New Scientist

WEEKLY 7 April 2018

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The incredible mind-reading headset

WHOLE-EARTH GENOME PROJECT The plan to sequence every known species

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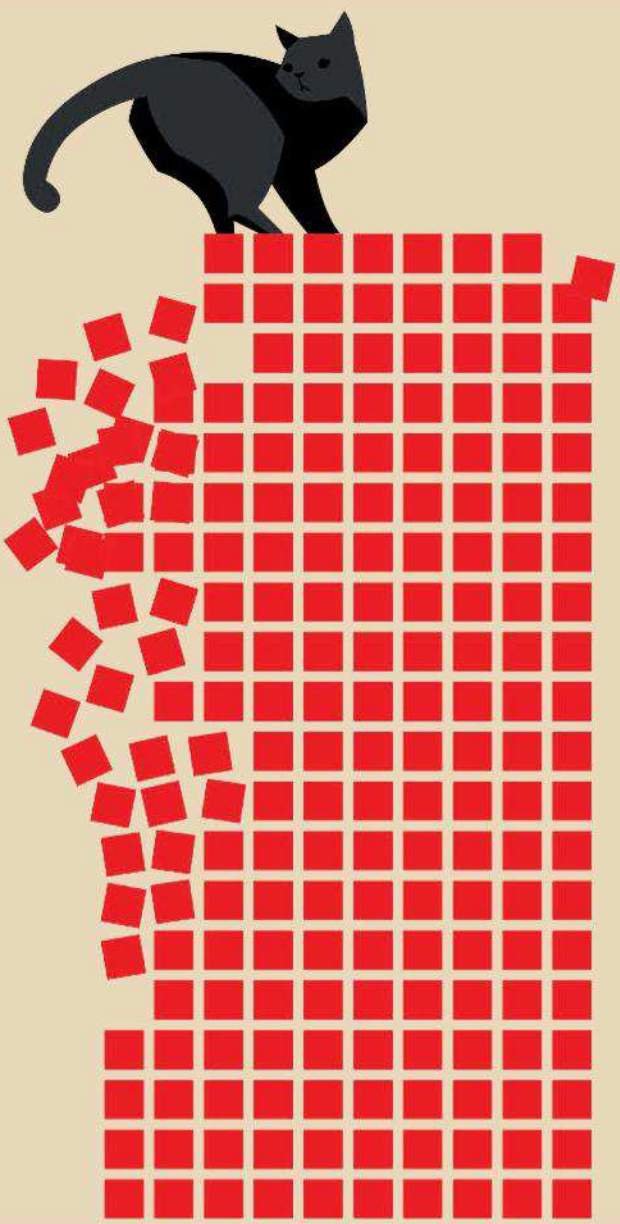

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Don't screen out the facts

Touching personal medical stories are no substitute for science

MEDICAL screening is one of those issues where getting the scientific facts across is extremely challenging. Common sense suggests that routine screening must be a good thing: what harm could it do to systematically test everybody for diseases such as prostate and breast cancer? But as has been shown repeatedly, routine screening is often, on average, harmful. For every life saved through early diagnosis, many more are blighted by psychological trauma, invasive investigations or unnecessary treatments (see page 44). False negatives, meanwhile, can lead people who are actually ill to take no action.

The issue reared its head in the UK last month when comedian and writer Stephen Fry revealed that he had recently undergone surgery for prostate cancer. A few days later, broadcaster Bill Turnbull announced that he has advanced prostate cancer.

Fry was diagnosed after a routine check-up found a high level of prostate specific antigen (PSA) – an indicator of prostate trouble but not a diagnosis of cancer. Turnbull went to his doctor with symptoms but said he regretted not requesting a test that could have picked up the disease earlier.

Both celebrities encouraged men to get checked out. Fry – rightly respected for his scientific knowledge and rationality – said "I would urge any of you men of a certain age to think about getting your PSA levels checked". Turnbull said "If one man gets tested who might not otherwise have gone to their doctor, it's worthwhile."

It sounds like a no-brainer, but men really ought to think twice about following this advice,

"Men should think twice about getting tested for prostate cancer, unless they have symptoms"

unless they have symptoms of prostate cancer or are acting on the advice of a doctor. Both stories are touching but are of the anecdotal "it (would have) worked for me" variety.

The reality is that PSA testing remains a blunt tool. Most prostate cancers aren't aggressive so don't require treatment; as the old saying goes "men usually die with prostate cancer rather than of it". And yet the majority of men who are diagnosed via a PSA test end up having treatment with a high risk of side effects including erectile dysfunction, urinary incontinence and heart attack.

The largest-ever clinical trial of PSA testing, published last month in the *Journal of the American Medical Association*, confirmed that while one-off tests in men with no symptoms do result in higher diagnosis, they don't increase survival rates. The UK's National Health Service doesn't have a national prostate cancer screening programme because the test isn't accurate enough.

The message is muddied, however, by the fact that some screening programmes do save lives. This week, former UK health secretary Andrew Lansley revealed that he has bowel cancer and called for improvements to the NHS's screening programme for 55-year-olds. In this case, that is the correct response, as screening for bowel cancer works.

We wish Fry, Turnbull and Lansley the very best. But famous people, however well respected, ought to be careful about giving health advice, and the rest of us should be even more wary about following it. ■

Google with your mind

AlterEgo deciphers brain signals when you think about speaking

Chelsea Whyte

SILENTLY think of a question and I will answer it. That might sound like a magic trick, but it is the promise of AlterEgo, a headset that lets you speak to a computer without ever uttering a sound. It's not quite a mind reader, but it is close.

The device brings us a step closer to a world where we can interact seamlessly with machines using only our thoughts. AlterEgo's creators believe that rather than embarrassingly saying things like "OK Google" or "Hey Siri" and then dictating an email or ordering a pizza, eventually we will just think it instead. AlterEgo is far from perfect, but shows what may one day be possible.

When you think about speaking, your brain sends signals to the muscles in your face, even if you don't say anything aloud. The current

LORRIE LEJEUNE, MIT

Arnav Kapur models the AlterEgo device he co-created

AlterEgo prototype (pictured above) has a hook that slips over the right ear and sensors placed at seven key areas on the cheeks, jaw and chin. The sensors can eavesdrop on these speech-related signals, before artificial intelligence algorithms decipher their meaning. The device can currently recognise digits 0 to 9 and about a hundred words.

AlterEgo is directly linked to a program that can query Google and then speak the answers back via built-in bone conduction headphones, which transmit the sound in a way that nobody else can hear. This means that the wearer can gain access to the world's biggest information source using only their mind. "It gives you superpowers," says Arnav Kapur, who created the device with Pattie Maes at the Massachusetts Institute of Technology Media Lab."Go ahead. Ask me something," says Kapur, as I sit with him for a demonstration.

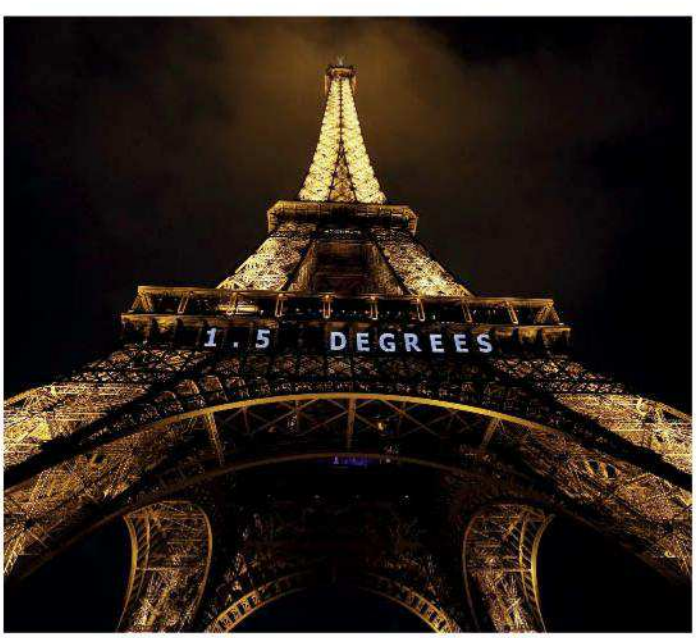
I ask him to tell me the time in Wellington, New Zealand. I can tell he's concentrating. His face goes blank and his eyes focus. Very slowly, a computer screen displays what AlterEgo thinks he is thinking. The words "Wellington" and then "New Zealand" appear. I don't hear it, but AlterEgo whispers something to Kapur. He then looks up and says "9.48 am". He's right.

Testing it out

I ask him the population of Santiago, Chile; the square root of 360005 and the product of 7589 and 4523. His answers are correct each time, although they come haltingly. He reads out each digit with a beat in between, because that is how AlterEgo is feeding the information to him. It feels a bit like magic as he retrieves answer after answer, as if his brain has had a superhuman upgrade.

Kapur says it is like having a conversation with a smarter version of yourself, "and this second self of yours is really good at maths".

However, it isn't a perfect system. The questions I asked had to be centred around a predefined



PATRICK KOVARIK/AFP/GETTY IMAGES

What a difference 0.5°C makes

SOMETIMES overreach is good – particularly when trying to stop climate change. Even a small cut in warming offers major benefits.

In the 2015 Paris Agreement, global leaders promised to keep warming to 2°C and possibly even limit it to 1.5°C.

It seems the two have dramatically different impacts. Three-quarters of countries studied may see a greater increase in food insecurity due to floods and droughts in the 2°C scenario compared with 1.5°C.

Meanwhile, the global average GDP per capita is projected to be 5 per cent lower at the end of the century under 2°C warming relative to 1.5°C. The loss will be felt most strongly by poor countries, upping global inequality.

And 1.5°C would see an extra 5.5 per cent of Earth acting as a "climate refuge" for wildlife, compared with 2°C (*Philosophical Transactions of the Royal Society A*, doi.org/gc7n4m).

Also, 1.5°C would cut the number of ice-free Arctic summers eightfold compared with 2°C (*Nature Climate Change*, doi.org/cmzj, doi.org/cmzk).

