associated with brain maturation," says Roberta Riccelli at Magna Graecia University, Catanzaro, Italy.

AI spots signs of skin cancer

DEEP learning is taking on dermatology, with a neural network matching doctors in its ability to identify skin cancers.

Researchers at Stanford University in California trained the neural network on more than 129,000 images of skin anomalies associated with 2000 diseases, including melanoma. It was then pitted against 21 dermatologists on new images. For each, the doctors said whether or not they would biopsy the area. The neural network matched or exceeded the clinicians' performance (*Nature*, doi.org/bxwn).

"I'm certain this is how melanomas are going to be identified in the future," says Richard Weller at the Royal Infirmary of Edinburgh, UK.

Pterosaur is flying version of *T. rex*

LACK of CGI didn't stop vintage movies from getting it right. *The Lost World* (1925), for example, depicted pterosaurs as giant flying reptiles that snacked on large prey, and could even threaten humans. New fossils uphold that view, challenging a recent consensus that all pterosaurs were more like overgrown cranes that preyed on rat-sized baby dinosaurs.

Pterosaurs grew large in the late Cretaceous, with a 10 to 12-metre wingspan. The biggest belonged to a family called azhdarchids, but even these had lightly built bodies and heads, with long, thin wings and necks.

The newly unearthed fossils from the Transylvania region of Romania date from 70 million years ago. They reveal a little-known azhdarchid, *Hatzegopteryx*, with a short, massive neck. Much stronger than others in the same family, it probably feasted on bigger prey, such as dinosaurs the size of a small horse (*PeerJ*, doi.org/bxvs).

"The bones we are taking out of Romania show a much more robust and massive animal than we previously imagined," says Mark Witton at Portsmouth University, UK. *Hatzegopteryx* would have been an apex predator, a bit like *T. rex*. With a jaw half a metre wide, it could have swallowed a small human or a child, says Witton.

NAISH AND WITTON (2017)

Parasite turns wasp into zombie then drills through its head

EVEN a master manipulator can be manipulated. The crypt gall wasp parasitises the sand live oak tree, encouraging it to form hollow galls – or "crypts" – in its woody stems. Young wasps develop inside the crypts during the second half of the year, chewing their way out to emerge as adults the following spring.

At least, most of them do. Some wasps begin to chew their way out several months earlier than expected. But instead of emerging they stop and die, blocking the exit with their head.

It now seems that the gall wasp was itself manipulated into an early death. Kelly Weinersmith at Rice University in Houston, Texas, and her colleagues found larvae or pupae of a smaller wasp inside the "head-blocked" crypts, slowly eating the crypt gall wasp.

Weinersmith's team suspected that the smaller wasp (*Euderus set*) might be a "hyper-manipulator – a manipulator of a manipulator. *E. set*, they suggested, might lack the powerful jaws needed to chew through the crypt to leave in the spring, so rather than just devouring the crypt gall wasp, *E. set* first encourages it to chew an exit. Results of their experiments fitted with their idea: if they placed a thin piece of bark over a head blocked exit, *E. set* wasps couldn't chew their way out (*Proceedings of the Royal Society B*, doi.org/bxvt).

Finding out more could carry economic benefits because some *Euderus* species infect agricultural pests. Euderus parasitoids could be released to help control particular pest insects, says Weinersmith.

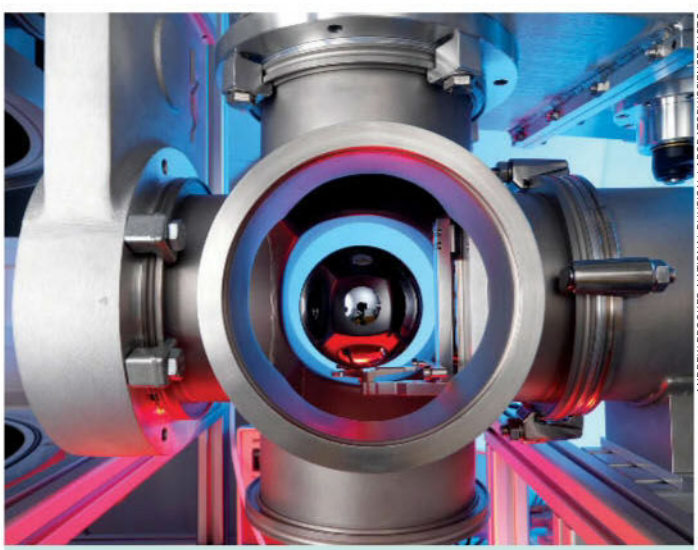
Tight squeeze turns hydrogen metallic

A MAJOR problem in physics may have just been solved. For the first time, metallic hydrogen has been created by squeezing it at pressures greater than exist at the centre of the Earth.

Isaac Silvera and Ranga Dias at Harvard University used the flattened tips of two synthetic diamonds to squeeze solid hydrogen at low temperatures, until the atoms were so packed that they started to share electrons. The shared cloud of electrons indicated a transition into a metallic state, making the hydrogen shiny and electrically conductive.

"If this experiment is reproducible, it solves experimentally one of the major outstanding problems in all of physics," says Jeffrey McMahon at Washington State University in Pullman. Other researchers have expressed scepticism that the feat has been accomplished, however.

The pair managed to turn hydrogen metallic at a pressure of 495 gigapascals, well beyond the 360 GPa of Earth's core (*Science*, DOI: 10.1126/science.eaal1579). The possibility of compressing hydrogen until it became metallic was first mooted in 1935.



ANDREW BROOKES, NATIONAL PHYSICAL LABORATORY/SCIENCE PHOTO

How weigh the perfect kilogram

HOW much does a kilogram weigh? The unit is due to be redefined in 2018, and now physicists have new tools for moving masses in a vacuum, a step vital to the work.

The kilogram is the only base unit in the International System of Units still defined with reference to a material artefact. One way to redefine it is in terms of Planck's constant, which relates the energy and frequency of a photon. A practical method involves a watt balance, a device that converts a measurement of mass into current and voltage.

But first physicists must find the exact mass of each copy of the prototype kilo, which sits in a vault in Paris, while they are in a vacuum. This is tricky because these copies can lose 6 or 7 micrograms as they are transferred from the air to a vacuum.

Also, the slightest touch of a hand can leave oily deposits that add mass, so contamination must be minimised.

Scientific-equipment maker Mettler Toledo has developed a tool to transfer the mass standards into vacuum weighing chambers. The company's stainless steel containers allow transfer from one apparatus to another in a controlled atmosphere.

Where there's smoke

"Eco-friendly" wood-burning stoves are a disaster for air pollution, health and the climate, says **Michael Le Page**

AGENCJA FOTOGRAFICZNA CARO / ALAMY STOCK PHOTO

LAST week, air pollution in London soared to heights not seen since 2011. The usual suspects were named and shamed, including traffic fumes and a lack of wind. But joining them was a surprising culprit.

"We think about half of the peak was from wood smoke," says Timothy Baker, part of a team at King's College London that monitors air pollution.

The trendy log-burning stoves producing much of this pollution are marketed as a source of renewable energy that can cut fuel bills while helping reduce global warming. But recent findings suggest they pose a serious threat to the health of their owners, and are also accelerating climate change in the short term.

If nothing is done to discourage log burning in homes, it could become the biggest source of air pollution in cities like London. In the UK as a whole, wood burning is already officially the single biggest source of an especially nasty form of air pollution.

"I love sitting by a log fire as much as the next person but maybe we need to think again before it's too late," says climate scientist Piers Forster of the University of Leeds, UK.

Air pollution is awful for our health. The smallest particles get into our blood and even our brains, increasing the risk of many disorders including heart disease.

Children are especially vulnerable: high pollution levels impair their lung and brain development. Air pollution from all sources is estimated to cause some 10,000 premature deaths a year in London alone, where it frequently exceeds legal limits.

Wood smoke may be natural, but it contains many of the same harmful substances as cigarette smoke. It's a massive killer worldwide, causing as many as 4 million premature deaths every year through indoor air pollution.

In the UK, however, the problem with pollution from wood fires was thought to have been solved by clean air laws introduced in the 1950s, which banned wood burning in open fires in cities. "The official view is that residential wood burning is a thing of the past," says Gary Fuller of King's College London.

"Stoves produce more pollution during actual use in homes than lab tests suggest"

Yet logs can still be burned in officially approved stoves in cities. Sales of these stoves have soared in the past decade, rising to nearly 200,000 a year. They are marketed as a way for people to drastically reduce their carbon emissions and save on fuel costs.

Even modern stoves described as "low emission" are highly polluting. And in an echo of the diesel car emissions scandal, measurements during actual use in homes show that the stoves produce more pollution than lab tests suggest.

In the "smokeless" fumes coming from the chimney of a house with a modern "eco-friendly" wood burner, Kåre Press-Kristensen of the Danish Ecological Council has measured 500,000 microscopic particles per cubic centimetre. The same equipment finds fewer than 1000 particles per cm^3 in the exhaust fumes of a modern truck. The wood stove was certified as meeting Nordic Swan Ecolabel emission standards, which are stricter than the ones stoves in the UK have to meet.

What this means is that a small increase in wood-burning stoves can produce a big increase in pollution. In Copenhagen, a city of 600,000 people, just 16,000 wood stoves produce more PM2.5 pollution – the most dangerous particles, smaller than 2.5 nanometres – during winter than traffic does all year round, says Press-Kristensen.

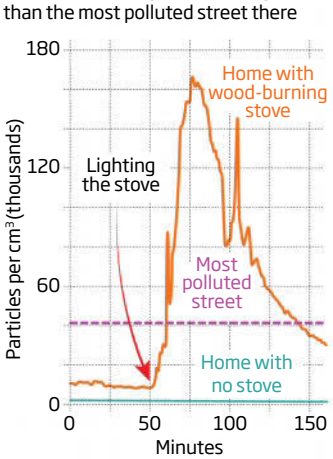
Wood burning is becoming a big problem in London, too. In 2010, when Fuller analysed particulate pollution to discover its source, he found that 10 per cent of all the city's wintertime pollution was from wood.

There are many reasons to think that figure is higher now. A 2015 government survey found that domestic wood consumption in the UK was three higher than previous estimates, with 7 per cent of respondents reporting that they burned logs. "Wood consumption is increasing substantially," says Eddy Mitchell at the University of Leeds, UK.

When he, Forster and others fed the data on wood consumption into a computer model of air pollution, their conclusion was disturbing: PM2.5 pollution from residential stoves is soaring in the UK (see diagram, left).

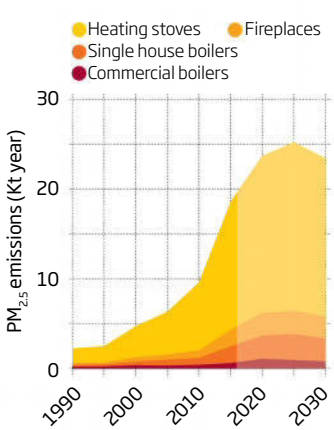
Smoking gun

A correctly installed wood-burning stove has made the air inside one home in Copenhagen more dangerous than the most polluted street there



SOURCE DANISH ECOLOGICAL COUNCIL

In the UK, particulate emissions from wood-burning stoves have risen steeply and are projected to keep rising



SOURCE ATMOSPHERIC ENVIRONMENT 2017

The environment going up in flames

"There is a real risk that if we have a lot more residential wood burning then it could undo our other efforts to control air pollution," says Fuller.

The harm far exceeds traffic pollution, he says. While people are exposed to high levels of traffic pollution mainly when travelling on busy streets, wood burning produces huge amounts of pollution where people live, when they are at home.

Indoor smog

Press-Kristensen has been measuring that pollution inside homes in Copenhagen. In three out of seven tests done so far, he has found very high levels. In one home with a modern log-burning stove, he found particulate levels several times higher than the highest ever recorded outdoors there (see diagram, opposite).

So do the health impacts outweigh any climate benefits? Astonishingly, there might not be any climate benefits, at least in the short term.

Burning logs is often touted as being carbon-neutral. The idea is that trees soak up as much carbon dioxide when growing as they release when burned.

In fact, numerous studies show that wood burning is not carbon-neutral, and can sometimes be worse than burning coal. There are emissions from transport and processing. Logs are often pre-dried in kilns, for instance.

Burning wood also emits black carbon – soot – that warms the atmosphere during the short time it remains in the air. Most studies ignore this, but Mitchell and Forster calculate that over 20 years – the timescale that matters if we don't want the world to go too far above 2°C of warming – soot cancels out half the carbon benefits of all wood burning.

For home wood burning, the figures are even worse. "On a 20-year timescale, wood stoves provide little or no benefit, but they do on the 100-year timescale as they remove some of the long-term warming effect of CO_2 emissions," says Forster.

Press-Kristensen's calculations show much the same thing. And both sets of findings almost certainly underestimate the problem, because they assume wood burning is carbon-neutral.

Defenders of wood stoves point out that there is a lot of uncertainty about how much black carbon is emitted when wood is burned and how large its effect is. Patricia Thornley of the University of Manchester, UK, thinks we need more real-world measurements before coming to conclusions.

"Inside one home, particulates were several times the highest level ever recorded outside"

But the uncertainties cut both ways. For instance, the effects of black carbon can be amplified if it is deposited on snow and melts it, exposing dark land that absorbs more heat. It's possible soot from wood burning is contributing to the fall in spring snow cover in Europe, but it's very hard to study.

More research is needed to pin down the precise climatic effects of wood burning, which can vary hugely depending on factors such as the source of wood and where the pollution goes. What is clear, however, is that burning logs in homes in towns and cities is not the best use of the wood we have.

It produces more pollution than wood-burning power plants that can be fitted with expensive filters, it produces that harmful pollution where lots of people live, and it has the least climate benefits, if any. "If we are going to burn biomass to meet climate targets, then we ought to do it in big, remote power stations," says Martin Williams of King's College London, who is studying the health impacts of the ways the UK could meet its climate targets.

Most researchers say it isn't their role to make policy recommendations, but it would be best if cities like London discourage private wood burning before it becomes an even bigger health problem. At the moment, all the focus is on diesel vehicles.

Press-Kristensen doubts governments will ban wood-burning; France recently backtracked on a proposed ban on open fires, for example. Instead, he proposes installing heat sensors in chimneys and taxing people when they burn wood, with the level of tax depending on how polluting the appliance is.

Most importantly, governments must not ignore health impacts when deciding climate policies, says Press-Kristensen. "I like fires, but I have to say they are as polluting as hell," he says. ■

THINKING OF GETTING A WOOD-BURNER?