Cancer diagnosis centres

TEN centres offering a one-stop shop for spotting cancer are to be set up in England. The aim is to provide rapid testing for multiple cancers, cutting the often lengthy wait for diagnosis.

The UK currently lags behind other

list of cities and basic arithmetic. And Kapur had to pause silently before thinking each question so the device didn't get confused by our actual conversations. Still, it is incredible, and a little creepy.

Kapur and Maes believe that the more AlterEgo is used, the more accurate it will become. In an eight-person user study, AlterEgo recognised words and digits with around 90 per cent accuracy.

It isn't the only device that is getting close to reading minds. James Gilbert at the University of Hull in the UK is working on one for people who have difficulty speaking. His prototype is for people who have lost their larynx because of cancer and is more accurate than AlterEgo. But it relies on magnets implanted in a person's lips and tongue, so it is unlikely to be used outside a medical setting.

Other devices exist that feature obtrusive caps with electrodes to pick up brain signals. "Some of these things that previous groups have done look more like torture instruments than a consumer product," says Gilbert.

The technology can't yet read someone's innermost thoughts. Even getting AlterEgo to recognise very deliberate internal speech was an uphill battle. Users had to train with the device for around 31 hours, learning to think in just the right way. This training also taught the algorithms underpinning the device to recognise different users' particular patterns of muscle activation.

NINO MASCARDI/GETTY

Soon, just thinking "Netflix" might be enough to bring your TV to life

More sophisticated devices that can better decipher thoughts may not be that far off. Both Facebook and Neuralink, Elon Musk's brain science venture, are attempting to build brain-computer interfaces that can turn thoughts into text by intercepting brain signals, rather than nerve signals. It isn't clear if there will be a way to choose the thoughts you share and those you would rather keep private.

Howard Chizeck at the University of Washington in Seattle says there are a few potential privacy issues, such as advertisers using your innermost feelings to market products or services to you. He also worries about the potential for governments to use your private thoughts against you in a court, superseding the fundamental right not to testify against yourself.

"His answers are correct each time. It feels as if his brain has had a superhuman upgrade"

Before I leave, Kapur tells me how he used AlterEgo to win a game of chess. Via his thoughts, he had access to a chess-playing computer program. At each turn, it whispered the best moves into his ear. "I felt so confident, I knew how to play chess so much better," he says. In the future, maybe we will all have devices whispering into our ears, helping us decide the best moves as we go about our daily lives. As thoughts go, that one is just as exciting as it is terrifying. ■

western European countries and nations such as Australia and Canada in terms of cancer survival. This is at least partly due to delays in diagnosis and treatment.

Around half of people with cancer have vague or non-specific symptoms, such as loss of appetite or weight. As a result, they can end up being referred to several specialists before receiving a diagnosis. The new centres will aim to test for multiple cancers at the same time, providing people with a diagnosis or the all-clear within two weeks.

Similar centres exist in Denmark. People are typically referred with symptoms like weight loss, fatigue, pain and nausea. A study found that 16 per cent of those referred by their doctors received a cancer diagnosis, most commonly of lung cancer.

Space station falls from the sky

A CHINESE space station has come crashing down to earth. Most of the 10.4-metre-long Tiangong-1, or "Heavenly Palace", burned up as it hurtled through the atmosphere on 1 April, but some bits may have survived and splashed down in the southern Pacific Ocean.

For two years, the space lab has been spiralling ever closer to Earth. It was orbiting at 27,000 kilometres per hour, making it hard to predict when it would enter the atmosphere.

Tiangong-1, China's first space station, launched in 2011 and hosted astronauts in 2012 and 2013. It was only planned to last two years, and was put into sleep mode at the end of its mission in case of problems with its replacement, Tiangong-2. When the Chinese space agency tried to send instructions to Tiangong-1 in 2016, they found that it had lost power. There was no steering it. Usually, when a spacecraft is brought down from orbit, operators use its thrusters to aim it at the ocean. In this case, they had to let gravity take the wheel.

Don't fear your robot overlords

MAYBE robots won't take all our jobs after all. The risk of jobs being handed over to artificial intelligence is a lot lower than previously forecast, according to an OECD report.

In 2013, an influential University of Oxford study warned that nearly half of all US jobs and 35 per cent of UK ones were at "high risk" of automation over the next 20 years. The new OECD report says it is more like 10 per cent of jobs in the US and 12 per cent of those in the UK that are under threat.

According to the OECD, previous forecasts were exaggerated because they clumped together jobs with the same title without considering differences in the roles.

The report also says it found no evidence that jobs requiring high levels of education and skill were already being affected by AI. However, entry-level posts and lower-skilled jobs, such as those involving cleaning, agricultural labouring and food preparation, face significant risk of automation.

Nationwide genetic testing

Andy Coghlan

THE Estonian government plans to provide free DNA-based health advice for 100,000 of its 1.3 million residents. It will be the first nation to provide a state-sponsored personal genetic information service – but some warn that this might cause unnecessary worry for those who find out they have an elevated risk for certain diseases.

The goal is to prevent or minimise future illnesses by forewarning people whose genes put them at extra risk of conditions such as cardiovascular disease or type 2 diabetes. To reduce their risk, they could then choose to adopt healthier lifestyles or take preventive medicines.

Each participant's DNA will be tested for more than 600,000 DNA variants linked to common diseases. The analysis will also look for more than 100,000 other variants associated with rare diseases or adverse reactions to 28 common medicines, including some common antidepressants.

The details are still being decided, but people will probably be able to select what kinds of results they would like to receive. For example, a person could choose to know their risk for common diseases, drug side effects and rare disorders, but could opt out of any feedback about cancer risks or whether they might pass genetic disorders on to their kids.

People will get the results from their family doctor, who will counsel them about what the DNA results mean and explain any options they may have.

Similar information is currently available commercially through firms such as 23andMe. Several countries – including the UK and Iceland – have launched biobanks that store and analyse DNA donated by citizens. But most of these state initiatives focus on providing anonymous gene data for medical research and don't give any feedback to donors.

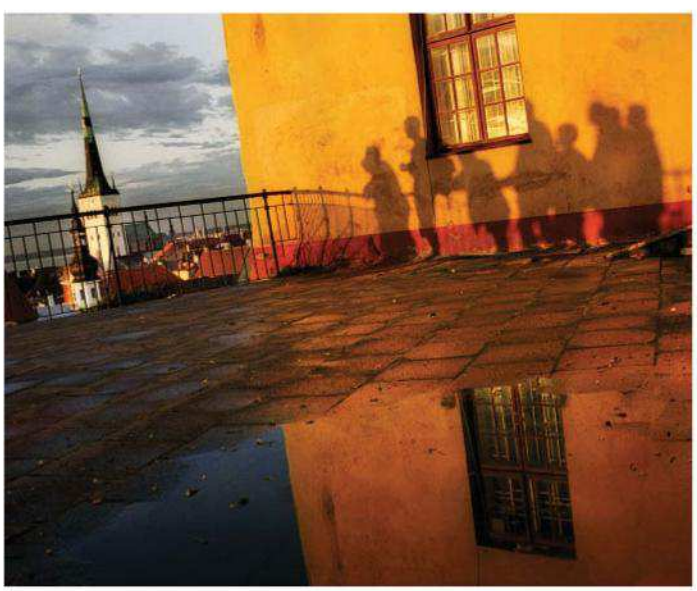
"We want to invest in preventing or delaying the onset of common chronic diseases by using genetics to identify people at high risk," says Jevgeni Ossinovski, Estonia's minister of health and labour. He says the country plans to one day have a national biobank and health information system that contains the genetic data of every inhabitant.

But the genetic advice could create unnecessary alarm. "An offer of free genetic profiling may seem tempting, but the information is often difficult to interpret, particularly in relation to risk of serious conditions," says Hugh Whittall of the UK Nuffield Council on Bioethics. "This may well create more questions than answers for those who take part and, in some cases, great anxiety."

The scheme was launched on 20 March. "Within the first 48 hours, we had 10,000 applicants. Our server was overwhelmed," says Lili Milani of the Estonian Genome Center, which will host the service. Ossinovski was the first person to sign up and the first to donate blood for testing this week.

"Initiatives that enable the public to make choices about their health should be welcomed," says Anna Middleton, an ethicist at the Wellcome Sanger Institute in the UK. "The key to success is open, transparent dialogue between the professionals doing the testing and the people who are being tested." ■

Estonia is bringing gene-based health risks out of the shadows



CHRISTOPHER ANDERSON/MAGNUM

Twitter bots can make opinions more extreme

PERHAPS we should stick to our own echo chambers after all. People forced to pop their social media bubbles were more likely to strengthen their political beliefs than soften them.

Over the course of a month, Republican Twitter users followed a bot that automatically retweeted posts from Democrat politicians, pundits and journalists, and vice versa for Democrat Twitter users. The experiment was organised by a team from Duke University, New York University and Princeton University, and more than 1000 people took part.

Before and after the trial, the team measured the political leanings of participants by asking them to rate how much they agreed with statements such as "government is almost always wasteful and inefficient" and "homosexuality should be accepted by society". Rather than becoming sympathetic to ideas retweeted by the bots, participants' views became more entrenched. Overall, after leaving their echo chambers, Republicans became substantially more conservative and Democrats slightly more liberal.

The results offer lessons for those who want to reduce polarised views. "Well-intentioned attempts to introduce people to opposing political views on social media might not only be ineffective, but counter-productive," wrote the team.

"Rather than becoming sympathetic to retweeted ideas, their views became more entrenched"

The study suggests that although a simple Twitter bot couldn't change someone's political leaning, it could strengthen their existing views (*SocArXiv*, doi.org/cmwx).

Showing content from the other end of the political spectrum to a partisan voter won't automatically soften their beliefs, says Javier Sajuria at Queen Mary University of London. "This paper seems to support [the idea] that not all exposure to diverse views is good," he says. "Some can produce acceptance to these views, but others can produce backlash."

Marie Le Conte ■

Rare glimpse at a black hole devouring a star

WE HAVE spotted what seems to be a star being torn up and eaten by a black hole more than 1 billion light years away.