Wood-burning stoves are touted as an eco-friendly way to heat your house cheaply. But tests now show that even new, properly installed stoves can produce dangerous levels of outdoor and indoor pollution (see main story). What other options are there?

Consider instead

Stick with gas or oil for heating, and spend your money on insulation. Get a heat pump if you can afford it

Fake it

You can get the same cosy feeling from a log-effect electric or gas fireplace, the best of which are hard to distinguish from the real thing

ALREADY HAVE A WOOD-BURNER?

Here's how to minimise its effects:

Don't burn scrap wood

Scrap wood or painted wood can release highly toxic substances such as arsenic when burned

Burn wood that's just right

Burning dry wood with a moisture content of about 20 per cent minimises pollution. But if wood is wetter or drier than that, pollution increases

Empathy's perilous pull

If only we could feel the suffering of others more, then the world would become a better place, right? Wrong, says **Paul Bloom**

I JUST wrote a book called *Against Empathy*, and some of my friends say they are embarrassed to read it in public. Isn't empathy something only a psychopath would object to?

Many see it as an indisputable force for good that makes the world better. Evil has been equated with "empathy erosion", people are urged to express greater empathy in everyday life, and children are being taught to empathise more in school.

One issue is that people use the term empathy differently; if seen as synonymous with kindness and altruism, it seems hard to object to. But what about when we mean the capacity to share others' feelings? This has its upsides, but as a guide for moral and political decisions, it is a train wreck. Empathy makes the world worse.

For one thing, it is biased. Neuroscience and everyday experience both reveal that it's relatively easy to put yourself in the shoes of someone close, who is attractive and friendly, or who looks like you. But empathy for your enemies, for distant strangers? That's a lot less natural.

Also, empathy makes us zoom in on an individual. We can't put ourselves in the shoes of a million people or even a dozen.

Finally, empathy is malleable, and can be abused to sway people into backing all sorts of positions, including cruel ones. Adam Smith noted that the more we empathise with someone who suffers, the more we wish to retaliate against those causing the suffering. Research finds that more empathic people are the most supportive of violent reprisals.

There is no shortage of real-world examples of how this can corrode judgement – like when the empathy triggered by stories of

Pain brings no gain

We have known for millennia that torture is no way to get at the truth, says **Shane O'Mara**

PRESIDENT Donald Trump says his nation should "fight fire with fire" by using torture on terror suspects, insisting it works.

Does it? Only if you want to coerce someone into stating something they don't believe or repudiate something they do. Or to gather material to fit a pre-determined political or legal process and spread fear. This has been known for millennia.

However, torture fails utterly as a means of getting at the truth, even more so compared with non-coercive investigative methods.

The purpose of a modern interrogation is to get reliable, replicable and verifiable information. Professional interrogators say torture is the worst possible method for this.

Neuroscience agrees. Imposing extremes of pain, anxiety, hunger, sleep deprivation and the threat of drowning does not enhance interrogation. It degrades it. We shouldn't be surprised. Behind the wheel of a car, mild states of sleep deprivation are as risky as drink-driving. Reactions slow, judgement is impaired, and recollection is damaged.

A torturer hopes that enough residual function is unaffected so that intelligence can be gathered. Instead, people say whatever is needed to make the torture stop.

"Imposing extremes of pain, anxiety, hunger and the threat of drowning just degrades interrogation"

What's the alternative? It is to talk. Humans like to talk. Perhaps 40 per cent of what we say to other people consists of self-disclosure. Remarkable brain imaging experiments show that during self-disclosure, the brain's reward system is activated. In other words, we like talking about ourselves. The legendary German interrogator Hanns-Joachim Scharff knew this, debriefing more than 500 allied airmen during the second world war. He never used coercion, but

innocent victims is used to stir up hatred for minorities or to garner support for an unnecessary war.

It's good, then, that we can transcend empathy. Our rationality can guide us to see that skin colour doesn't determine the value of a life, that one person is not worth more than a hundred, that important decisions should be based on cost-benefit analyses and appeal to moral principles.

Some worry that if we don't empathise with others, don't feel their pain, we won't care enough to help. But the drive to improve people's lives doesn't require putting ourselves in their shoes.

Indeed, when study volunteers are taught to be compassionate without empathy, they become kinder and enjoy helping. In contrast, action motivated by the empathic urge is often exhausting – it's unpleasant to experience others' suffering.

I wouldn't want to live in a world without empathy. It's a source of pleasure – enhancing the joy of literature, for instance – and central to close relationships. But for moral choices, there are better alternatives. ■

Paul Bloom is the Brooks and Suzanne Ragen Professor of Psychology at Yale University. His book *Against Empathy* (HarperCollins/Bodley Head) is out now

was incredibly well prepared, cross-checking information carefully. He never asked a direct question, and never indicated any interest in any answer he got. He was adept at taking the pilots' perspective and actively listening. These skills can be learned, and are not so different from the skills of a highly trained doctor.

The lesson for Trump is simple: fighting fire with fire burns down the neighbourhood. ■

Shane O'Mara is a professor of neuroscience at Trinity College, Dublin, and author of *Why Torture Doesn't Work: The neuroscience of interrogation* (Harvard University Press)

INSIGHT Censoring research

ANDY CLARK / REUTERS

Canada's experience holds lessons

To resist US science crackdown, look north

Debora MacKenzie

FREEDOM, said the British writer George Orwell, is the right to tell people what they do not want to hear – such as, he suggested, that two plus two makes four. Empirical facts can be especially unwelcome to political establishments that want to provide their own "alternative" facts.

During his first week in office, President Trump launched orders to gag scientists in federal agencies, and raised the possibility that political officials may now need to clear empirical findings before they can be published. Canadian scientists, who endured a decade of repression under an ideologically similar government, could usefully advise their American colleagues.

The Trump crackdown became apparent last week, when the new administration hit the Environmental Protection Agency with a freeze on all contracts and grants. According to Trump staffers, all existing information published by the EPA would also be examined, and the release of new work put on hold pending possible case-by-case scrutiny. Agency staff have also been barred from updating its social media accounts or talking to the press without clearance from the top.

The EPA isn't the only target. The Department of the Interior's Twitter accounts were shut down after its National Park Service retweeted a comparison of Obama's and Trump's inauguration crowds. The Department of Health and Human Services was ordered not to communicate with external officials – including members of Congress – and cancelled a major meeting on health and climate, apparently to avoid trouble. Similar caution may have led the Department of Agriculture to remind staff to get clearance before talking to the press, and its research division was briefly told not to issue public statements.

"Researchers in Canada reported being leaned on to alter politically sensitive conclusions"

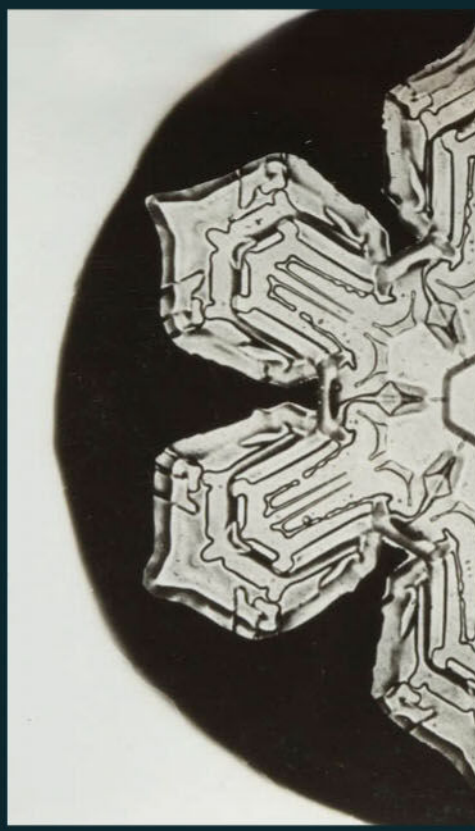
This pattern of gagging and censoring scientists will have a familiar ring in Canada. Between 2006 and 2015, the conservative government of Stephen Harper sacked more than 2000 fisheries and environmental scientists, and cut climate, Arctic and air pollution research.

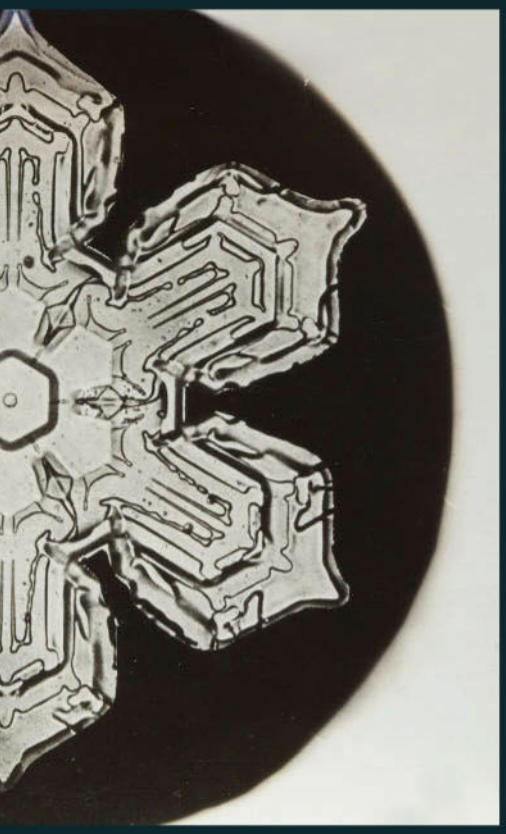
In the course of this, dubbed the "war on science", libraries' journal collections were trashed and researchers reported being leaned on to alter politically sensitive conclusions. Federally employed scientists were banned from speaking in public or t o the press without permission – which was often denied or delayed. Government chaperones sat in on press interviews. Some scientists learned not to speak up at all; climate stories nearly vanished from the press.

"The lesson from the Canadian war on science for US scientists is: speak out now, organise, stand in solidarity, be an activist, and resist," says Michael Oman-Reagan of Memorial University in St John's, Canada.

Some are already doing that. After warnings from Canadian data archivists, US scientists have started making additional precautionary backups of publicly funded environmental data sets. A scientists' march on Washington is in the works. An action group is trying to get more scientists to run for political office.

But political action moves slowly, and scientists face more immediate battles. The first job might simply be to resist self-censored silence and, as Orwell also said, keep restating the empirically obvious – because "the quickest way of ending a war is to lose it". ■





Vintage snow

THESE are some of the first ever photographs of individual snowflakes – "tiny miracles of beauty", as photographer Wilson "Snowflake" Bentley would have it.

Born in Vermont in 1865, Bentley was fascinated by snowflakes from an early age. At 15, he tried drawing them as viewed through an old microscope his mother had given him, but they melted before he could finish the intricate details.

After years of experimentation, Bentley finally perfected the process of catching snowflakes on a blackboard, transferring them to a microscope slide and capturing them on camera. Armed with this technique, he took the first photograph of a single snowflake in 1885, and amassed more than 5000 images this way over the course of his life.

A selection of Bentley's photos form part of the Sixfold Symmetry exhibition, currently on at the Tang Museum in Saratoga Springs, New York.
Timothy Revell

Photographer

Wilson A. Bentley, Snowflakes, 1905-1931
Photomicrographs, Jack Shear Collection; Tang Museum photographs by Arthur Evans

Hidden depths

We are uncovering a new, uncharted layer of reality, says **Anil Ananthaswamy**

STRETCH out your hand. Ever wonder what it's made of? The skin masks flesh, blood and bone sure enough. But those tissues are made of molecules, which are made of atoms. And atoms are made of electrons, protons and neutrons. It's only when we drill down to fundamental particles and energy that we reach bedrock.

Or do we? The history of physics certainly gives us pause. For more than 300 years we have been asking ourselves about the true nature of reality – what, ultimately, stuff is made of. Time and again, we have found another layer beneath what we thought was the lowest. What's more, with each new depth we plumb, our old understanding of reality is swept aside.

Now we could be on the cusp of another revolution, thanks to efforts to reconcile our two most successful but incompatible theories of reality. Not particles, energy, space,time or anything else we might think of as fundamental truly is: instead, the essence of reality is a thing whose workings we're only just beginning to grasp.

Every age has had its own list of reality's basic elements. For the philosopher Democritus, everything was made of atoms. For Aristotle, it was earth, air, water and fire. In the late 19th century, all the talk was of the luminiferous ether, a medium which was thought to carry light.

For most of the past three centuries, however, Newton guided our thoughts on what all things are made of. He thought that reality had three elementary components: time, a cosmic clock ticking away in the background; particles with mass; and a space in which the particles moved, which he called the "sensorium of God". With this trio, Newton constructed a framework for understanding the workings of the universe that was and continues to be astoundingly successful – as long as the particles are not travelling near the speed of light.

But even without that caveat, Newton's work didn't explain everything. Although it provided a description of gravity, the attractive force governing the movement of masses in space, it did not explain what it was. Soon there were other forces, like electromagnetism, which were similarly mysterious. Ever since, we have been embroiled in an ongoing renegotiation of the essential ingredients of reality (see diagram, page 30).

> "Every tangible aspect of reality is likely to be an illusion"

Today, the pressing issue is to unify quantum theory, our best description of the world at the smallest scales, with general relativity, Einstein's masterly theory of gravity. When we try to describe black holes, dense cosmic objects that suck in everything including light, or the big bang, we require both these pillars of modern physics to work together. Then things stop making sense.

The trouble is that quantum theory treats forces as coming in discrete chunks called quanta, but general relativity treats gravity as a smooth and continuous force. All efforts to harmonise things by quantising gravity have so far failed – but they have yielded some clues about what might underlie both theories.

The story of the latest revolution in our thinking begins in the late 1990s, when Juan Maldacena at the Institute of Advanced Studies in Princeton, New Jersey, was working on string theory, a proposed route to unifying things based on the idea that elementary particles emerge from the vibrations of one-dimensional "strings". Maldacena showed that, for a given volume of space-time, a string theory describing gravity inside can be mathematically equivalent to a set of quantum equations, which describe the boundary of the volume but don't include gravity. It all sounds rather technical, but this "Maldacena duality", as it came to be known, hinted strongly at a connection between general relativity and quantum mechanics. That made it worth investigation.