At the centre of every large galaxy lies a supermassive black hole. If a star gets too close to one of these giants, the pull of gravity will be stronger on the near side of the star than on the far side. It will be stretched until it rips, in a tidal disruption event.

The black hole then swallows bits of the shredded star. These pieces release enough energy to remain bright for months or years. "In a typical galaxy it might occur once every ten thousand years at most," says Julian Krolik at Johns Hopkins University in Baltimore, Maryland, who was not involved in the work.

A team of astronomers led by Ben Shappee at the University of Hawaii thinks it has seen the aftermath of this process. The group reported four sets of telescope observations on 24 March on the Astronomer's Telegram website, where people post observations of cosmic phenomena.

At first glance, a star being shredded resembles a supernova, because both generate sudden, bright bursts of light. So, when researchers spot a potential tidal disruption event, they collect as much data as possible to try to tell the difference.

A few factors indicate that this signal might be tidal disruption. It seems to be in the centre of its galaxy, a requirement for a tidal disruption event but not for a supernova. Its light is very blue, meaning it is extremely hot, whereas supernovae tend to cool as they expand. It also shows no sign of the heavy elements that absorb some light from a supernova.

"There are rare kinds of supernovae that produce signals similar to this one early on, so we cannot rule out that kind of supernova just yet," says Sjoert van Velzen at the University of Maryland. The event is just reaching peak brightness, so there is still plenty of time to look for clues. Leah Crane ■

PIUS UTOMI EKPEI/AFP/GETTY IMAGES

The majority of Yoruba people live in Nigeria

African DNA hints at mystery hominin species

Michael Marshall

SOME of us carry mysterious genes that may belong to another species of early human. The finding in people from West Africa hints that primitive hominins lingered in Africa until fairly recently.

Our species has repeatedly interbred with other hominins, in particular with the Neanderthals and a less well-known species called the Denisovans. This happened after some members of our species first left our African homeland, probably within the last 100,000 years. As a result, all people whose recent descent is non-African carry some Neanderthal DNA, and some Asian people also have Denisovan DNA.

But it is hard to spot if people whose ancestors never left Africa also carry DNA from other species. We don't have DNA from any extinct African hominins to compare because the hot and wet climate there tends to destroy preserved DNA.

To get around this problem, Arun Durvasula and Sriram Sankararaman at the University of California, Los Angeles, devised a statistical method to identify out-of-place DNA, without needing to know the genome of the hominin it came from. The model correctly identified the known Neanderthal DNA in human genomes.

"On average, 8 per cent of the genomes of tested Yoruba people was from an archaic population"

The pair applied it to 50 Yoruba people from West Africa, who had had their DNA sequenced for the 1000 Genomes Project. On average, 8 per cent of their genome was from an archaic population. The mystery DNA wasn't Neanderthal, and didn't match modern pygmies, who might plausibly have interbred with the Yoruba (*bioRxiv*, doi.org/cmzh).

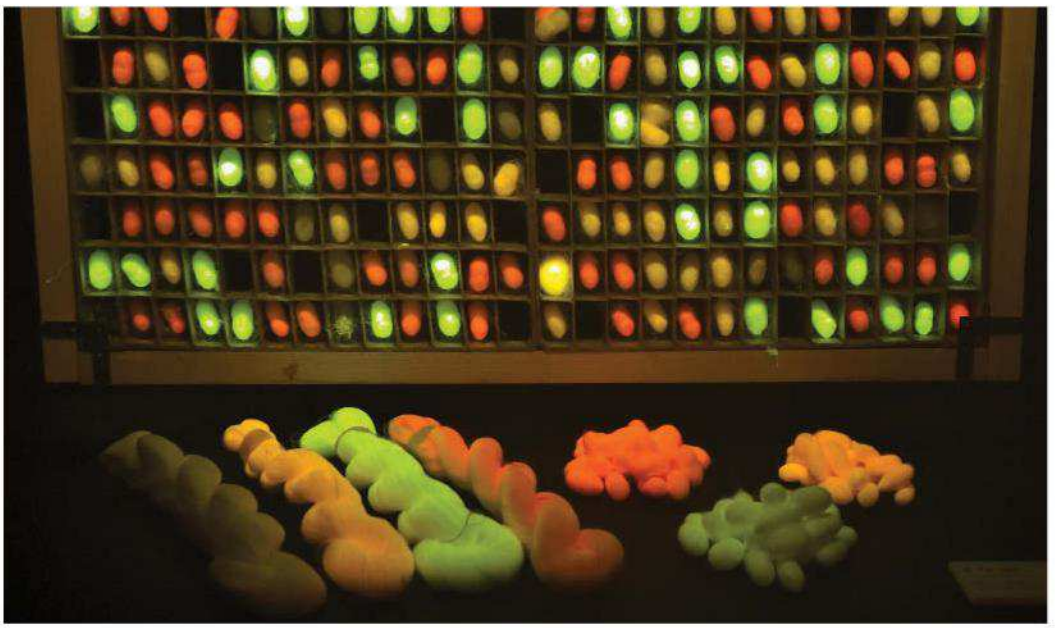
It appears that the ancestors of modern Yoruba interbred with members of a distinct population, but it's not clear what this "ghost lineage" was. It might have been a group of *Homo sapiens* that remained isolated from the rest of the population for thousands of years, or it may have been another hominin species altogether.

As with the Neanderthal interbreeding, many of the archaic gene variants in the Yoruba have been strongly selected against – suggesting that the hybrid children from these mysterious matings were only just viable. However, some parts of the Yoruba genome, notably a tumour suppressor gene, still carry archaic DNA – hinting that these fragments were advantageous.

So who did the Yoruba's ancestors interbreed with? The Neanderthals and Denisovans aren't in the frame because there is no record of them living in Africa. The recently discovered *Homo naledi* was present in South Africa about 250,000 years ago, so it overlapped with our species, but it seems unlikely humans would have mated with them. Their brains were smaller than ours, and they may have been too different from us to breed successfully. "I would be amazed if there was anything of them in us," says Mark Thomas of University College London.

A better candidate is *Homo heidelbergensis*, which was present in Africa until some 200,000 years ago. It was a fairly big-brained, advanced hominin, and has been proposed as the common ancestor of modern humans and Neanderthals. A small population of *H. heidelbergensis* may have lived on in the forests of West Africa until relatively recently, suggests Eleanor Scerri at the University of Oxford.

There is also archaeological evidence that relatively primitive hominins lingered in West Africa, isolated and evolving, after fully modern humans had emerged elsewhere. ■



YOSHIKAZU TSUNO/AFP/GETTY

Glow-in-the-dark silk is just one of many possibilities

GM silkworms make super-silk

Michael Le Page

SILKWORMS have had their genetic code hacked, allowing them to create a kind of silk not found in nature. The hacking goes beyond the usual genetic modification, fundamentally altering the nature of the silk the animal makes. And unlike previous attempts at this, it will work on an industrial scale.

"The silkworm is the first ever industrially useful animal engineered to incorporate synthetic amino acids," says Hidetoshi Teramoto of the National Agriculture and Food Research Organization in Japan. A few animals have been modified in similar ways, beginning with a nematode worm in 2011, but only for research purposes.

Silk isn't just used for clothing. Many groups are developing medical implants made of the silk protein, such as scaffolds on which replacement organs could grow. Silk is useful as it doesn't cause immune reactions in the body and is already approved for medical use.

What's more, silk proteins can be turned into transparent films, sponges and solid shapes. A company called Orthox is developing a knee cartilage replacement made from silk protein, for example.

But while the inertness of silk proteins is an advantage for replacing cartilage, it can be a problem for other body tissues, says Neil Thomas at the University of Nottingham, UK. For instance, it is hard for cells to attach to a silk scaffold.

There is no easy solution, as chemically altering silk after a silkworm has produced it doesn't work well, says Thomas. That is partly because there is no way to control exactly which parts of the protein get altered.

So Teramoto and his team set out to create a silk protein with synthetic components that would act as anchor points for useful molecules, such as growth factors to help organs grow.

Every protein, including silk, is made of a chain of amino acids. To create a given protein, a cell strings amino acids together in a specific order, which is encoded by a gene. All told there are 20 natural amino acids for the cell to use.

Teramoto's team has modified silkworms so that the silk proteins they make contain an artificial amino acid called AzPhe in place of a natural one called phenylalanine.

The method relies on hacking the silkworms' cells. When a protein is being made, each of the 20 natural amino acids is carried into position by a molecule called transfer RNA. Each amino acid has its own kind of tRNA, which the cell uses to ensure it has the right amino acid at each stage.

"The silkworm is the first ever industrially useful animal to incorporate synthetic amino acids"

There is an enzyme that bolts phenylalanine onto its tRNA. Teramoto's team tweaked the gene for this enzyme so it instead adds AzPhe.

Their first attempt, in 2014, didn't work very well. The silkworms had to be fed lots of AzPhe, which is both expensive and bad for the animals.

So he and his team have now created a version of the enzyme that is much better at recognising AzPhe. They did this by generating thousands of versions of the gene, getting bacteria to make the enzymes and selecting the one that was best at incorporating AzPhe. Then they put this gene in silkworms.

In these silkworms, AzPhe replaces around 6 per cent of the phenylalanine in the silk protein when the caterpillars are fed just 0.05 per cent AzPhe by weight (*ACS Synthetic Biology*, doi.org/gc3m5t). That means the silk should cost little more to make than the normal version.

This doesn't affect silk's desirable properties like strength. "It's still more silk than artificial," says Chris Holland at the University of Sheffield, UK.

The modified silk protein can easily carry all kinds of molecules – something called "click chemistry". "It's basically a reliable reaction for attaching things," says Thomas.

For instance, it could be used to attach dyes to silk, as normal silk doesn't hold these well. The silk may also be easier to bolt cells onto when growing organs.

Several other groups are pursuing similar approaches. In 2016, Thomas and his team used *E. coli* bacteria to make spider silk with synthetic amino acids, enabling click chemistry. They then attached an antibiotic to the silk proteins. The aim is to create dressings for wounds that don't heal properly.

But *E. coli* can only produce mini-versions of a silk protein. And while everything from goats to potatoes has been engineered to produce silk proteins, we have yet to find a way to turn those proteins into fibres as strong as those spun by insects. ■

The workings of a dog's mind

Chris Baraniuk

WE HAVE had a sneak peek into a dog's mind. Scientists can now work out what a dog is looking at, just by examining a scan of its brain.

In recent years, researchers have shown what dog owners claimed: our furry friends can recognise human facial expressions. A 2015 study showed that dogs can tell a happy face from an angry face (*Current Biology*, doi.org/f64zrj).

Now Laura Verónica Cuaya at the National Autonomous University of Mexico in Mexico City and her colleagues have studied how dogs do it. They used functional magnetic resonance imaging (fMRI) to scan the brains of four border collies, who were trained to sit still in the scanner.

The dogs were shown four facial expressions – happy, sad, angry or fearful – made by humans they didn't know, and the fMRI recorded their brain activity.

By looking at patterns of activity across the whole brain, the team could tell what facial expression each dog had seen. A computer algorithm found small sites of activity – clusters of firing neurons – that appeared in certain locations, depending on what human emotion the dogs had seen. It was therefore possible to predict what emotion the dogs had seen just by looking at this brain activity (*bioRxiv*, doi.org/cmwr).

The findings mirror a recent study of the human brain. Earlier this year, researchers revealed an AI that could tell what image a person was looking at, just by examining a scan of their brain.

Cuaya's team found that seeing a happy face produced a highly distinctive pattern of activity, mainly in the temporal cortex on the side of the brain. This region is thought to handle complex visual information, such as faces, in humans and animals including dogs, primates and sheep.

"This is a really similar activity to human processing of emotions in general," says Cuaya.

WESTEND61/GETTY

What's going on inside that adorable little head?

However, it was harder to differentiate between the more negative emotions, especially anger and sadness.

The work is more evidence that dogs acquired the ability to read human facial expressions as they adapted to live with us, says Alexandra Horowitz at Columbia University in New York. "I like to think of dogs as 'canine anthropologists' among us, carefully noting our behaviour patterns."

The findings "demonstrate the high sensitivity of the dog brain to human emotions", says Márta Gácsi at Eötvös Loránd University in Budapest, Hungary. However, she says the sample size is too small to draw strong conclusions about how all dogs process faces and emotions. ■

Our unknown organ may help cancer spread

A NEWLY discovered network of fluid-filled channels in the human body may be a previously unknown organ, and it seems to help transport cancer cells around the body.

This discovery was made by chance from routine endoscopies, which involve inserting a thin camera into the gastrointestinal tract. Newer approaches enable doctors to get a microscopic look at the tissue inside a person's gut, with some surprising results.

One team using this technique to look at the bile duct had expected to find that it is surrounded by a hard, dense wall of tissue. But instead, they saw weird, unexplained patterns. They took their findings to Neil Theise, a pathologist at New York University School of Medicine.

When Theise looked under the skin of his own nose with an endomicroscopy device, he saw a similar result. Further investigation of other organs suggested that these patterns are made by a type of fluid moving through channels that are everywhere in the body.

Theise believes that every tissue in the body may be surrounded by a network of these channels, which essentially form an organ. The team estimates that the channels contain around a fifth of the total fluid volume of the human body. "We think they act as shock absorbers," says Theise.

This organ was probably never seen before because standard approaches for imaging human tissue cause the channels to drain, and the collagen fibres that give the network its structure to collapse. This would have made the channels appear like a hard wall of dense protective tissue, instead of a fluid-filled cushion.

Aside from its cushioning role, the network may also aid the spread of cancer. When Theise's team looked at samples taken from people with invasive cancers, they found evidence that cancer cells that had worked their way out of their original tissues could find their way into these channels, which took them directly to the lymphatic system (*Scientific Reports*, doi.org/gc6zh6). "Once they get in, it's like they're on a water slide," says Theise. "We have a new window on the mechanism of tumour spread."

"It's a water slide for cancer cells. We have a new window on how tumours spread around the body"

Theise and his colleagues are now investigating whether analysing the fluid in these channels might lead to earlier diagnosis of cancers. They think the organ might also be involved in other problems, including oedema, a rare liver disease and other inflammatory disorders.

Jessica Hamzelou ■

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BOURNEMOUTH NEWS/REX/SHUTTERSTOCK

Like people, monkeys can learn by watching others

Social monkeys sync their brains

Helen Thomson

MONKEY see, monkey sync. Rhesus macaques have been found to synchronise their brain activity when they interact – a trait that may help them learn just by watching each other.

Miguel Nicolelis at Duke University Medical Center in North Carolina and his colleagues have developed a system that can record the activity from two monkey brains simultaneously.

They used this to measure activity in the motor cortex – which controls movement – during an experiment in which one monkey was propelled in an electric wheelchair towards a fruity treat, while a second monkey sat across the room and watched. This monkey was encouraged to pay attention by giving it more treats the more closely it watched. When the passenger monkey reached the fruit dispenser, the observer received a large juice reward. The experiment was repeated with various pairings from a group of three monkeys.

The team found that specific groups of neurons showed the same pattern of activity at the same time in both monkeys' brains. This synchronisation could be used to predict what was going on. For instance, certain groups of neurons in the observer's brain only matched those in the moving monkey when they got within touching distance of each other. Other neurons became synchronised only when the moving monkey was travelling at a certain speed (*Scientific Reports*, doi.org/cmwz).

"Analysing brain synchronisation in humans might help us learn to work better together"

Intriguingly, the monkeys' social status affected how well their brains synchronised. When a less dominant monkey was observing a more dominant monkey, synchronisation was higher than when a more dominant monkey was doing the observing. It suggests that brain activity is heavily influenced by social relationships among these animals, says Nicolelis.

The team hypothesises that the brains of less dominant animals mimic the brains of more dominant animals more because they are trying to understand their actions. The mirroring of their brain activity might help them to put themselves in the other's shoes, and to learn skills merely from observing.

The team thinks similar synchronisation might take place in humans. Analysing this might allow us to quantify how well people are working together in a group. Neurofeedback – in which people view their brain activity in real time and learn to modulate it – might help them improve those interactions.

Ron Frostig at the University of California, Irvine, says that more research is needed to understand how different aspects of the room, the monkeys' movements and the social cues might influence brain synchronisation. But he thinks the work has exciting potential – perhaps for understanding social interactions in conditions like autism, for example. ■

Shrimp is as bad for the climate as eating beef

WILD-caught seafood is usually an environmentally friendly option. But a few species have greenhouse-gas footprints as large as that of beef.

Because those high-footprint species are growing in popularity, greenhouse gas emissions from the world's fisheries have risen sharply over the past two decades. The extra effort needed to catch depleted species is also contributing to the rise.

Robert Parker at the University of British Columbia in Vancouver, Canada, and his colleagues pulled together data about the amount of fish caught at fisheries in a number of countries. They combined this with estimates of fuel use for each class of fishery. Because fuel accounts for the majority of greenhouse gas emissions from fishing, they could calculate the total carbon footprint for each fishery.

Globally, they found that carbon emissions from fisheries rose by 28 per cent between 1991 and 2011, even though total catch has barely changed (*Nature Climate Change*, DOI: 10.1038/s41558-018-0117-x). That contrasts with other foods, where improved efficiency has led to lower emissions per kilogram of product.

One reason is that we are eating more shrimp and lobster. Compared with beef, these have higher emissions per kilogram, partly because they are hard to catch. Most other fish are good choices for a climate-friendly diet. "The typical fish product is going to have a similar footprint to chicken, which is the most efficient land-based animal source," says Parker. Some small fish, such as anchovies, do even better. The team is now developing a website that will let people look up the greenhouse gas footprints of different seafood.

The best way to reduce greenhouse gas emissions from seafood is to manage fisheries well. This will allow fish populations to rebuild to higher levels. "The more abundant your fish are, the easier it is to catch them," says Ray Hilborn at the University of Washington in Seattle. Bob Holmes ■

A galaxy missing its dark matter

Leah Crane

THERE is a strange, distant galaxy that seems to be missing something big: dark matter.

Stars at the edges of most galaxies orbit so quickly that they should be flung away. They aren't, though, which implies that the gravity of some unseen extra mass – thought to be dark matter – holds these galaxies together.

We measure a galaxy's total mass using the velocities of the stars it contains. Subtracting the mass indicated by the amount of the stars' light from that total reveals how much dark matter the galaxy might have. When Pieter van Dokkum at Yale University and his colleagues did this for a galaxy called NGC 1052-DF2 that is some 65 million light years away, they found that it probably has no dark matter at all.

In some galaxies, dark matter hides towards the edges. But "in this particular galaxy, because it's so big and diffuse, there's nowhere for the dark matter to hide", van Dokkum says. The team found that DF2 is about 340 million times the mass of the sun. That is an upper limit, so there is a 90 per cent chance that it is smaller. The mass of the stars in DF2 is between about 100 million and 300 million solar masses (*Nature*, doi.org/cmwd).

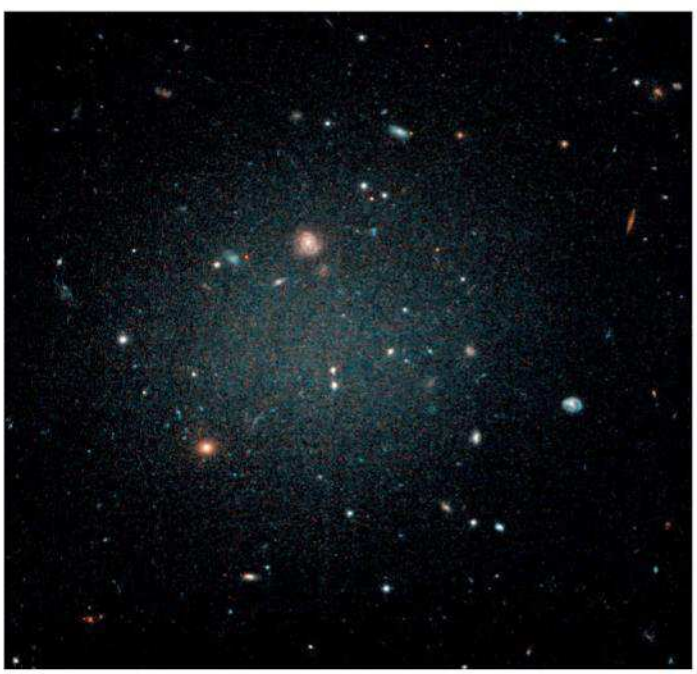
The numbers are imprecise because the galaxy is so distant and dim, but if its mass is below its upper limit and the visible mass is at the top end of its range, there is no room left for dark matter. The team's simulations indicate that this scenario is likely. If there is any dark matter there, it is just 1/400th of what is expected in a such a diffuse galaxy.