It turned out to have an intriguing link to another concept in physics. In 1935, Einstein and his colleague Nathan Rosen had shown that two black holes could be connected by a peculiarity of space-time, called an Einstein-Rosen bridge – or colloquially, a wormhole. In 2001, Maldacena used his duality to show something extraordinary about wormholes: that they form because the quantum states of the two black holes, as seen from the outside, are entangled, which means they can spookily influence each other's states over distance.

Then in 2009, Mark Van Raamsdonk at the University of British Columbia in Canada, ›

HARRIET LEE-MERRION

began looking at what happens if you change the amount of entanglement between the black holes. He found that this controlled the width of the wormhole: increase it, and the wormhole expands, decrease it and you can snap the connection entirely. It was as if entanglement, a quantum phenomenon, could create space-time, as described by general relativity (*New Scientist*, 7 November 2015, p 30).

Raamsdonk's work led Maldacena and his colleague Leonard Susskind of Stanford University in California to an audacious hypothesis: that space-time in general is created by entanglement. It was a glimpse of a lower level of reality.

Make some space

But only a glimpse. The idea is not yet a fully formed theory, as became clear when Susskind started to mull it over in more detail in the context of a different quirk of space-time: single black holes. These cosmic monsters gobble up matter and create vast swathes of space-time in their innards. It became clear that entanglement can't account for all that virgin space-time. "The numerical value of the entanglement is not big enough to explain what happens behind black holes' horizons," says Susskind.

That needn't be game over though. "There is another element, the capacity for complexity, which goes way beyond the capacity for entanglement," says Susskind. Quantum systems can exist in a superposition of many different states at once, and complexity is a property that grows exponentially with the number of states. It's the growth of black holes' quantum complexity that Susskind reckons might be connected to the growth of space-time inside them, though he doesn't yet have a clear sense of how that would work.

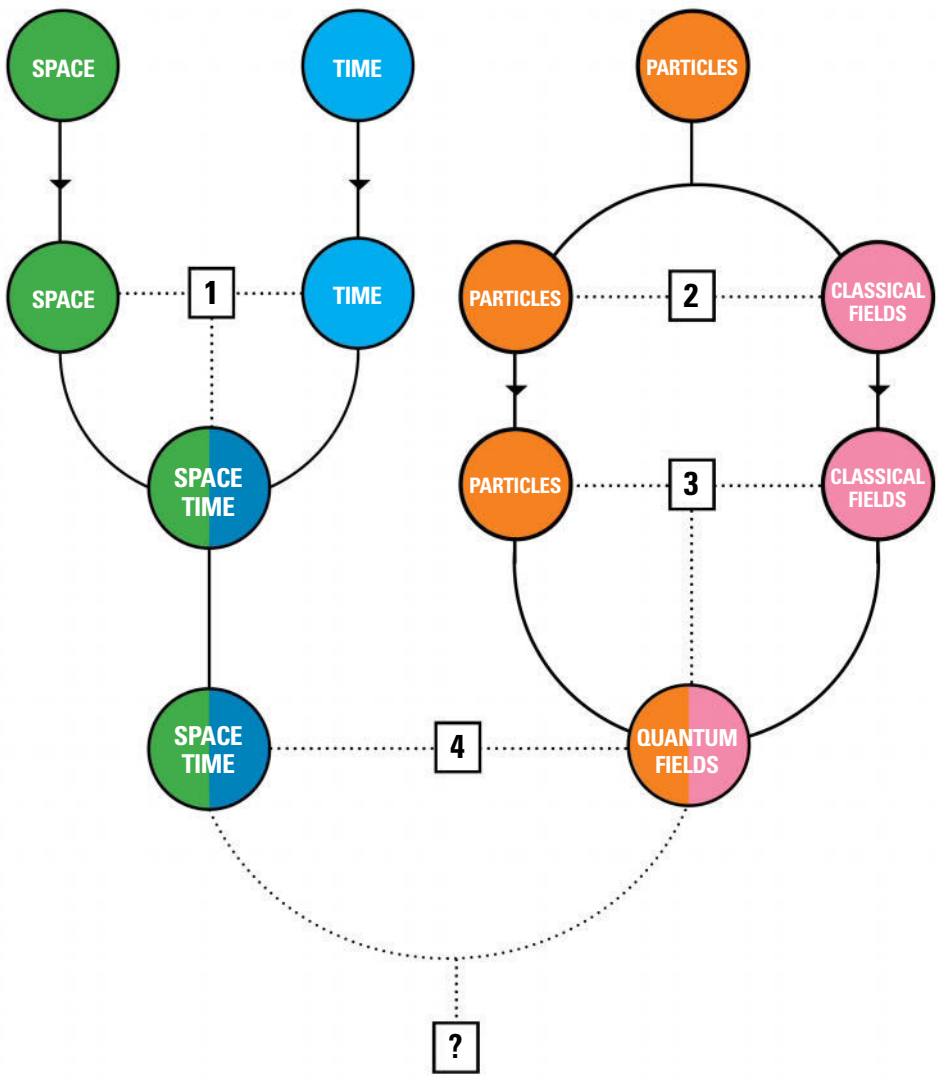
There is, however, a more fundamental objection to all this. The suggestion that entanglement can create space-time was spawned initially by the Maldacena duality, but its underlying mathematics still require a form of space-time to already exist.

For Sean Carroll of the California Institute of Technology in Pasadena, the fact that space-time is not being created from scratch makes it problematic to say these quantum phenomena somehow underlie it. He too thinks there might be some fundamental link, and he's exploring what that might be. But he is not using the duality to do it. "That would be cheating," he says.

Carroll and his colleagues are taking a different tack. They have left out the confusing

Essence of reality

Isaac Newton conceived a universe made of three basic ingredients: particles, space and time. But since then we've narrowed in on just one component



1
To explain how gravity works, Einstein merged space and time into a composite: space-time

2
Michael Faraday added the concept of a classical field that carries forces through empty space

3
Quantum theory showed that all mass and energy are really excitations of underlying quantum fields

4
Quantum fields and space-time are incompatible, so perhaps there is a more basic component hidden beneath (see main story)

entity that is time for the moment (see "About time", right) and begun their work from an abstract mathematical object called a Hilbert space. The elements of this entity represent all the possible states of a quantum system. Any Hilbert space can be thought of as being built up from smaller such spaces. Carroll and his team looked at various Hilbert spaces, identified the smaller constituent spaces each was made from and figured out how much entanglement existed between them. Next, they tried to draw a graph in which the more entangled the parts, the closer they are together. Their question: does such a graph approximate to the familiar, smooth geometry of space?

For any old graph, the answer was no. "It'll be a horrible mess," says Carroll. But when his team sifted through carefully, they did find some graphs that were promising. "There are very specific quantum states that look geometric, and those are the ones we are looking at," says Carroll. For these, as one moved from one position on the graph to another, the transition was relatively smooth,

"Saying space and time are made of entanglement only gets us so far"

suggesting the smooth geometry of space as we observe it could emerge from a purely quantum system.

But both Carroll's and Maldacena's lines of attack only take us so far. It is all very well to suggest that space and time are made of quantum entanglement and possibly quantum complexity – but what are they made of? Here is where we edge closer to finding the true bedrock of reality. Because both approaches suggest the same tantalising answer: information.

The mathematician and engineer Claude Shannon gave us a neat way to define information in 1948. He showed that the amount of information in something like a stream of bits or letters is related to its entropy, a measure of disorder. The greater the entropy, the greater the information. For example, a stream of three-bit numbers that are always 000 contains less information than a stream in which the numbers can also be 001, 101 or 111.

So in what sense is information at the root of things? Well, entanglement is information: the greater the entanglement between two systems, the more information they share. ›

ABOUT TIME

"Time is what prevents everything happening at once." Physicist John Wheeler's statement is as fair a summary of what time does as any other – especially given that our hunt for the most basic ingredients of reality (see main story) has left us a trifle muddled about its status. One culprit was Einstein, whose theory of general relativity merged time with space. But even before him, out understanding of the laws of physics worked the same regardless of whether you travel forwards or backwards in time. That just doesn't tally with our experience. So what is time really? Here are five of our best ideas.

Time… just is

Quantum mechanics arrived fast on the heels of general relativity and reinstated our familiar notion of time. The buzzing of the quantum world plays out according to the authoritative tick of a clock that sits outside of whatever system of particles is being described. Yet for all its respect, quantum mechanics' portrayal of time isn't persuasive. Take the Wheeler-DeWitt equations that describe the quantum state of the whole universe. If the system happens to be everything we know, then where exactly is the quantum clock doing its ticking?

Time is… an illusion

The independent physicist Julian Barbour thinks we might need to kill time entirely. He starts from the view that space and time, united by Einstein's general relativity, must be decoupled. The only way to define space, he argues, is to consider it as the geometric relationship between observable particles, which means no reference to time. This leads him to a picture in which the universe is a set of possible configurations of the three-dimensional geometry of space. He calls each configuration a "snapshot", with each existing "in a space of possibilities". In Barbour's conception, only these snapshots exist. Time is not real, but merely something we perceive – an illusion that comes about because the universe is constantly changing from one snapshot to another.

Time is… an entropic arrow

Yet Barbour's scheme does not address a more subtle question. All of our physical laws are time-symmetric, which means that, mathematically speaking, it is equally possible for things to run backwards or forwards. There is only one exception. The second law of thermodynamics says that entropy, or the amount of disorder, always increases over time in isolated collections of particles and energy. The second law explains why a pot of water doesn't spontaneously warm up, for example. The unique asymmetry of this law has led many physicists to suspect that the resolute forward flow of time we observe is linked to entropy. There is also a quantum version of this "entropic arrow of time", developed by physicist Sandu Popescu at the University of Bristol, UK. Popescu and his colleagues have shown that we can view increasing entropy as the result of increasing quantum entanglement.

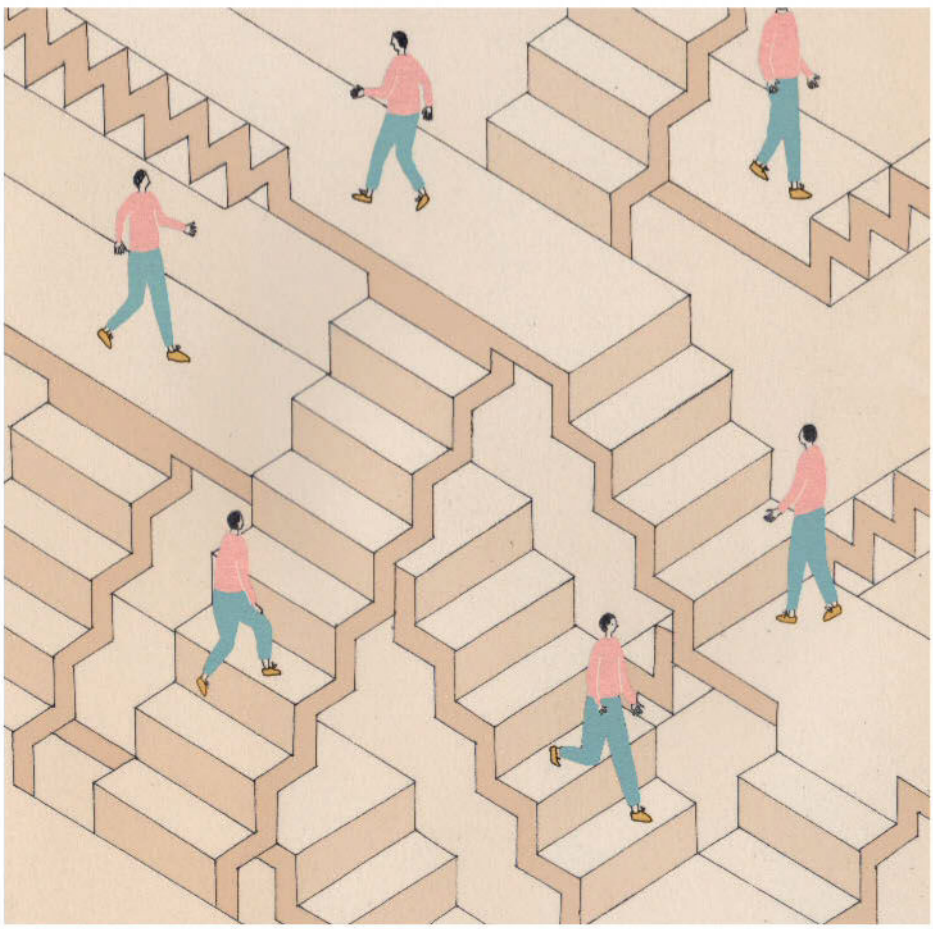
Time is… real after all

The entropic arrow of time might not be the whole story, says Lee Smolin of the Perimeter Institute in Waterloo, Canada. He points out that, if entropy constantly increases, then the universe at the time of the big bang must have been in a low-entropy (highly ordered) state. There is no obvious explanation for why it would have started that way. That returns us to the question of why our physical laws are time-symmetric. Perhaps we simply have the wrong laws, says Smolin. He and his colleagues have been trying out alternative fundamental laws that have time directionality built in. The only snag is that this leads to mind-bending questions, like whether those laws might themselves change over time.

Time… deserves equality

Joan Vaccaro of Griffith University in Australia has been experimenting with putting time and space on an equal footing. Quantum mechanics allows a particle to exist at one location and not another. Maybe, says Vaccaro, it should also let a particle exist at one time and not another, without the need to include interactions that create or destroy it.

When she tried adding in such equations it sent the theory haywire, because they violate a cornerstone of physics – the conservation of mass. But Vaccaro has shown how to recover a tweaked form of quantum mechanics from the wreckage. There may be some experimental evidence to support her ideas. In 2012, the BaBar experiment at Stanford University's SLAC National Accelerator Center in California found that the decay of particles called B mesons is different at different times. That should just not be possible if the laws of physics are time-symmetric. Maybe Vaccaro is on to something – but let's take things one step at a time.



But there's a caveat. The information Shannon defined certainly seems to exist and has real effects. Experiments just last year showed a nanomachine could use information to chill metal. But the sort of quantum information that might underlie space-time must be a little different. The information in a stream of words is about something. By contrast, the quantum information from which space emerges in Carroll's work is just there. "The quantum state is not of or about anything," says Carroll. "It is simply our best mathematical description of the universe."

It actually makes sense that quantum information would be the foundation everything is built on, says Carroll. If you start with quantum mechanics and don't presume anything else exists, then "basically all you have to play with is quantum information". That would make information a basic constituent of the universe. "You can find people who think that information is all there is," says Carroll.