Either way, the discovery has the same consequences: it may kill off some theories of modified gravity. These posit that there is no dark matter and galaxies hang together instead because gravity acts differently in their outer reaches from how it works in our part of the universe. That would account for the quickly orbiting stars that seem to indicate dark matter exists.

"It's counter-intuitive, but the absence of dark matter here is actually proof of its existence elsewhere – it's a real substance that can be associated with a galaxy, or not," says van Dokkum. That is, dark matter isn't a force that is applied evenly across the cosmos, but tangible matter that can clump in various ways.

A lack of dark matter in DF2 may also change our ideas of how some galaxies form. "Galaxies begin as a blob of dark matter that accretes gas, which turns into stars, which turn into galaxies," says van Dokkum. If that's the case, how did DF2 come to be? Van Dokkum says it could have formed as a cloud of gas was flung out of a collision between two other galaxies. Or a pool of gas could have been contained by high-speed winds blowing off black holes in the early universe.

"This either indicates some new and unusual way of forming galaxies, or it's a clue that our standard picture of how dark matter works is wrong," says Jeremiah Ostriker at Princeton University. ■



In galaxy NGC 1052-DF2, what you see may be precisely what you get

NASA/ESA/P. VAN DOKKUM

Drill through bones in virtual reality

A VIRTUAL reality system looks set to help teach surgeons to do their job.

Most surgical training involves reading textbooks, watching videos, practising on plastic models or cadavers, and assisting in real operations. But this often isn't enough. According to one estimate, more than 30 per cent of US trainee surgeons are unable to perform operations independently by the time they graduate. The solution could be to get some virtual reality practice.

Orthopaedic surgeon Justin Barad has developed a virtual reality platform called Osso VR for simulating orthopaedic operations such as knee surgery and shoulder reconstruction.

Barad recently invited eight first-year medical students to try the system. Half followed an instruction manual to show them how to nail a rod into a shin bone, while the other four trained using the VR system for 15 minutes. Afterwards, the volunteers who had trained using the VR performed twice as well as the others when asked to repeat the procedure on a plastic model.

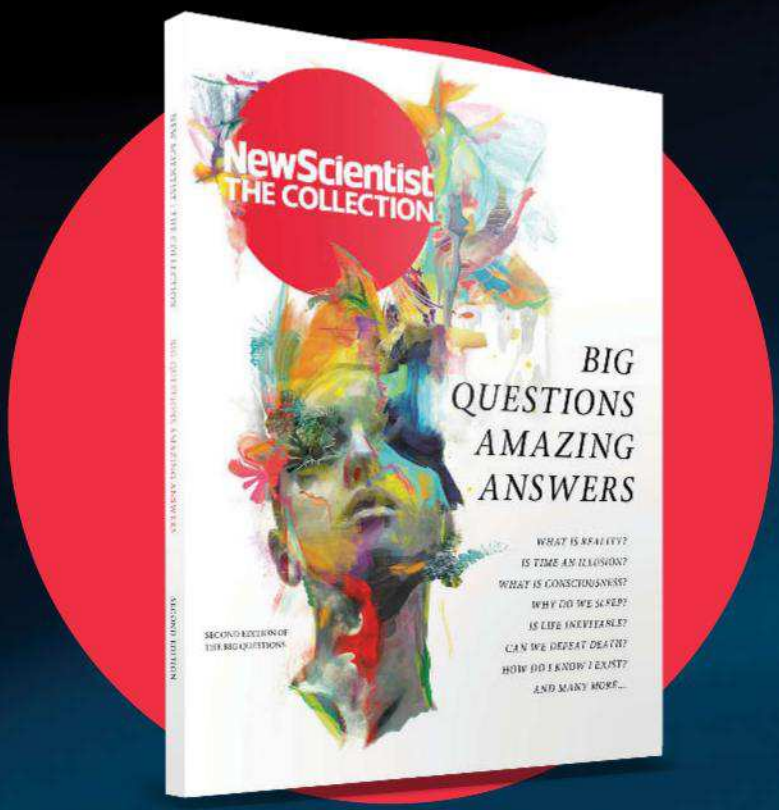
Six universities in the US have now signed up to use the technology in their orthopaedic surgery training programmes.

Osso VR consists of a headset and two hand controllers that allow students to cut open virtual patients and operate on them with virtual drills, screws and hammers. Activities like drilling through bone transmit sensations to your hands that change with the type of bone being drilled.

"There is a patient on the bed in front of you and you have to walk around to reach different tools"

"You look around and it's like a real operating room. There's a patient on the bed in front of you and you have to walk around to reach different tools," says Gideon Blumstein, a third-year orthopaedic surgery student at the University of California, Los Angeles.

VR is likely to be more helpful than textbook-learning, says Matthew Donaldson, an orthopaedic junior fellow at University College London Hospital. "Familiarity with equipment and ability to go through the steps of an operation in real-time are definite advantages," he says. Alice Klein ■



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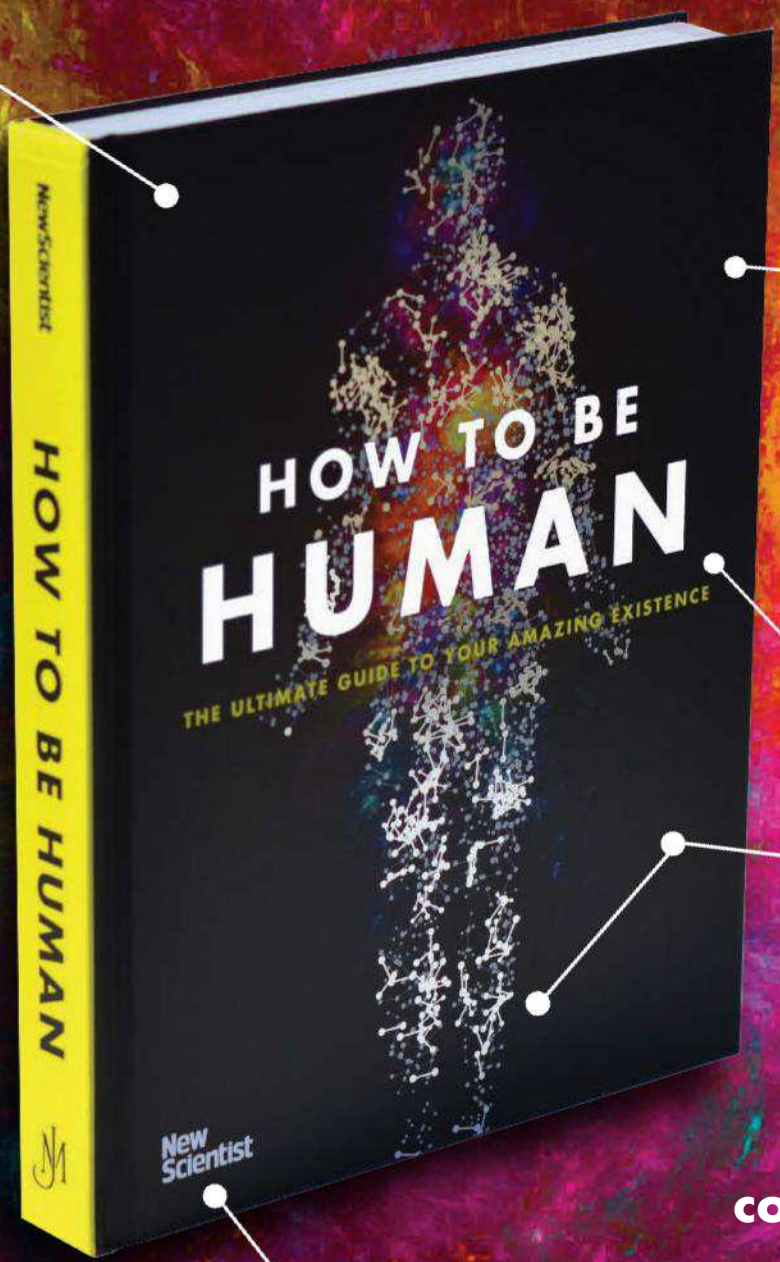

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DOUGLAS WOODHAMS

A handful of frogs bounce back from brink of extinction

THERE is hope for frogs and other amphibians being wiped out by the killer chytrid fungus. Some seem to be evolving resistance, with nine species in Panama almost back to previous levels.

"It offers us all hope," says Jamie Voyles at the University of Nevada in Reno.

The chytrid fungus (*Batrachochytrium dendrobatidis*) has been causing mass die-offs of amphibians all over the world since the 1980s. It is thought to be a hybrid strain created and spread by the global trade in amphibians.

Field surveys carried out at three sites in Panama showed that, after the chytrid fungus arrived from 2004 onwards, the populations of many species plummeted. Among the victims were variable harlequin frogs, which are now critically endangered, and common rocket frogs.

But ongoing surveys by Voyles's team show that, even though the chytrid fungus is still present, there has been a recovery in nine of the 12 species for which they have good data (*Science*, DOI: 10.1126/science.aao4806). Tests show the fungus is just as deadly as before, so the most likely explanation is that these species – like a handful of others – have evolved resistance.

However, it seems there were once 70 amphibian species in the area, of which 50 were hit by chytrid. So the nine recovering species probably represent just 20 per cent of those that declined because of the fungus.

Are you afraid of virtual reality?

IF YOU'RE not scared yet, you will be. A new virtual reality horror game uses the player's heart rate to gauge how terrified they are – and if they're not petrified, it ups the fear factor.

To play *Stigma*, people use a VR headset and a heart rate sensor. Players make their way along dark and creepy corridors full of unexpected dead ends as creatures scuttle around their feet. If their heart rate rises, the game takes that as a sign they are scared enough and continues unaltered.

But if their heart rate remains steady, players are taken on a scarier route that ramps up the creepy visual features and adds strange sounds like distant footsteps to the mix. The game was demonstrated by researchers from Bunkyo University at a conference on intelligent user interfaces in Japan last month.

Other games that monitor heart rate exist. *Nevermind* challenges players to stay calm in stressful situations, such as trying to escape from rooms filled with blood. Another, called *Deep*, serves up soothing experiences in a fantasy underwater world, helping to lower heart rate and slow breathing. It has become a popular tool for reducing anxiety in children.

Jupiter's hefty twin spotted nearby

A JUPITER-like planet has been found orbiting a star just 12 light years away from Earth, making it the closest confirmed gas giant outside the solar system.

The planet, called Epsilon Indi Ab, has the mass of 2.7 Jupiters and takes an extraordinary 52.6 Earth years to orbit its star – among the longest exoplanet orbits yet discovered (arxiv.org/abs/1803.08163). Its star is three-quarters the size of our sun, with just one-quarter the luminosity. The system also has two brown dwarfs – objects too big to be gas giants, but too small to be stars – in a binary orbit.

Fabo Feng at the University of Hertfordshire in the UK and his team detected the planet through changes in light caused by its gravitational pull on its star. Feng says Earth-sized planets could also be nearby, which would give us a star system like our own to study what makes planets habitable.

Product plugs that flout the rules

MILLIONS of "affiliate marketing" videos on YouTube may be in breach of advertising rules.

The practice describes when a video carries a review of a product and a link to purchase it in the video's description – with the reviewer getting a cut of sales made via the link. The practice is lucrative for many YouTube stars. It is allowed, so long as you are transparent about it.

Now a study by Princeton University's Arunesh Mathur and his colleagues has found that around 90 per cent of affiliate marketing on YouTube and Pinterest isn't disclosed (arxiv.org/abs/1803.08488). That is in contravention of rules drawn up by the bodies that protect consumer rights in the US and UK.

How birds really see the world

IT IS hard to focus on an object when your eyes are on opposite sides of your head. So when birds want to direct their gaze, they rapidly bob their heads from side to side to give both eyes a look.

We have eyes on the front of our heads, so our fields of vision overlap, but most birds' eyes are on the sides. Three strategies have been suggested for how they could focus on an object: use just one eye, focus on the area above their beak where they do have binocular vision or look once with each eye then switch.

All these methods would ensure that the most sensitive area of the retina, the fovea, does the looking.

But when Shannon Butler of Purdue University in Indiana and her colleagues tracked the gazes of European starlings, they found the birds don't use any of these three strategies.

Instead, they do something never seen before: they look several times with one eye, then turn their head so the other eye can take several looks, and so on (*Behavioral Ecology and Sociobiology*, doi.org/cmqh).

Eye tracking suggests the birds "are actually using multiple regions of the retina, not just the fovea, to look at objects", says Butler. It's not clear why, but starling retinas are oddly variable in their sensitivity. This might let them see more visual information, such as fine colour.

MAURO ZARKAND/EYEEM/GETTY

Lost villages from centuries ago found in the Amazon

THE remains of dozens of fortified villages, built before the arrival of Europeans, have been discovered in a remote part of the Amazon. It seems the southern periphery of the region was home to a million people before AD 1500.

The first Europeans to reach the Amazon described roads and widespread settlements, including cities. But their reports were later dismissed as fantasies.

In recent decades, deforestation has helped reveal signs of ancient settlements, such as earthworks. It now appears the whole river basin was home to perhaps 10 million people before Europeans arrived. Disease and genocide wiped most of them out, and the rainforest hid the evidence.

So far, almost all indications of past habitation have been on fertile floodplains beside major rivers. Only scattered sites have been found higher up in areas that don't flood regularly, known as terra firme.

Jonas de Souza at the University of Exeter, UK, and his colleagues studied an area of terra firme in the Tapajós river basin in Brazil, nearly 2000 kilometres from the mouth of the Amazon river.

By scouring satellite images, the team found 81 pre-Columbian sites, ranging from single hamlets to large fortified villages, as well as roads (*Nature Communications*, doi.org/cmv3). The largest site spanned 20 hectares. The researchers visited 24 of the sites to confirm their ages and are now excavating one of them, which dates to between 1410 and 1460.

The findings suggest there were settlements across a broad swathe of the southern Amazon.

Lupus may have bacterial trigger

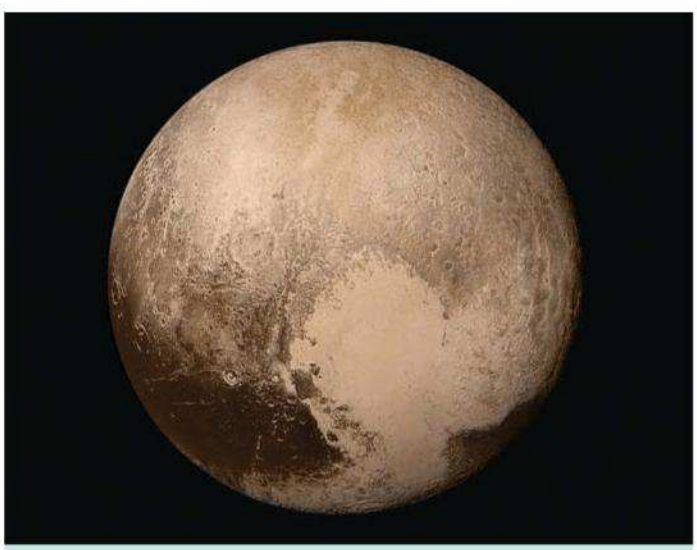
BACTERIA in our bodies may trigger the autoimmune disease lupus in some people.

Lupus occurs when a person's immune system starts to attack their own body, and can cause skin rashes and damage to the kidneys and other organs. In the early stages, a protein that normally protects body tissues, called Ro60, seems to be targeted.

Martin Kriegel at Yale University and his colleagues looked at bacteria from the skin, nose and guts of people with and without lupus, and found that they make proteins similar to Ro60. In people with lupus, these proteins were found to be triggering an immune response.

When the team gave these bacteria to mice that had been stripped of their natural bacteria, they showed a similar immune response and early signs of kidney failure (*Science Translational Medicine*, DOI: 10.1126/scitranslmed.aan.2306).

Kriegel thinks genes might predispose some people to lupus, but the disorder is triggered and sustained by bacteria. The finding could lead to new treatments. "Genes are fixed, but microbes are really malleable," he says.



NASA/JHUAPL/SWRI

Gooey ice gives Pluto a facelift

PLUTO'S heart looks surprisingly fresh, and flowing nitrogen ice may be acting as its fountain of youth.

Images from the 2015 flyby of NASA's New Horizons probe showed that Sputnik Planitia, part of a bright, heart-shaped plain, has no craters. Most bodies in the solar system are pockmarked from rock impacts, and the rest of Pluto's surface has craters large and small, so Sputnik Planitia shouldn't have been spared.

Qiang Wei at Peking University in China and his colleagues calculated that nitrogen ice, which is softer than water ice, on Pluto's plains may flow like molasses to fill in craters as they form. They found that the ice might travel at up to 600 metres an hour, far faster than glaciers move on Earth (*Astrophysical Journal Letters*, doi.org/cmvc).

If the ice is only 4 kilometres thick and its viscosity resembles that seen in lab simulations, a 2-kilometre-deep crater could be filled in just 10 months. If the ice is thicker, such a hole could be erased even faster. But if the ice is stiffer than measured in the lab or it is mixed with other compounds, the process could take tens of thousands of years.

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octopus
A brighter way

Best behaviour

When entire industries treat customers badly, their business is all but broken. That has created huge opportunities, says Simon Rogerson

SIMON ROGERSON is musing on the forces that make good businesses behave badly. Take the financial services industry, for example. Between 2010 and 2014, UK banks paid out about the same amount of money in fines as they did in bonuses. It's a statistic that gets to Rogerson.

"How does an industry behave like that? When you've had to pay £38.5 billion in fines and compensation, how can you think it's right to pay yourself £32.6 billion in bonuses?" he asks. "It's no wonder this is the least trusted industry in the world."

For Rogerson, this kind of behaviour is an opportunity. He and his colleagues Chris Hulatt and Guy Myles were young graduates, working for one of the largest financial companies in the world, when they decided it was time for change. They had an idea: if they created a company that made it easy for people to understand what happened to their money, to feel connected to their investments and be confident in the results, customers would come.

And they were right. They launched Octopus in 2000, and it has since become a company with 700 employees overseeing £7.5 billion-worth of investment. It has also helped Rogerson and his colleagues hone a business model that has expanded into other industries, such as healthcare and energy, and is changing them from within.

There's a common thread here, says Rogerson. All these businesses involve things that matter most to people, namely money, health and the environment. Yet incumbents in these industries tend to be a source of confusion and stress. The aim of the Octopus Group of companies is to give control back to the customers.

Rogerson still remembers their first investor who posted them a £9000 cheque back in 2001. Excited, Rogerson called them. "I don't know what was going through my head but I said 'You are our first ever customer'," he recalls. "We spoke about the investment industry and what he believed was wrong with it. Things like 'I find them difficult to relate to', 'I can't understand the information they send me', 'this really matters to me because I feel responsible for my family.'" Now, 18 years later, this customer is still with Octopus, demonstrating the kind of loyalty that validates the company's mission.