We may even be able to test these ideas, says Sabine Hossenfelder of the Frankfurt Institute for Advanced Studies in Germany. "It's exceedingly unlikely that something truly perfect ever comes into being," she says. Just look at some of the most perfect structures we know of: crystals, defined as being composed of precisely repeating molecular units. In real life, even the most pristine crystals have defects. Something similar might happen if space-time is the product of something more basic. "If space-time is not fundamentally the real deal, then there should be defects left in it," says Hossenfelder. The defects would lead to fleeting deviations from general relativity that we might be able to spot – by monitoring the behaviour of light arriving from billions of light years away, for example.

> "There is no boundary to the universe, so the result could still be wrong"

We are a long way from tests like that. And, regardless, we still harbour a nagging doubt about the finding that started it all: the Maldacena duality.

The thing is, the sort of space Maldacena considered is not quite like real space. He was working with something called anti-de Sitter space, which is mathematically simpler. It has a well defined boundary and volume, the very things Maldacena was able to relate to one another.

It might sound uncontroversial, but the space we observe in the universe has important differences. Crucially, real space is expanding at an ever-increasing rate. This means that there is no sure boundary to our universe, and so no one is yet clear if the duality holds for real space. If it does not, that throws into question all the results built on top of it.

But although our universe does not have a boundary, it does have a horizon from beyond which nothing, not even light, can reach us. And this might offer a way forward. Last November, Erik Verlinde of the University of Amsterdam used this horizon and a set of assumptions to suggest that entanglement really is related to the space-time of our universe. "It's motivated by some of the arguments that Susskind and Maldacena had in their picture," Verlinde says. Based on this leap, he alighted on a modified form of Einstein's equations and showed how space-time and gravity can emerge from entanglement even in ordinary space.

Though there's considerable debate over some of Verlinde's assumptions, there is excitement too. His work provides an explanation for dark energy, one of the most perplexing puzzles in physics. It is thought to be the driving force behind the expansion of space, but this effect arises naturally in Verlinde's framework without the need for any mystery dark ingredient.

If Verlinde is correct, then maybe information really does underlie space and time in the real world. It would be a world in which every tangible aspect of reality is an illusion, with something ephemeral at the bottom.

But to Susskind at least, the idea that reality might be rooted in 0s and 1s is poetically beautiful. Perhaps, he says, we will one day be able to sum up the universe in a simple epigram: "ah, everything is information". ■

Anil Ananthaswamy is a consultant for *New Scientist*

Murder most foul

New Zealand's ecologists have pests and death on their mind, writes **Veronika Meduna**

ENTRY to Zealandia is past a checkpoint where all bags and pockets are turned inside out to stop unwanted stowaways, and then through a double gate. Inside the 2.2-metre-high fence is an ancient world, completely unlike the humming urban environment we just left behind. Bird song soon takes over, the tracks narrow and the forest closes in.

We are inside the old water reservoir for New Zealand's capital, Wellington. Over the past two decades, it has undergone an extraordinary transformation, from urban utility to ecological haven. During the day, large forest parrots called kaka swoop over tuatara, the only survivors of a prehistoric group of reptiles. Night-time visitors have a good chance of crossing paths with a little spotted kiwi. Hihi – small black, white and yellow birds that had once disappeared from New Zealand's main islands – are flourishing.

What you won't see are many mammals: virtually all have been eradicated. Mice (and humans) are the only exception and pest control keeps mouse numbers low.

The sanctuary is a pocket version of something the government would like to see rolled out nation-wide: a step into New Zealand's rich and unusual ecological past. Apart from bats, all terrestrial mammals in New Zealand are invasive species, introduced by humans in recent times. They pose a real threat to native animals, so in July last year, the country's then Prime Minister, John Key, announced an audacious plan. Dubbed Predator Free 2050, it seeks to rid the country of three major alien pests – rats, European stoats and Australian possums – by mid-century. Nothing on this scale has ever been attempted before. But is it feasible?

New Zealand's wildlife is particularly ill-equipped to deal with competition from invasive aliens. When it broke off from Gondwana 80 million years ago, mammals hadn't spread that far. It drifted off into the South Pacific with a cargo of birds, amphibians, invertebrates and a few reptiles.

For millions of years, they evolved without predators, bar a few birds of prey. Evolution veered off in unique directions. Huge cricket-like weta and flightless kiwi scurried around ›

NGA MANU IMAGES

Busted: a possum and a rat share a nocturnal feast of nestlings

TOBIAS BERNHARD/GETTY

Killing to be kind? To save native species, New Zealand is targeting alien invaders

on the forest floor. Giant flightless birds called moa – now extinct – browsed on vegetation like deer. Unfortunately, the process also left these unusual animals with few defences against new competitors and predators.

When humans finally made it to New Zealand, starting 750 years ago, they brought Polynesian and Norway rats, all manner of exotic birds and game like the Australian brushtail possum, imported in 1837 to start a fur trade. The invaders soon got to work. Possums now munch through vast quantities of vegetation each year, prey on nestlings and carry bovine tuberculosis. European stoats, introduced in the 1870s in the hope they might control rabbits, rapidly switched to eating nesting birds and eggs instead.

Ravenous

A single stoat demonstrated the power of mammalian invaders in 2015. Like Zealandia, the Orokonui eco-sanctuary in the South Island is fenced in, but that winter one stoat snuck in. By the time it was caught weeks later, the sanctuary's entire population of a rare bird called the saddleback was gone.

Predator Free 2050's initial focus will be to eradicate invasive predators from all offshore island reserves. By 2025, the hope is to have added a million hectares to the 100,000 hectares of existing pest-free land, and to demonstrate that it is possible to keep 20,000-hectare swathes of land pest-free without fences. And by then, the government also wants to have developed the means to remove at least one alien invader entirely.

"If the proposal was to start working now on the single target of total eradication across all of New Zealand, I would say there was no hope," says Chris Johnson, at the University of Tasmania. "But the concept is scaled in a sensible way, to start with discrete large-island eradications that are highly ambitious but feasible, and move on to still more ambitious projects as new methods are developed." Each of these steps, he says, would be worthwhile even if total eradication is not reached. And the scale of the overall effort is warranted: "Previous success in eradicating predators has saved quite a few species from extinction," he says, "but many of those species persist in numbers that are too small for survival over long periods and they have almost no evolutionary potential."

Piero Genovesi, the chair of the IUCN's Invasive Species Specialist Group, likens the goal to global efforts to eliminate infectious diseases like smallpox. "There is no technical impediment to achieve the targets of the campaign, if adequate resources are invested," he says.

Offshore islands and conservation areas and sanctuaries like Zealandia offer test beds for solutions, and the country is building on a long history of successful eradications. Off the coast of Auckland, for instance, is the 1-hectare Maria Island. Invasive rats threatened the storm petrels that bred there until, in 1964, the Royal Forest and Bird Protection Society got a £5 grant to buy anticoagulant poison. Two years after the poisoning operation, the island was rat-free. "Every decade since then, the size of an island that we have been able to eradicate rats from has gone up by a factor of 10. We are on track to do 100,000 hectares successfully," says Kevin Hackwell, a campaign manager for the Society. "In two more decades we can do the North and South islands."

In New Zealand
40% of native birds
& 85% of reptiles
are threatened or at risk of extinction

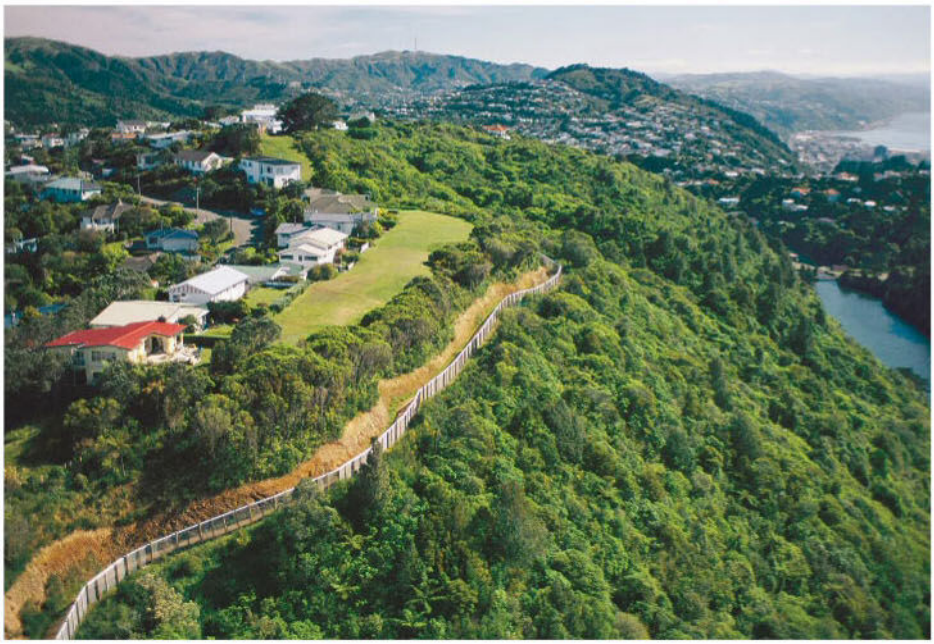
Poison, dropped by helicopter, is standard practice for clearing rats from offshore islands. The poison is incorporated into baits like flavoured cereals, designed to be attractive to pests but not native wildlife. Aerial drops are effective but not an option in populated areas. So on the mainland, good old-fashioned traps and bait stations are frequently used, including by hundreds of pest-busting community groups. They target invasive species in halo zones around fenced sanctuaries and build corridors between protected areas.

In Dunedin, for instance, volunteers hope to establish a pest-free corridor from the Orokonui sanctuary to the Otago peninsula, where residents are using traps that can take out a dozen possums without having to be emptied or reset by people. Once it has removed all possums, the Otago group will run a dense line of traps across the peninsula's narrow neck to keep them from coming back. The government plans to build similar networks to help achieve the national goal.

Controlling pest populations outside sanctuaries is one thing, but exterminating them is another. The hardest part is finishing the job. For this, New Zealand is going to need new solutions. "We're thinking about what rats do when they are lonely," says Al Bramley, CEO of Zero Invasive Predators, a start-up that is developing ways to find and kill mammals. His company is testing a scent-based lure in

DAVID MUDGE/NGA MANU IMAGES

Life used to be a lot easier around here



FRANS LANTING/MINT/GETTY

Zealandia is a fenced-in safe haven for kiwi and other wildlife

the hope of attracting lonesome rats. In field tests, they found that hanging 1 gram of used rat bedding inside a trap allowed them to catch 50 per cent more rats than if they use food. At Victoria University of Wellington, ecologist Wayne Linklater is hoping to identify the chemical substances in rat urine that are such a draw to them. His research could then be used to make synthetic lures. James Russell of the University of Auckland and a lead researcher on the government project says biosensors that could detect rare predators better than dogs are another focus.

Elsewhere, teams are turning to the pests' genomes to develop species-specific toxins that wouldn't pose a threat to native wildlife. Stoats are notoriously hard to catch and poison. Using their genetic sequence, a team at Lincoln University has developed a stoat-specific poison that stops their red blood cells from carrying oxygen. It was approved for limited use in 2011.

Finding ways to kill pests isn't the only issue. With any large-scale ecological project there is the chance of unwanted repercussions. Take the effort to remove invasive feral cats from Macquarie Island in the South Pacific in the 1990s. Once the cats were gone, rabbits bred out of control, devastating the vegetation. The subsequent rabbit eradication cost $23 million.

These sorts of links between pests have to be taken into account when deciding how and in what order New Zealand's predators are wiped out, says ecologist Andrea Byrom, a lead scientist for the project. For example, if you started by only killing possums, you would risk giving rats a boost, since they eat the same plant seeds. And stoats eat rats as well as native wildlife. So if only the rats were taken out, native species would probably suffer. "There are going to be complex ecosystem-level responses," says Byrom.

Her favoured approach would be to use poisons, traps, lures and genetics to eradicate several species simultaneously. If that's not possible, she believes it would be best to take a bottom-up approach, removing prey first. "Then you would move really fast to take top predators out as quickly as you can," she says, "accepting that in the short term you'll see prey switching, possibly to native species."

COSTING UP THE KILL

Extermination doesn't come cheap. The New Zealand government has pledged NZ$28 million ($20 million) towards the goal of eradicating rats, stoats and possums from the entire country. An associated joint venture aims to triple that through investments and donations, but that is still only a small portion of what is needed. Ecologists and economists put the overall cost at NZ$9 billion.

But the financial cost of not doing it is also large. Invasive predators damage crops and both possums and stoats carry bovine tuberculosis, itself a target of national eradication at an annual expense of NZ$40 million. The Department of Conservation already spends NZ$20 million each year keeping possums, stoats and rats at bay – more than that during "mast" years, when unusually high beech seed production fuels rodent plagues.

Paul Jansen, of the government's Department of Conservation, believes the benefits will be seen relatively quickly. "If you suppress pests below a certain level, wildlife and plant life recover, so even if it takes 50 years to eradicate, we'll start to see the benefits within the first decades," he says.

Another ecological consequence could well be that some native birds do too well. "We're already starting to see tui, kaka or pukeko becoming a nuisance to people in urban gardens and horticultural areas," says Byrom.

The fight for New Zealand's native species may be won or lost in the backyard. Here, rats are the primary target, and every citizen will have to be on board. Ecologists not involved in the project have called this an enormous and largely unconsidered cloud. Success, Russell concedes, will hinge on a "virtuous social tipping point where trapping in your backyard is considered absolutely normal and there's something wrong with you if you don't do it".

2-6% per year

Rate at which kiwi are declining in areas without pest control – fast enough to disappear within a human generation

It's a big ask, but cities are on-board. Wellington has declared its own goal to become the world's first predator-free capital. Neighbourhoods and schools are setting rat traps and there are already a few rat-free corridors. Whether or not that attitude will prevail, only time can tell. ■

Veronika Meduna is a freelance writer based in Wellington, New Zealand

Mental blocks

We can rebuild memories to remove debilitating scars of past traumas – and perhaps more besides, finds **Helen Phillips**

RICHARD WILKINSON

LOUISE had been haunted by his face for 30 years. Racked with anxiety, she could barely sleep. When she did, horrific memories of being raped, aged 12, by her doctor spilled into nightmares. Then, after a single, experimental treatment, the haunting stopped.

Louise is one of an increasing number of people who have been helped by techniques that seem to free individuals from the torments of a traumatic memory. Those who have been raped are not the only ones to benefit. Soldiers haunted by visions of war and survivors of terror attacks and natural disasters are being helped by pills, electric shocks, even video games.

And as we continue to learn about how our brains form and maintain memories, far more might be possible. The focus until now has been on removing a memory's emotional sting, but we might also excise entire memories at will, or even recover ones wiped out by Alzheimer's disease. "We can break into the time machine and really reverse-engineer it, hijack it or jump-start it," says Steve Ramirez at Harvard University. "We can really try to fix memories."

Memories are physically imprinted on your brain. If you remember any of this article in a few days' time, it's down to changes in how your brain is wired. Over a number of hours or a night's sleep, your initial memory is consolidated for long-term storage by a suite of genes, which switch on to make the proteins that rework and reinforce neural connections. Only when this process is complete does a memory become permanent, like a book shelved in a vast library.

That, at least, is what we thought. But in 2000 Karim Nader, a neuroscientist then at New York University, showed something rather different. He had set out to test whether retrieving a memory, like its consolidation, required protein synthesis. He trained rats to associate a particular sound with a small electric shock, until they learned to fear the sound. When Nader then injected a drug known to block protein synthesis into the rat's brain as he played the sound, he found the association was erased: the rats were no longer afraid. They could later relearn the association, however, and there was no effect on the rest of their memory.

Nader says he was blown away. The implication was that recalling a memory renders it unstable all over again, just as if it were a new memory being laid down. This means that memories are not permanent, but are built anew every time we recall them – a process now called reconsolidation.

That opens up new avenues to manipulating memories. "We normally think of memory as a tape recorder or like a video of the past, but it's actually very reconstructive in nature," says Ramirez. "It's becoming more obvious that memory is really dynamic and it's very easily modifiable when recalled."

An open window

Even before Nader's 2000 study, clinicians had had patchy success alleviating the terrifying flashbacks of post-traumatic stress disorder (PTSD) using cognitive behavioural therapies, and also a drug called propranolol that more typically treats high blood pressure, anxiety and migraine. The trouble was that people had to be treated within a few hours of a traumatic event, before the memory had consolidated.

Nader's insights brought the realisation that there was a window for treatment that could be gently eased open at any time. In the past few years, that's just what researchers have begun to do. In 2013, Marijn Kroes, a neuroscientist at New York University, succeeded in manipulating the memories of people with severe depression who were undergoing electroconvulsive therapy. First, he showed them two stories with unpleasant narratives – a car crash and an assault. A week later, just before their scheduled ECT session, the volunteers were given a brief reminder of one of the stories to reactivate the memory.

When asked to recall the stories 24 hours after their ECT – long enough for reconsolidation to have occurred – they could not do so for the memory that had ›

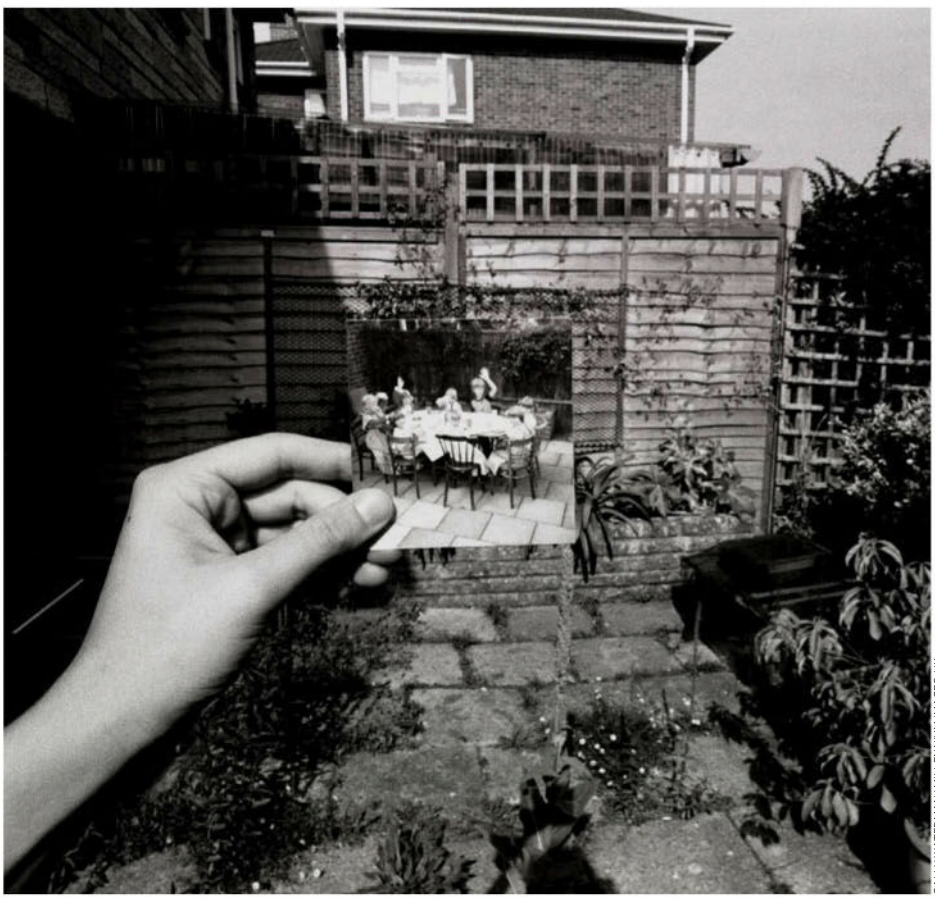
been reactivated. They remembered no better than chance, says Kroes; they might as well have been guessing. This confirmed that ECT had blocked reconsolidation, that remembered experiences can be lost – and that the effect is not limited to conditioned fear.

You don't need shock therapy to achieve similar results, either. Alain Brunet, a clinical psychologist at McGill University in Montreal, Canada, works with those who experienced the April 2015 earthquakes in Nepal and the November 2015 terror attacks in Paris. Initially, he asks people to write about the worst aspects of their trauma in the first person. Then they take a dose of propranolol at weekly intervals over six weeks. On each occasion they reread what they wrote, thus reactivating the traumatic memory under the drug's influence. "More or less two-thirds of people benefit from the treatment," says Brunet. "Which is as good as it gets in psychiatry."

Exorcising ghosts

It's not clear exactly what propranolol's mode of action is. Some researchers think it must interfere with protein synthesis directly. Others surmise that the benefits seen in PTSD are an indirect result of its calming effect on the physiological symptoms of stress or emotions through lowering blood pressure. Whatever the case, it seems to work. It was what helped Louise, who was tormented by memories of her rape. After treatment with propranolol her insomnia was gone, and her depression and nervousness of other people were a distant memory.

Encouraged by such successes, Brunet has recently begun trials with substance abusers to suppress memories that underlie cravings or cause relapse, as well as with people haunted by accidents and those struggling to recover from a romantic betrayal.



SALLY WATERMAN/MILLENNIUM IMAGES, UK

Forgotten but not gone: new treatments can help retrieve hidden memories

Phobias might be eliminated in the same way. In 2015 Merel Kindt at the University of Amsterdam in the Netherlands asked people with a lifelong fear of spiders to spend 2 minutes facing a tarantula in a terrarium. Many of them had trouble even entering the room. Immediately afterwards she gave them a dose of propranolol and asked them to return to the terrarium a day, a month or even up to a year later. Despite some initially reporting that their horror of spiders was unchanged, all the volunteers who had taken the drug entered the room, and all were calmer and more confident than those who had taken a placebo. Most were even willing to touch or hold the spider.

If taking a drug to manipulate memories sounds sinister, it seems even playing a video game might do the trick. Emily Holmes at the Karolinska Institute in Stockholm, Sweden, and Ella James at the UK Medical Research Council's Cognition and Brain Sciences Unit in Cambridge asked volunteers to watch videos of distressing events. A day later, they were shown images from the films to reactivate their memory and then asked to play *Tetris*. The game was chosen for the demands it makes on the brain's visual and spatial processing. The idea was that it would compete with the largely visual flashback memories the participants would be

"We can reverse-engineer the brain's time machine, hijack it or jump-start it"

ANTI-MEMORIES

The progress in taming traumatic memories (see main story) raises a question: what makes them so persistent in the first place? We know that stress can make memories stronger – something that makes sense if improved recall of dangerous situations can help us survive and reproduce. But it's far from helpful when our memory system causes terrifying flashbacks and panic attacks.

Normal brain functioning depends on a delicate balance of excitatory signals that stimulate an individual neuron's activity and inhibitory processes that dampen activity. Too much excitation can lead to uncontrolled epilepsy, for example.

With that in mind, Helen Barron at the University of Oxford has proposed that inhibitory connections might also be stabilising the network of neurons during memory formation, perhaps to keep memories from being expressed at inappropriate times. She calls these inhibitory connections "anti-memories".

Last year, she and her colleagues were able to show for the first time that inhibitory memories do indeed play a part in human memory formation and recall. She showed volunteers pairs of shapes and used functional brain imaging to reveal the neural activity associated with the newly formed memory. Over time these memory traces seemed to fade – not, Barron surmised, because they were being lost, but because they were being masked by inhibitory anti-memories. Sure enough, by blocking the main inhibitory signal chemicals using an electric current applied near the scalp, she was able to reveal the memory, still present.

This suggests a new way to tackle unwanted or intrusive memories – as well as memories that fail to surface. "If a memory isn't stored properly, that could be because the inhibitory part of the memory is not perfectly balancing the excitatory part," says Barron.

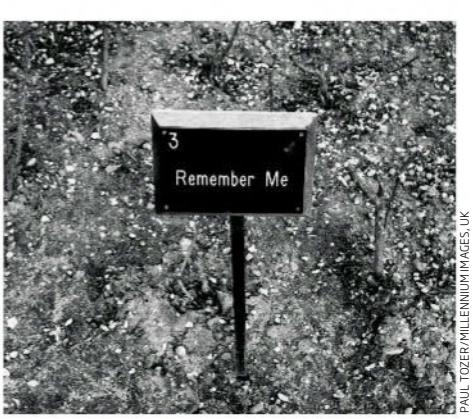
It's early days yet, but such insights raise the prospect of creating therapies for all kinds of memory-related conditions, not least Alzheimer's disease, where memories may lie hidden – irretrievable, rather than lost entirely. Even conditions that don't seem like memory problems, such as schizophrenia and autism, could come down to faulty anti-memory networks, Barron thinks, with the spontaneous activation of imagery and memories experienced as delusions or hallucinations.

vulnerable to during reconsolidation.

It worked. Playing *Tetris* seemed to reduce intrusive flashbacks without hindering intentional recall. The approach is now being tested in people who have experienced real trauma as a way to prevent harrowing memories taking hold. Lali Iyadurai at the University of Oxford, for example, has taken it into the emergency room, to help people who have been in road accidents. Antje Horsch at Lausanne University Hospital, Switzerland, is using the technique to help women who've had a bad experience during childbirth.

Nader argues that reconsolidation therapy, as it's now called, has such striking benefits that there's no reason it can't be used to treat every kind of psychopathology, providing the timing and nature of the intervention is carefully controlled. As we delve deeper into the mechanics of memory consolidation and reconsolidation, there are even suggestions we might revive memories thought lost to degenerative brain conditions such as Alzheimer's (see "Anti-memories", above).

We might even soon develop drugs to delete problematic memories entirely. In 2006 Todd Sacktor, a neurologist at the State University of New York in Brooklyn, identified a molecule without which memories simply wither and die. The enzyme PKMζ seems to linger and perhaps even replicate at synapses, the neural junctions that are rewired as memories form and strengthen. Mice with extra PKMζ have exceptional memories. Without it, they can't remember a thing. Sacktor found he could delete a specific memory if, during its reconsolidation, he blocked PKMζ using a chemical called ZIP. It even seemed to reduce the memories that create drug cravings in addicted rodents.



PAUL TOZER/MILLENNIUM IMAGES, UK

The idea suffered a wobble in 2013 when two groups showed that mice lacking the gene for PKM could still form long-term memories, and that ZIP could still wipe memories in those mice. But Sacktor and his colleagues recently showed that a molecule called PKMι/λ takes over in the absence of PKMζ.

Ethics warning

Even so, ZIP is toxic and too risky to test in humans. Nevertheless, Sacktor and Nader, who has also worked with ZIP, believe that eventually an alternative way to manipulate PKMζ will be found. Chronic pain, in which pain signals are enhanced by a process in the brain that looks a lot like memory formation, is among the conditions Nader suggests as suitable targets.

But even if practical problems can be overcome, is it ethically right to meddle with memories? If you find the idea unsettling, you're not alone. Questions were being raised almost as soon as Nader discovered how to soften up memories for reshaping. In 2003 the US President's Council on Bioethics warned that using pharmacological agents to rewrite memories "risks making shameful acts seem less shameful or terrible acts less terrible than they really are". Some have drawn parallels between the research and the 2004 film *Eternal Sunshine of the Spotless Mind*, in which scientists erase the shared memories of a couple who have been through a painful break-up.

The dystopian scenario is that these techniques might be used for military advantage, to wipe memories of genocide or other atrocities, for example. For that reason it is important to maintain a distinction between wiping memories and ridding them of their negative emotional associations, says Holmes. "Our ethical position is quite clear: we should not erase memories. We think it is irresponsible, and you don't need to erase memory to treat trauma." We devote a lot of resources to alleviating physical pain, after all. Why should we treat the psychological version any differently? ■

Helen Phillips is a *New Scientist* consultant based in Devon, UK

Sibling saviours of the maternity ward

When Shiranee Sriskandan rescued a box of 80-year-old infection samples from the wrecking ball, she rediscovered pioneers of the dawn of antibiotics, **Leonard** and **Dora Colebrook**

LAURA GALLAGHER/IMPERIAL COLLEGE LONDON

THE stranger's warning came to Shiranee Sriskandan by email: an irreplaceable collection of streptococcus bacteria was about to be destroyed. The samples were in a building awaiting demolition at Queen Charlotte's Hospital in London, and if she didn't save them, they would be gone forever. Sriskandan had no inkling of the journey through history this tip-off would set her on.

It was 1998, and Sriskandan – an infectious disease physician and microbiologist – was studying group A streptococci at Imperial College London. Intrigued by the message, from a retired microbiologist, Sriskandan and her PhD student hightailed it to Queen Charlotte's. Construction workers let them into the boarded-up building, empty except for an enormous cardboard box.

The box was full of broken sample bottles and smaller boxes. "I could see the labels. They looked like some quite alarming potential pathogens," says Sriskandan. So she and her student donned protective clothing, extracted three or four intact boxes, put them in a big biohazard bag and made their exit. Experts were called to safely dispose of the rest.