Rogerson believes people increasingly want to use their money to help make the world a better place – by creating jobs in small start-ups and claiming the tax benefits that come with this, for instance, or helping to generate renewable energy. "With this information, people suddenly want to talk about what their money has done, it becomes interesting and engaging," says Rogerson. "And that builds a stronger relationship with the customer."

Building these stronger relationships is a key part of all the group's businesses. In 2011, for example, Octopus built a solar farm, the first of 154, and began selling green energy straight to homes in 2015. The company is now the UK's largest investor in solar power and attracts growing numbers of people who want to help create a sustainable planet.

Octopus Energy also aims to make life easier for people by allowing them to change energy suppliers quickly. Using the company's app, customers can sign up in around 80 seconds. One person managed it in 42.

"We've been creating quite a stir in the energy industry, by lifting the lid on what has been happening for decades"

2000: Three founders launch Octopus Investments

2004: Funds raised for Venture Capital Trust investments

2005: Range expands to include Enterprise Investment Schemes and inheritance-tax products

2007: Octopus Ventures launched

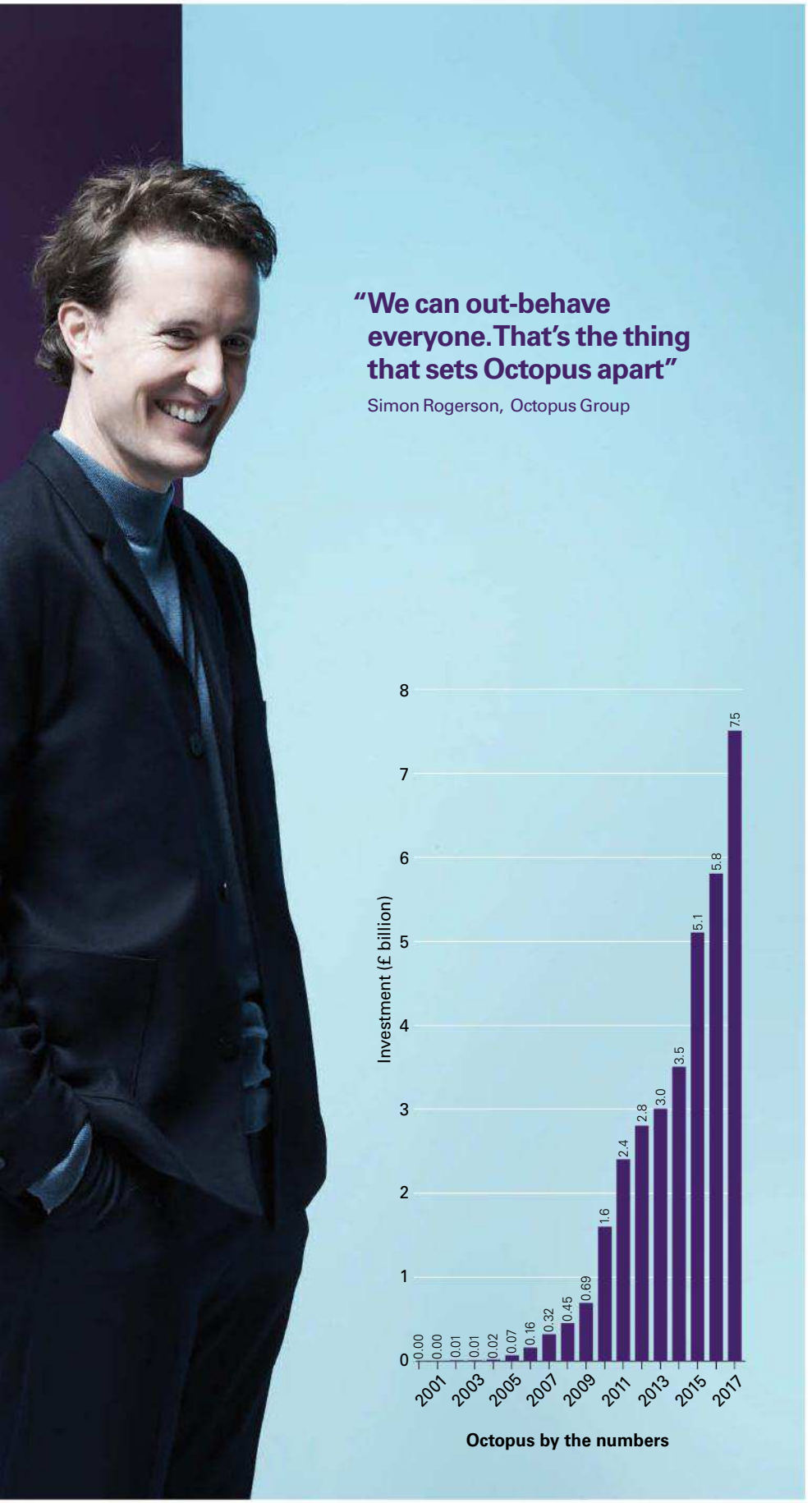
2008: Named by Sunday Times as one of the UK's 100 best SMEs to work for

2009: Reaches £1 billion assets under management

2011: Reaches £2 billion under management

2014: Healthcare specialist MedicX becomes Octopus Healthcare

2015: Octopus Group formed: Dragonfly Property Finance renamed Octopus Property, Octopus Labs and Octopus Energy launched



"We can out-behave everyone. That's the thing that sets Octopus apart"

Simon Rogerson, Octopus Group

Octopus by the numbers

In the spirit of transparency, it's also easy for customers to move away again. At the bottom of each bill, Octopus Energy tells its customers how they can get a cheaper tariff elsewhere – if they want it.

Few do. On the contrary, the company attracted 180,000 customers in its first two years and its customer base is currently growing at a rate of around 10,000 a week.

That's partly because the energy industry has treated customers so badly in the past, says Rogerson. "The Big 6 [UK energy companies] lose money on you in the first 12 months deliberately and then on average put up their tariff by more than 30 per cent," he says. "But their websites emphasise 'customer service', 'responsibility' and, 'ethics'. Who are they kidding?"

Octopus Energy does things differently. It has successfully campaigned for a price cap to limit how much companies can

"People suddenly want to talk about what their money has done"

charge for energy. "We've been creating quite a stir in the energy industry, by lifting the lid on what has been happening for decades," says Rogerson.

Another sector the group has focused on is healthcare and education, in part as a safe investment opportunity. The thinking is that demand for schools, hospitals, doctors' surgeries, care homes and so on is unlikely to drop in the near future. And that creates a financial environment that is "reassuringly boring".

But the desire to tackle things that matter to people is central to this business as well. "Schools for students with learning disabilities tend to be owned by charities that are passionate, but don't have the capital to expand," says Rogerson, by way of an example. So Octopus Healthcare builds new infrastructure and then runs it as a business, allowing the charity to focus on its core skill of care-giving.

Rogerson says that, above all, the standard of behaviour is paramount. Other companies fill their brochures with words like "out-perform" and "out-compete" as a way of luring customers who want a quick buck. Never mind those, he says. "We can out-behave everyone. That's the thing that sets Octopus apart."

Find out more at: www.octopusgroup.com

Stop being the product

The obsession with everything being "free" on the internet led to Facebook's data-slurping model. It might be time to change our approach, says **Jacob Aron**

INFORMATION wants to be free. This decades-old slogan is the philosophical heart of the internet, putting nearly all human knowledge at our fingertips, free to anyone with a connection.

Here is another old slogan: if you're not paying, you're the product. We might not hand over cash for many of the services we get from the internet giants, but we do pay in cold, hard data. On the whole, we have been happy to make that pact. But as the row over Facebook data gathered by Cambridge Analytica shows, many are starting to realise the true price of "free". Perhaps it is time to re-evaluate how much we value our own data – and make tough choices about what we will pay to wrest back control

It wasn't meant to be this way. The free internet championed by those who determined the first online norms had little to do with monetary cost. "Free as in free speech, not as in free beer," was their slogan.

But we were soon led to expect free beer, too. The huge growth of companies like Facebook was supercharged by venture capitalists, happy to fund loss-making start-ups in the hopes of hitting it big. To grow, companies needed scale. To achieve scale, they had to be free.

As access to the internet widened, new users inherited this culture. Yes, the online world provided a playground for ideas, but nobody wanted to pay for anything there. People didn't want the cost of setting up their own email provider when they could use an ad-supported one for free, for example.

"All the marketing associated with the internet has been designed to lead people to value convenience overwhelmingly, and to devalue anything else such as your own freedom and other people's freedom," says Richard Stallman, founder of the Free Software Foundation and a long-standing critic of Facebook.