Inside the boxes were yet smaller ones, containing about 1000 glass ampoules labelled with codes. Digging around in the boxes some more, Sriskandan found index cards listing patients' names – like Ada and Florence – alongside dates from the 1930s. Each card also had a code matching the ones on the ampoules, and gave the source of the sample, such as blood culture.

Investigating further, Sriskandan discovered that her rescued samples had been collected by Leonard Colebrook, a doctor at Queen Charlotte's in the 1930s. His research had focused on puerperal sepsis: bacterial infections acquired by mothers during or after childbirth, a common and deadly occurrence at the time. Sriskandan had been unaware of Colebrook, but he turned out to be a fascinating character. He was a friend of Alexander Fleming, who discovered penicillin in 1928. Yet Colebrook's crucial role in pioneering antibiotics is largely forgotten.

"Almost at once there was a surprising and most gratifying change"

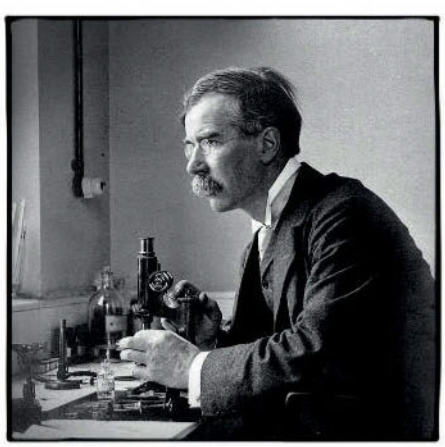
Before 1930, about 2000 women died each year from puerperal sepsis in England and Wales. The main cause had been established as group A streptococcus, which also causes tonsillitis and scarlet fever. But doctors had no weapons with which to fight the bacteria. Then in 1935, before penicillin's potential was realised, there was a breakthrough. German scientist Gerhard Domagk infected 26 mice with streptococci from a human infection. He injected 12 of the rodents with a single dose of a red dye called Prontosil red. The treated mice all survived. All the untreated ones died.

After discovering Domagk's report, Colebrook got hold of the drug and repeated the experiment. It worked, but some of the mice showed kidney damage. As a result, he was reluctant to give the drug to his patients, but faced with a dying woman and no other options, he was obliged to take the chance. While the mice had turned pink from the dye, this woman's skin turned blue. But her high temperature returned to normal overnight, the harmful bacteria disappeared from her blood and her colour returned. The same thing happened in the next patient. "Almost at once there was a surprising and most gratifying change," Colebrook would later recall.

By August 1936, he had given Prontosil to 64 women. In the five years before using the drug, the death rate among his patients with puerperal sepsis was 1 in 4. With Prontosil, he reported, that rate plummeted to just 1 in 20. Colebrook's study was the first ever clinical trial of any antibiotic. It was a very big deal.

Within a year, French scientists discovered that Prontosil was broken down in the body into a simpler compound, sulphanilamide, which was curing the infections. Colebrook repeated his study with sulphanilamide and found it had the same effect. It was soon manufactured in huge quantities, predating

Shiranee Sriskandan rescued about 1000 sample ampoules, collected and tested by Leonard Colebrook and his (sadly, camera-shy) sister Dora



WELLCOME LIBRARY, LONDON; ABOVE: DAVE STOCK

the general use of penicillin by a decade. Sulphanilamide was widely used in the second world war to prevent and treat wound infections, saving countless lives.

Sriskandan was stunned to discover the medical history of her rescued samples, and it gave her an idea. Using modern techniques, she attempted to regrow the streptococci from the ampoules. Most were no longer viable, but she succeeded with about a dozen.

Two regrown samples looked unlike any streptococci Sriskandan had ever seen: the capsule surrounding the bacteria was much bigger than usual. She thought they must be from the same patient, but the cards showed otherwise. They were from two different women, and the samples were taken three weeks apart. It was no coincidence, though – genetic analysis of the bacteria suggested the two cases were linked.

Sriskandan was excited to have traced the progress of an outbreak that happened 80 years earlier. But what she had worked out using modern genetic techniques had already been pieced together in 1935. Leonard Colebrook's sister Dora, also a scientist at Queen Charlotte's, had used a much more basic – and painstaking – method to find links between cases.

Dora Colebrook was investigating how streptococcal infections were passed around the hospital. She meticulously collected samples by swabbing patients, their families and staff. To work out which bacteria were related, she grew them from the swabs, boiled the cultures and, once cool, injected them into rabbits so they produced antibodies against that particular strain. Next, she extracted these antibodies and pitted them against bacteria from other swabs. If the antibodies reacted, she knew the bacteria must be similar.

Colebrook's work brought home to the medical community that the group A streptococci that endanger women around childbirth also circulate in the general population and cause sore throats. "They're not special bacteria and therefore people with respiratory tract infections due to group A streptococci are a threat to women who have recently given birth," says Sriskandan.

Colebrook stressed the importance of wearing masks and gloves in obstetrics, of sterilising instruments, handwashing and isolating people with infections. She was not the first to appreciate the risk medical staff posed to their own patients, but many still believed that women carried the bacteria before giving birth, and that cleansing the birth canal could prevent harm. Colebrook showed that the bacteria are acquired after childbirth, not before.

Reinvent the wheel

Even now, medical staff often have to relearn these lessons. In 2011, after an outbreak of group A streptococcus killed two mothers in the UK, Sriskandan was part of a team that published new guidelines on preventing such infections in hospitals. "I felt that we were reinventing the wheel because the advice about isolation of patients with streptococcal infection, about the importance of hygiene, was known thanks to Dora Colebrook."

The 1930s bacteria that Sriskandan revived were witness to a pivotal period in the history of medicine. The first antibiotics, pioneered by Leonard Colebrook, and the establishment of good hygiene practices, spurred by Dora Colebrook, helped to turn bacterial infections from a deadly horror into a treatable affliction.

Leonard Colebrook has faded unfairly into obscurity, while his friend Fleming passed into the history books. Fleming had a story of great serendipity on his side, which his employers exploited to great effect in fundraising and PR efforts. Colebrook was altogether more modest. "Credit should never be given to any one person," he used to say. "Medical research is like continuing the building of a wall: you only add your work on to the work others have done before you. If you're lucky… you may be the one privileged to add a whole new brick. I hope perhaps I have added a little mortar. Only time will show whether that mortar will hold."

And hold it has. What's more, saved from the wrecking ball at Queen Charlotte's Hospital, his samples have helped Sriskandan discover new insights into the long-term evolution of group A streptococcus – knowledge that could prove crucial in ongoing efforts to develop a vaccine against it. ■

Sam Wong is a reporter for *New Scientist*

Death to nature

There is no natural world separate from humans, finds **Frank Swain**

Making Nature: How we see animals, Wellcome Collection, London, to 21 May

DO you smile?
Do you make your bed?
Do you plan in cooperation with others?
(Male) Can you be sure you are the father of your children?
Are you rational?
Do you love?
Have you bitten a penis off?

These amusing, beguiling, disturbing questions are among dozens posed by Marcus Coates in *Degreecoordinates, Shared Traits of the Hominini (Humans, Bonobos and Chimpanzees)*, a wall-spanning artwork that confronts visitors to the Wellcome Collection's Making Nature show. It makes a fitting prologue to its year-long examination of our relationship with the natural world, showing how tenuous the lines we use to separate ourselves from it really are.

The Paris Agreement came into force in November and there is a growing consensus that the Anthropocene is real. When all of Earth is touched by human activity and worldwide efforts are under way to redirect climate patterns, does it make sense to talk about a "natural" world?

For the show, the curators have selected 100 objects to chart how the natural world has been catalogued, displayed, watched and remade over the past 300 years. Inside the exhibition space proper, we start with botanist-zoologist Carl Linnaeus, who divided the world into plant, animal and mineral, creating a tree of life in whose branches we remain entangled today. While cataloguing the world, Linnaeus and contemporaries such as Charles Bonnet found it impossible to resist the temptation to create a hierarchy.

After placing humans among the animals for the first time, amid the apes, Linnaeus subdivided humans into racial groups, complete with notes on their various temperaments. Constructed this way, the arrangement could be used to justify the exploitation of people and animals. It directs our attitudes still, as we struggle with racism and shun scientific experimentation on "higher" animals while accepting equivalent work on "lower" ones.

"If we created a modern diorama, would we include monoculture farmlands, buried waste, car parks?"

And while it's generally accepted that we shouldn't allow animals to suffer for our entertainment or convenience, we grapple with squaring our demands with their rights. We spend billions to keep our pets healthy while condoning the mass slaughter of livestock, and go viral over the death of Harambe the gorilla at an Ohio zoo without questioning the ethics of a life spent in captivity.

In the centuries since Linnaeus, our exposure to the natural world and our attitudes to it have been largely shaped by the agendas of museums, zoos and other venues. Making Nature takes visitors through an abridged history of these places, from the anthropomorphised tableau of writer-painter Beatrix Potter and taxidermist Walter Potter (no relation) to the emergence of more natural dioramas in the late 19th century, featuring animals in lifelike poses and settings.

But just as zoos replaced cages with moats to disguise the fact that visitors are looking at captive animals, these dioramas removed humans entirely. If we created a modern diorama, would we include monoculture farmlands, buried waste, car parks and bare, deforested mountains? Why do we think of nature as no longer being something that occurs in these places?

All credit to the Wellcome Collection for inviting the Center for PostNatural History, an institution in Pittsburgh, Pennsylvania, that collects organisms altered by humans in a way that echoes through their offspring. This includes dogs, horses and lab rats bred for particular traits, as well as transgenic goats and irradiated rats. Even so, the centre's curator, Richard Pell, points out the need to include the caveat of "intentionality" when discussing transformed animals. If not, where would we draw the line?

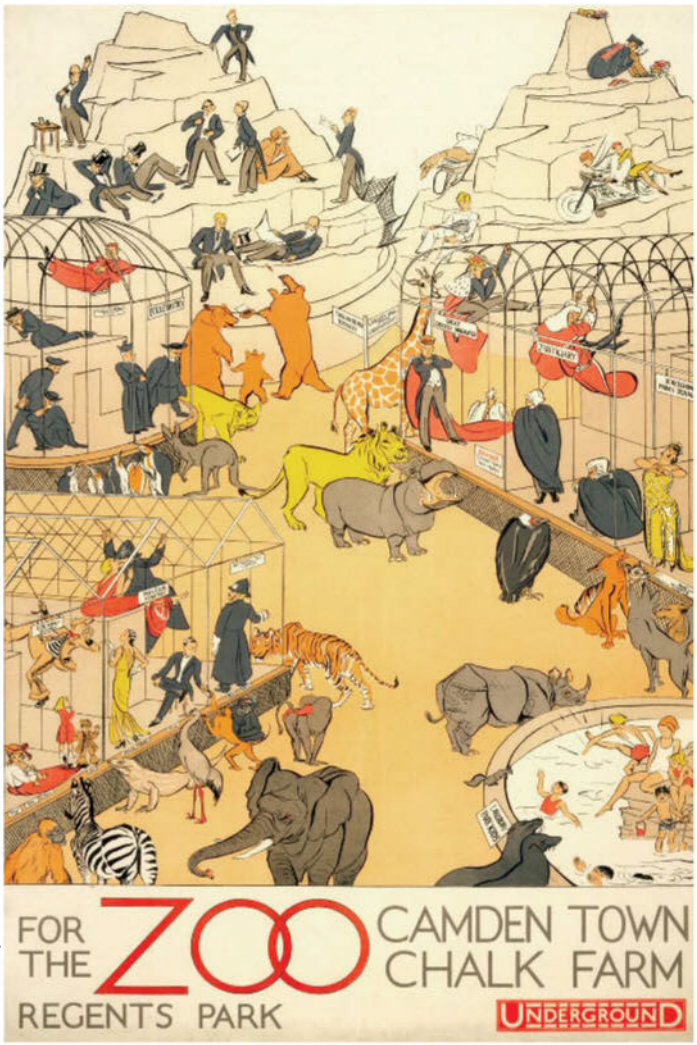
It's not just peppered moths or tuskless elephants: humans have transformed whole ecosystems beyond recognition. Jarring as it is, a discarded badger in the corner of one room (an unlisted taxidermy by artist Abbas Akhavan) is the most naturalistic item in the exhibition. It is presented not for our delight, but as a reflection on how we turn a blind eye to one very familiar view of wildlife – as roadkill.

There have always been those who challenged how the natural world was catalogued and depicted. Charles Waterton, for example, was famous for his satirical taxidermies and, in 1824, created the Nondescript, a Bigfoot-type creature that sidestepped attempts to confine it to the realm of either ape or human.

Another theme of the show is the struggle to objectively present the "real world". This is rendered beautifully in Herman de Vries's ongoing series *From Earth*, in which soil from different places is rubbed directly onto the canvas to form a vibrant patchwork of Rothko-esque blocks. *Galapagos*, on the other hand, shows Hiroshi Sugimoto's efforts to reconstruct natural locations, using photos of museum dioramas to create

RICHARD ROSS, MUSEUM NATIONAL D'HISTOIRE NATURELLE, PARIS, FRANCE 1982 © THE ARTIST

Taxidermy, dioramas and zoos created a single view of nature



ARNRID BANNIZA JOHNSTON, REGENT'S PARK ZOO, 1930. TFL POSTER © LONDON TRANSPORT MUSEUM

an image that floats uncertainly between the fake and real.

Both zoos and museums have raised awareness and respect for the natural world, fuelling support for its conservation. But by presenting nature as a utopia, with foxes gambolling in plastic brush or lions perching on plaster outcrops, we tell a story that the natural world only truly exists where humans do not. While biodiversity mostly does nosedive when humans encroach on an environment, it's not a practical basis for conserving areas where we can't prohibit human activity.

Worse, if we only frame environmental protection in terms of human cost, the environment always loses. No surprise then that most wilderness preserves are in economically unproductive areas: moors, mountains, deserts and other places where we haven't so much decided that they are worth preserving as that they aren't worth exploiting. If we saw nature as something in which we are one element among many, we might create environments that serve us all, rather than dancing between development and remediation.

"All corners of Earth are under our management – all that changes is the direction and efficacy"

These are not new arguments, but as we stride on through the Anthropocene, our default view has to be that the manufactured world is indistinguishable from the natural world. All corners of the planet are under human management – all that changes is the direction and efficacy of that management.

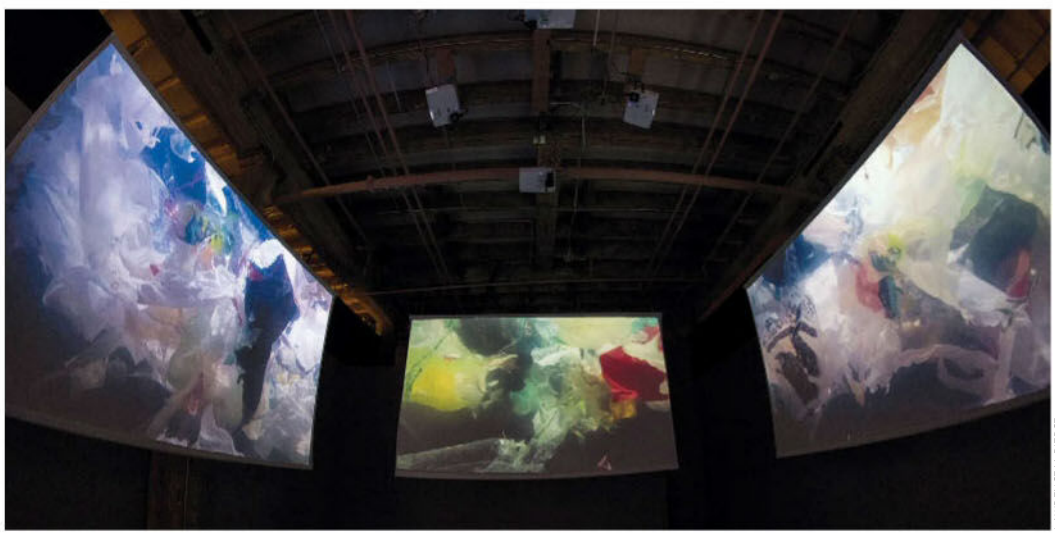
Nowhere is this more pointed than in the growing call for "rewilding", a term evoking a returning of the land to the state it was in before humans. The reality is that given the time, energy input and management required, the results are scarcely likely to be any "wilder" than other curated landscapes, from cornfields to car parks. We just swap one view of what the countryside should look like – rolling fields of superfluous crops – for another.

It is impossible to reach the end of Making Nature and still believe we can take an objective view of nature, or that we are fundamentally separate from it. Yet our moral tendencies and our ability to predict the consequences of our actions mean we are more culpable than, say, a seagull preying on the last Hawksbill turtle hatchling.

Accepting our place among the beasts may allow us to make peace with our own rapacity, to see our needs as being as essential as the seagull's, even if we have greater responsibilities. After centuries of standing apart from nature, we might finally be ready to join it. ■

Swimming in our mess

Sandrine Ceurstemont on a visceral way to tackle filthy seas



LAWRENCE M. PIERCE

Is this how marine animals see our achievements?

Entangled, The Animal Museum, Los Angeles, until 19 February

COLOURFUL plastic bags swirl ethereally underwater. The sound of waves intermingles with human-made sounds such as shipping noise, commonplace in oceans. It's like being inside a gyre. Could this be a sea animal's view of human waste and noise? That's the question posed by artist Ethan Turpin, who has created an immersive video installation, *Deep Blue Plastic*, now on display at the Entangled exhibition in the dry confines of The Animal Museum, Los Angeles.

By creating a 360-degree projection, Turpin aims to make us face up to the growing problem of plastic pollution. With an estimated 240,000 tonnes of debris in the oceans, animals can mistake the waste for plants and eat it, often dying from starvation as their stomachs fill with indigestible plastic. Tiny pieces also pass up the food chain, as fish are eaten by larger animals or humans.

Turpin says the piece is "intended to be beautiful as well as claustrophobic and alarming at the same time". Using immersive art to tackle environmental issues is a common thread in Turpin's work, because he aims to create a visceral connection to the content rather than merely providing stark statistics. "It's not an abstract phenomenon when you're confronted with it all around you," he says. "It becomes more of a part of your life."

It may be working. The piece seemed to provoke those who saw it into either thoughtful silence or comments that the government should take urgent action.

In an earlier installation, Turpin surrounded viewers with wildfire footage, allowing them to feel how quickly flames spread and objects can be consumed. The piece was presented in Santa Barbara, where residents live with the threat of such fires. Despite that, and residents receiving official advice on how to cope with the threat, the art seemed to have a galvanising effect. "People were commenting that they had better clear the landscape around their house," says Turpin.

Along with the visceral, Turpin is also struggling with the complexities of the negotiated boundaries between nature and civilisation. The effect we have on climate is especially complicated, prompting him to wonder whether climate change could be visualised. "There is constant debate and denial about causality and result," says Turpin. "It's an interesting challenge for artists to step into that space and try to represent it in a meaningful way."

"Animals mistake waste for plants and eat it, dying from starvation as their stomachs fill with plastic"

Together with Naomi Tague and her colleagues at the University of California, Santa Barbara, Turpin is now working on an interactive digital landscape map for a show in 2018. It will combine a range of environmental information, such as wildfire forecasts and climate data. Visitors will be able to probe it using an on-screen slider, for example, checking how fire and water would behave if the climate warms by 2 °C compared with just 1 °C in 15 years.

Turpin is also building on his wildfire work by exploring a different tool: virtual reality. While the Rey fire blazed in Santa Barbara last year, he accompanied firefighters to capture footage, using a fireproof camera housing to get close up. Later, he brought a 360-degree camera to the site once a month to document the aftermath. The images will be combined into a two-year time-lapse piece that visitors can take in using VR goggles.

Turpin wants to create an augmented reality app for use on location. A view of the fire and its legacy would be superimposed on the landscape along with live animations that could show, for example, how much water a tree takes up on that day.

He is keen to find out how headsets will affect the way people interact with his work. As he says: "It creates more of a personal context but it's also isolating. You won't be able to turn to a friend beside you who is having the same experience."

Even so, the power of work like Turpin's lies in this ultra-personal, grass-roots effect – which may be humanity's best chance of forcing genuine political action. ■

Sandrine Ceurstemont is a writer based in Morocco

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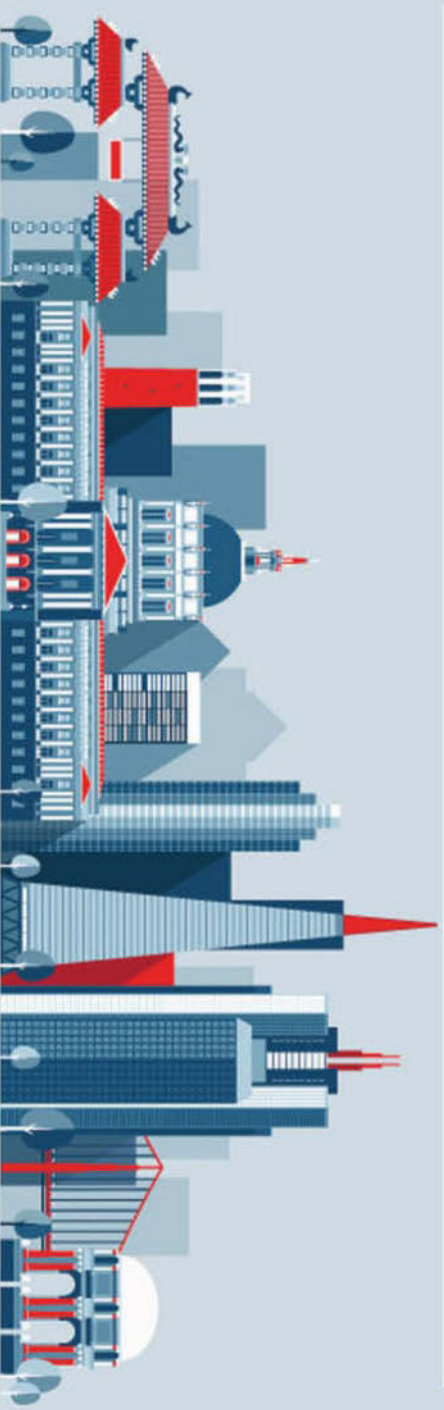

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EDITOR'S PICK

Holding out for a hero? Try a scientist

From Danny Kermode, Vernon, British Columbia, Canada

Sophia Chen describes the lack of consensus over interpretations of quantum mechanics, presenting it as some sort of crisis (7 January, p 11). But, despite that lack of consensus, quantum science has transformed the world in which we live. Many would hold that having a "true interpretation" is not required for science to drive progress.

But if quantum science is an example of a success, climate science is an example of a failure.

Climate science has failed because scientists and science journalists have failed to argue that, although scientific hypothesis is not fact, it is by far the closest we are going to get to fact.

Political leaders get elected by talking in absolutes. The one thing all traditional heroes have in common is that they can tell right from wrong: leaders aspire to that aura.

However, today's real heroes do not champion what is "right". They spend years painstakingly collecting and understanding data so that they can tell us clearly and concisely what is best. Today's heroes are scientists.

Artificial intelligences could be set to be selfish

From Carl Zetie, Waterford, Virginia, US

Sandy Ong raises fascinating questions about the ethics of autonomous cars (7 January, p 36). There is an even darker ethical issue not yet touched upon: programmed selfishness.

In a world where the vast majority of cars are autonomous and follow agreed rules, there will be a temptation for some car companies (or individual owners hacking their car's code) to deliberately program their vehicles to run red lights, poach parking spots, overtake dangerously, and otherwise drive more riskily, to get their passengers to their destinations sooner. They will be counting on other autonomous vehicles to behave selflessly and take evasive actions. If two such selfish cars meet, they may find themselves playing out the prisoner's dilemma in real time. By acting selfishly rather than cooperating, both cars will end up worse off.

And this is far from a fanciful risk. Compare the current automotive scandal in which some manufacturers went to great technological lengths to evade emissions regulations. They may have caused hundreds of premature deaths – for the sake of claiming better performance numbers than their competitors.

Perhaps automotive engineers should be studying not only philosophy, but also sociology.

From Tony Castaldo, San Antonio, Texas, US

I can think of two solutions to the major moral dilemma facing autonomous cars. The first is for their owners to have general

"What if we just haven't identified the smart ones as psychopaths?"

Meryl Whisker joins many in querying a finding on an average psychopath's intelligence (28 January, p 12)

liability insurance, much as physicians must have cover for everything that might cause a patient injury or death.

Second, if the car is intelligent enough to recognise moral dilemmas, it should be smart enough to know or discover the owner's preference: do they always choose self-preservation, or kids first, or women and children first?

Insurance companies may then choose to set premiums based on the predicted risk of paying damages given what the car was programmed to choose.

From Brian Horton, West Launceston, Tasmania, Australia

Driverless cars indeed raise moral and ethical issues. One that is rarely considered is that speed limits are set for human drivers. They are a compromise between going slowly enough to avoid an unacceptably high level of deaths, while going fast enough to get where we want without unnecessary delays.

We expect driverless cars to be much safer than those with human drivers. I modestly propose that speed limits be raised, to reduce delays while retaining the "acceptable" number of deaths and injuries.

What we can learn from inscrutable translators

From Malcolm Shute, La Tour d'Aigues, France

Nello Cristianini asks whether statistical machine translation is "teaching us something about how humans extract meaning from sentences" and answers "hardly" (26 November 2016, p 39). But surely, if all the old attempts at performing natural language translation using grammar-based sentence analysis have failed, and the statistical analysis of translated documents on the internet has been a resounding success, that may speak volumes about how natural language works.

Talking to machines may harm human protocol

From Alec Cawley, Penwood, Hampshire, UK

Victoria Turk describes how people try to engage digital home assistants in social interaction (17/24/31 December 2016, p 16). Since they use what is normally a human-to-human channel, it is hardly surprising that we follow the normal protocols of communication, such as thanking the other party for assistance given. And it is good that we do so.

Which is the worse outcome: thanking a computer that cannot appreciate it, or failing to thank a friend who can, and will, miss it if omitted?

I am more worried by the possibility that in trying to emulate humans, through speech or any other human channel, computers will unintentionally train us to interact with their slightly alien presence better than with actual humans. This could damage communication between people.

Artificial intelligence knows no better

From Eleanor Crosby, Gaven, Queensland, Australia

Allan Paxton suggests that "super-AI will surely inject a sorely needed mega-dose of rationalism into human affairs, since it will be unbound by (often psychotic) human bias" (Letters, 7 January). I beg to differ. Any ›

super-AI will unavoidably have biases in the data on which it was trained built into it.

Atheism comes naturally to this reader at least

From Lucy Roberts, Wantage, Oxfordshire, UK
I can easily believe that I am not always rational, as Graham Lawton suggests while discussing innate superstition (10 December 2016, p 29). I could even justify it if I wanted: after all, it is hard work considering an action from all angles all the time.

I can believe that sometimes the "rational" thing to do is to take the shortcut, go with your gut instinct and spend the time you've saved lying in a hammock.

However, I am pretty sure that I, and many others I know, are atheist to the core. As such I disagree with Lawton's statement that "atheism is hard work" and "only skin deep". It seems to me that belief in a god has to be taught, and regularly reinforced.

I suggest that atheism is the "natural" state for which no effort or education is required.

Rationality probably isn't a "natural" state, and it may be that we are not always as rational as we would like to think, but being rational is not the same as being an atheist. I can be a rational or an irrational atheist, but I don't see how you can be a rational theist.

Who are these 'people' who are showing bias?

From Felicity Harper, Clevedon, Somerset, UK
You describe how people shown a picture of a black man were more likely to be biased if shown the picture during a heartbeat (21 January, p 7). Do you mean white people? Great care needs to be taken with the use of the word "people" when describing experiments. Apart from failing to help readers draw considered conclusions, it can come across as racist or otherwise prejudiced.

The editor writes:
■ There's some evidence that black people can also show unconscious bias against black people but, examining the paper's methods, it turns out that the participants in this particular study were white men and women (doi.org/bxn6).

Preserve habitat rather than resurrect species

From Sarah Moles, North Branch, Queensland, Australia
Cloning species threatened by extinction sounds like a cute idea (17/24/31 December 2016, p 37). But which species would we choose to save? Who would decide whether to save, say, a rare plant or an iconic wild animal like the critically endangered rhino?

The biggest threat to most species is habitat loss, usually to meet human needs. It'd be far easier, cheaper and more sensible to curb the threat of extinction by preventing further destruction of the habitats needed for the survival of vulnerable species.

Warning: that's a half-boiled egg-quation

From Paul Whipp, Cedar Creek, Queensland, Australia
You give a formula for soft-boiling an egg (17/24/31 December 2016, p 86). I warn readers against using this, because it will frequently undercook the egg.

It fails to account for the volume of water in the pan and rate of energy supply. These factors are of crucial importance because adding the egg will typically take the water off the boil.

Untangling the cross over of visual fields

From John Smaje, Manchester, UK
You say the "brain's right hemisphere… is the one that receives signals from the left eye" (14 January, p 10). Only the inner-side or "nasal" retinal optic fibres from each eye cross over at the optic chiasm, near where the optic nerves enter the brain. The right hemisphere receives information from the left visual field, rather than the whole of the left eye.

Siamese cats, and members of many species (including humans) with albinism, can have eye-to-hemisphere pathways that cross over almost completely, but for some reason tend to suffer visual problems as a result.

TOM GAULD

Inter-universal travel: I wouldn't start from here

From Samuel Walker, Tenbury Wells, Shropshire, UK
Shannon Hall states that in alternative universes the laws of physics may differ more or less from ours: gravity might even work in the opposite direction (21 January, p 28). So is it possible that somebody in one of these alternate universes could develop a method of travel between them?

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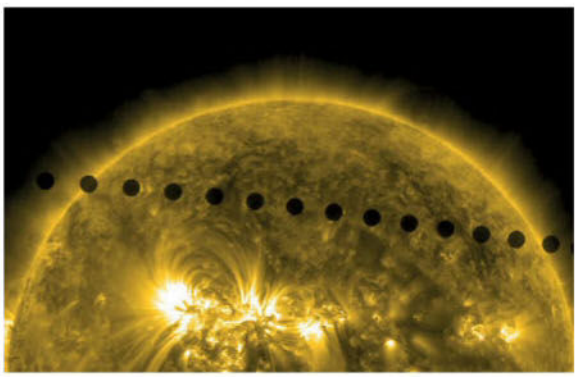
OLD SCIENTIST

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



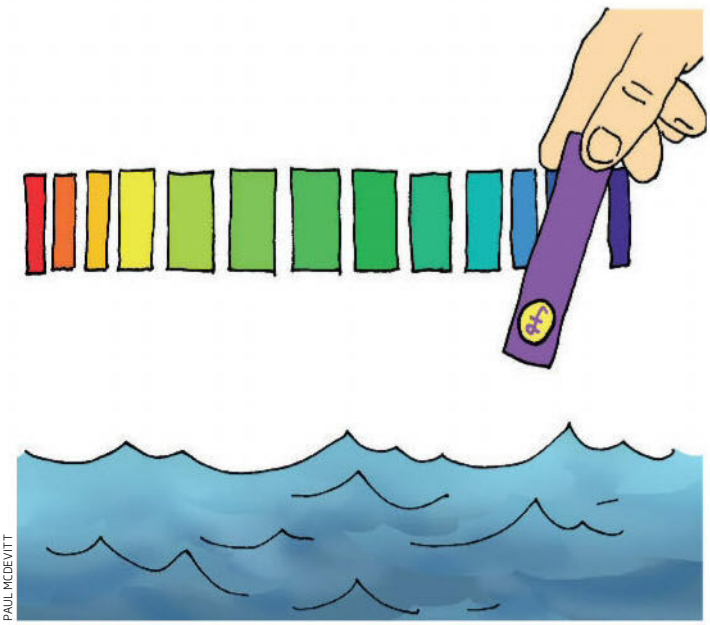
NASA

NEITHER the Iron Curtain nor Czechoslovakia exist today, but back in 1966 *New Scientist* was reporting from one behind the other. Deep in the cold war we covered a story from the former eastern bloc state. It seemed students learned languages more rapidly when "taught" by recordings in their sleep. The phenomenon even had a name – hypnopaedia. We reported on 24 February the case of two Soviet students who had acquired passable English in only 14 nights. Not surprisingly, there were sceptics, especially when it emerged the lessons conducted during sleep simply repeated what the students had heard while awake. V. Fried, a Czechoslovak lecturer in English, thought that "the amount of tuition the students received while they were awake plus their homework" easily accounted for their fluency. Still, it might have made teachers feel happier about sending their students to sleep.

More prospective pseudoscience appeared in our 26 February 1976 issue. Two hundred scientists had felt it necessary to rubbish astrology in the journal *Humanist*, prompting us to examine the work of Michel Gauquelin at his Paris-based Laboratory for the Study of Relationships between Cosmic and Psycho-Physiological Rhythms. Gauquelin had "amassed mountains of statistical evidence to prove that correlations do exist between planet positions and human activities". We spluttered a bit, but concluded that his work had more scientific credibility than horoscopes or Uri Geller-style spoon-bending. We even suggested that such lab work would continue long after Geller and his like had been forgotten. Erm…

Fourteen years on, we showed we weren't above dubious causal inferences of our own. In the 3 February 1990 issue our Feedback columnist apologised for any deficiencies in the magazine. Apparently "a window blew in on one of the top floors of the tower block in which *New Scientist* was based" and everyone had to be evacuated – an excuse as flimsy as that window frame. **Mick O'Hare** ■

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



PAUL MCDEVITT

YOU may have heard about the ongoing issue of ocean acidification (perhaps even from our erstwhile colleagues). But UKIP MEP Roger Helmer isn't having any of this "ignorance".

The politician set the world to rights on Twitter, declaring that the oceans "cannot be MORE acidic, because they are not acidic at all". As the East Midlands representative sees things, the oceans are in fact alkaline, and thus getting less alkaline rather than more acidic.

Helmer stuck to his alternative view, despite gentle insistence from Bob Ward at the Grantham Institute on Climate Change that "the oceans really are getting more acidic".

PERHAPS what is needed to save the world's oceans is some alkaline water to buffer the change.

Step forward "blk. premium alkaline water", a soot-coloured thirst quencher that promises trace fulvic minerals (that's dirt to you and me) and the thrilling gamble of "pH 8.0+". At £4.40 a litre though, it's going to be quite a costly bioremediation project.

ALSO finding herself in a pickle is Natasha Corrett, author of the bestselling *Honestly Healthy* cookbook that champions the benefits of an "alkaline diet". This involves eating foods to calibrate the pH of your body, a goal that is both meaningless and impossible.

Corrett previously told the *Daily Mail* that "the body can't get cancer in an alkaline state; cancer creates disease in the body through acidity", but backpedalled when the incredulous journalist asked if this meant her alkaline diet could prevent cancer (it can't).

Unfortunately, reality has caught up with the pH practitioners. The inspiration behind this fad, Robert O. Young, currently faces jail time for practising medicine without a licence, after he tried to treat a young woman with breast cancer using intravenously injected solutions of sodium bicarbonate, or baking soda to the rest of us.

In a perfect world, that would be enough to spell the end of the alkaline food fruitloopery. Yet having witnessed the rise and fall of many esoteric and sometimes dangerous food fads, from coffee enemas to "vibrational ingredients", Feedback knows it's only a matter of time before the glossy food gurus find some new nonsense to serve up.

THE post-truth era entrenched itself last week, as the White House press secretary Sean Spicer used his first briefing to excoriate the media for accurately reporting the middling crowd numbers at Donald Trump's inauguration ceremony, and issued a number of unverified claims that painted a much rosier picture of the event.

An aide later appeared on NBC News to explain that Spicer's pronouncements were not falsehoods, but "alternative facts".

Trump even requested the National Park Service to provide photographic evidence that his inauguration crowd was bigger than Obama's, but this alternative fact proved difficult to, er, prove.

READERS may recall that George W. Bush strategist Karl Rove also questioned the existence of facts, admonishing journalist Ron Suskind for being party to what he called the "reality-based community" who "believe that solutions emerge from your judicious study of discernible reality".

Rove felt this was "not the way the world really works anymore. We're an empire now, and when we act, we create our own reality."

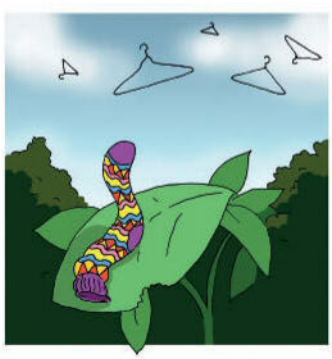
The question remains whether we'll be forced to live in President Trump's reality, or he in ours.

FROM alternative facts to alternative measurements: writing on the website of conservative think tank The Heartland Institute, Isaac Orr announces that oil pipelines are "safer than safe sex".

For those who don't see the connection (other than the contents of both might be described as crude), Orr expands on his hypothesis. Despite the occasional oil spill, 99.999 per cent of piped oil reaches its destination, whereas the effectiveness of condoms is 98 per cent. Feedback thinks that in both cases though, it only takes a tiny leak to spell disaster.

SHEILA BURCH discovers that Sainsbury's organic instant porridge sachets advise customers that "of the ingredients that are organic, 99% are organic".

Which would mean that 99 per cent of the remainder was organic. And 99 per cent of that… Feedback wonders if the instant porridge contains any organic content at all?



MORE missing socks (14 January). John Ripley says that the mystery of where they go was solved back in the 1980s, when he correlated his sock drawer with his wardrobe and noticed an inverse relationship. He concludes that "socks are the larval form of the coat hanger".

FINALLY, Chris Smith notes that Westminster Abbey has appointed the Reverend Anthony Ball in a new senior role, making him Canon Ball. "We just have to hope that he doesn't get fired," says Chris.

Garry Sturley spies a sign at Macclesfield Cemetery: "Garden of Remembrance temporally closed for refurbishment." But it remains open for spiritual matters, one presumes

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

Sugar, sugar

Sugar is the new evil: it is in many processed foods and is considered a danger if eaten in large amounts. But years ago it was expensive and considered a luxury by many of us. What happened? How come there is now so much of it and it is so cheap?

■ Sugar was indeed so expensive once that only the very wealthy could afford to become obese from it. Like spice, sugar can make mediocre-tasting food more palatable, so was highly prized. Sugar is also a preservative and so boosts our food supply, in effect.

Sugar cane reached the Mediterranean from India around AD 600, and until the 16th century the sugar trade was monopolised by Arab and Venetian traders. In 1300, sugar cost around £350 a kilogram in Britain (at 2010 prices), falling below £100 by 1500 as supply grew. This was also when Europeans began seeking direct sea routes to India to avoid these monopolies, which ultimately gave rise to the colonisation of the Caribbean.

Cane plantations with effectively free (slave) labour and free (expropriated) land sent the price crashing to around £10 per kilo (at today's prices) by 1800. Sugar beet production in Europe from this time onwards also boosted supply. Eventually the price fell below £5 per kilogram in 1900 to around £1 today.

We have an instinctive appetite for sugar, and demand did not stop when automation meant we needed fewer calories for work and travel. Sugar's ability to improve mediocre food is important to food manufacturers, and the food industry will do all it can to maintain a cheap supply. The costs of obesity are borne by the wider society.

Hillary J. Shaw
London School of Commerce, UK

■ Sugar was indeed very costly in medieval times. The English king Henry III and his court must have had a sweet tooth because, in 1288, they spent some £60,000 (at today's prices) on about 2700 kilograms of sugar. That works out at more than £22 per kilogram.

That sugar would have come from around the Mediterranean. However, sugar cane needs heat and quite a lot of water to grow, but rain in the Mediterranean falls mostly in winter, when the cane is least able to benefit from it. It also requires a lot of fertiliser, which wasn't well appreciated at the time. So productivity was low and the price high.

"Oliver Lyle, of sugar refiner Tate & Lyle, and his brother were the architects of today's energy efficiency"

European colonisation of the Americas solved the climate problem. The Caribbean proved good for sugar cane, and in areas where there was abundant water the crop flourished. By the end of the 16th century, the price of sugar had dropped considerably and continued to do so as the plantations grew.

From 1650 to 1800, British sugar consumption multiplied 25 times, reaching 2 kilograms per week per family, much of this for sweetening tea. The government raised more revenue through its sugar tax than from wine or tobacco.

Today, much sugar is extracted from sugar beet, which grows in temperate climates, making it more affordable. Our present high consumption is because sugar has been incorporated into many foods, including some we do not even think of as sweet.

Peter Bursztyn
Barrie, Ontario, Canada

■ Sugar is cheap because there are two plants that contain lots of it – sugar cane (*Saccharum officinarum*) and sugar beet (*Beta vulgaris*). Harvesting them and extracting their sugar were made efficient by the technology of the industrial revolution, notably the steam engine and the multiple-effect evaporator.

Incidentally, engineer Oliver Lyle, managing director of sugar refiners Tate & Lyle, and his accountant brother Philip were the architects of modern-day energy efficiency. After the first world war, the UK government decided to subsidise home-grown beet to reduce reliance on sugar imports. The general strike of 1926 cut fuel supplies, leading the brothers to marry the first law of thermodynamics and accountancy to produce, in 1936, the first analysis of the energy required to run a factory. This later became known, entirely erroneously, as the "energy audit". They were able to nearly halve the energy used by their east London refinery. Sugar is now cheap, therefore, in part because we process it efficiently.

Peter Harris
Watford, Hertfordshire, UK

■ The UK is considering a sugar tax on soft drinks, which could spark a major switch to low-calorie sweeteners. But sugar is not the only obesity culprit. Starch, which is found mainly in potatoes and cereals, is rapidly metabolised into simple sugars, so both should be grouped together.

In the meantime, perhaps airlines could put people off sugar if they started to weigh passengers as well as baggage, and charged accordingly.

Nick Roxburgh
Drummoyne, New South Wales, Australia

This week's question

SALVAGING HUBBLE

The illustrious Hubble Space Telescope will eventually re-enter Earth's atmosphere and be destroyed – or so I understand. Could it be returned to Earth safely and put in a museum? If so, what would be the cheapest way to do it?

Martin Gorst
London, UK

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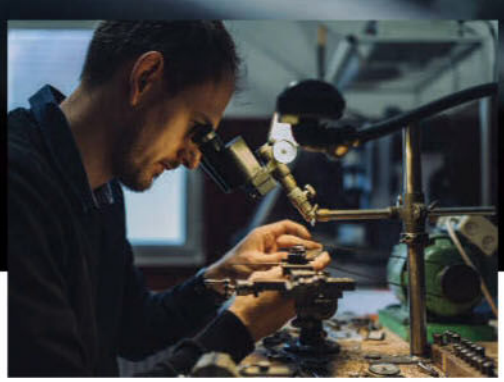

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