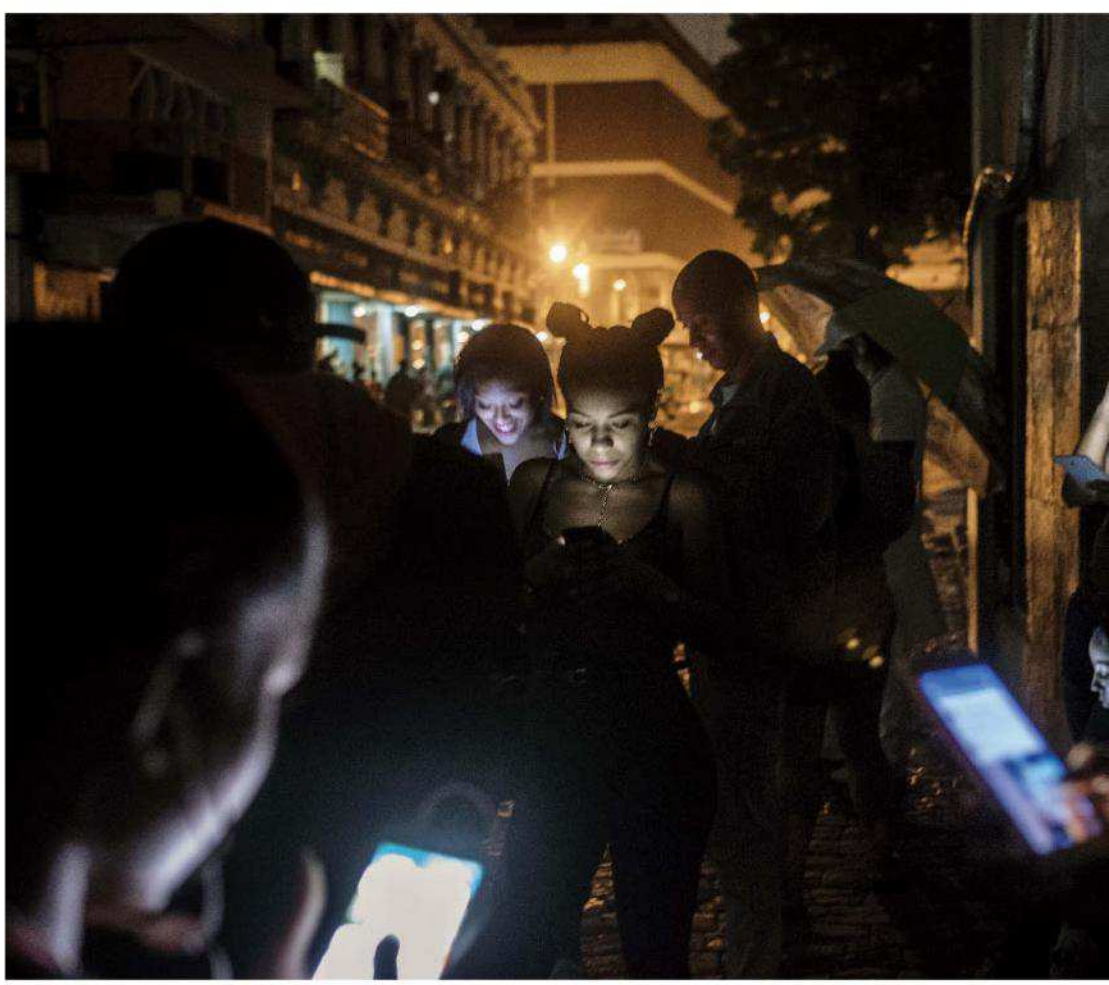
This is how we have ended up relying so heavily on the "free" data-slurping tech giants. But some people are trying to change the dynamic.

"The online world provided a playground for ideas, but nobody wanted to pay for anything there"

Aral Balkan is an activist and co-founder of Indie, which develops privacy-minded tools and services. He is working with the Belgian city of Ghent to provide an alternative to social media sites.

Citizens will be able to sign up for their own .gent website, which will be able to follow and update other .gent sites. The sites will also connect to other like-minded services such as Mastodon, a privacy-respecting alternative to Twitter (see "Ditch and switch", right). The idea is that it will work much like a Facebook profile, but each person will own their own site – there is no central authority hoovering up your data.

On the face of it, that sounds a lot like the old web, where people created simple pages hosted on computers they controlled. The



crucial difference is that it used to be difficult to put things online without technical know-how – which is partly why easy-to-use services like Facebook are popular.

Balkan wants the .gent project to be simple to use, with plans forthe webhosting and domain registration to happen in the background. "We solve that problem, and that's where we change the game," he says.

The project is being funded by the city of Ghent, which Balkan says is a model for the way forward. "We need to start funding these ethical alternatives from the commons, for the common good," he says.

He's not calling for social media to be run by the government or for Facebook to be nationalised, he says – the potential for surveillance is too high. The Chinese government plans to use personal data to rate individual citizens, for example. Instead, the taxpayer could fund online services, which are kept at arm's length from the state.

FRANCESCO PISTILLI/BLOOMBERG VIA GETTY

Take the power back

"The government can provide the underlying infrastructure, but the control of the data should be with citizens themselves," says Francesca Bria, founder of the DECODE project in Barcelona and Amsterdam.

This European Union-funded initiative is combining a blockchain, the distributed ledger technology behind bitcoin, with an extra layer of encryption to let citizens in each city share their data for the common good. The idea is that companies or governments could build services that use this data to improve citizen's lives, and the citizens get to choose which projects they take part in.

These projects are small in scale and unlikely to take down Silicon Valley any time soon, but the EU is already mulling stronger responses. In the same week as the Cambridge Analytica revelations emerged, the European Commission announced plans for a digital tax aimed squarely at the data-hawking giants. "Profits made through lucrative activities, such as selling user-generated data and content, are not captured by today's tax rules," it said in a statement.

Bria says that the revenue from this digital tax should be invested in creating alternatives that protect users' privacy.

The tax may not happen; countries like Ireland and Luxembourg, which attract the European headquarters of US tech firms by offering low-tax regimes, aren't happy about the proposal and may still block it.

But the EU has an even stronger weapon to deploy. An EU-wide law called the General Data Protection Regulation (GDPR) will come into force in May – including in the UK, regardless of Brexit – and stipulates that companies must give people much greater control over their data or face heavy fines.

It is an interesting coincidence that the GDPR is coming in just as everyone is focused on Facebook, says Paul Bernal at the University of East Anglia, UK, as the law requires companies to seek a higher standard of consent from people before exploiting their data. "It's a big opportunity to see whether the regulators are going to use it," he says.

It could lead to companies having to explicitly ask people to opt-in to data use. This is a conversation that is long overdue. When our data was increasingly monetised in the early 2000s, we all just went along with it, says Rachel Coldicutt, CEO of UK internet think tank Doteveryone. "There was never an explicit moment of consent."

Anger against Facebook has generated its own hashtag – #DeleteFacebook – and some believe that the outrage is unlikely to subside. "In the past, it has always blown over, but I do feel that it is different this time," says Balkan.

"When our data was increasingly monetised in the early 2000s, we all just went along with it"

If Mark Zuckerberg wants to make a radical apology and regain trust, he should turn Facebook ads off for a year, says Coldicutt. "They could say they are going to spend a year looking at alternative business models," she says. "The fact that they are not means the responsibility is coming back to us as individuals."

"It is important that we are finally realising that this is a structural problem," agrees Balkan. "The business model is unethical, and we need alternatives." ■

DITCH AND SWITCH

Want to take back control of your data? Try these privacy-respecting alternatives to online services:

DITCH: FACEBOOK
Facebook's data-slurping habits are legendary, with many users choosing to delete the app from their phones in the wake of recent revelations.
SWITCH: DIASPORA
Diaspora decentralises social networks by letting people set up their own servers to host content. Users retain ownership of their data and aren't required to use their real name.

DITCH: GOOGLE
Google stores your entire search history and uses it to make website and video suggestions, profile you and sell adverts.
SWITCH: DUCKDUCKGO
Search engine DuckDuckGo doesn't store any information. All users see the same search results, so they aren't tailored to your particular interests.

DITCH: TWITTER
Twitter uses the information it knows about you to sell ads – things like your age, gender or location.
SWITCH: MASTODON
Mastodon offers similar features to Twitter but is decentralised, meaning that anyone can set up a Mastodon server that is independently owned. Users on one server act as a single community, but can also communicate with people on other servers.

DITCH: GMAIL
Gmail used to make money by scanning your inbox for keywords, then showing you adverts based on your interests. Last year, Google announced it would no longer sell ads in this way – but emails are still scanned to power flight reminders, calendar updates and other Google features.
SWITCH: PROTONMAIL
Protonmail encrypts all of its users' emails, meaning it has no access to your inbox. A basic account is free, while extra features like folders require a subscription. The service is so secure that Cambridge Analytica reportedly used it.

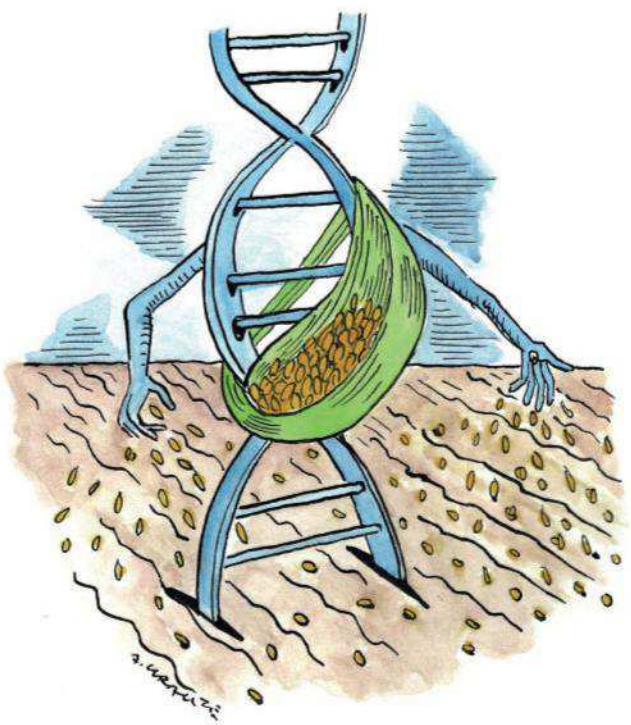
Still cultivating change

End the irrational opposition to genetically modified crops. They could help subsistence farmers, says **Mark Lynas**

PRO-SCIENCE types, while lambasting those who campaign against genetically modified crops, often point out that no one has ever been harmed by the food produced from them. After 3 trillion meals, they insist, nobody has credibly reported even so much as a headache. August science bodies all agree.

Perhaps I am the first person harmed by dealings with a genetically modified organism (GMO). During a recent trip to see GM maize in a trial in Uganda, I got quite a severe sunburn. But the maize looked impressive. With an insect-resistance gene called *Bt*, it was clearly better able than non-GM maize to fend off pests. It also has a drought-tolerance trait.

While there, I spoke to a farmer called Lule Monica. She told me she was "praying" for the day when the modified maize, produced under the banner of the philanthropic Water Efficient Maize for Africa group, would be available. She worries about fall armyworm, a pest that has hit maize crops in Uganda and elsewhere in East Africa.



However, anti-GMO activists in Uganda, often supported by well-meaning European donors, have so far managed to block its release. This has also hit the likes of GM bananas and cassava. All are staples for subsistence farmers in some of the poorest regions and have nothing to do with the corporate behemoths that are the usual targets of suspicion in the GM debate.

Talking to farmers denied the opportunity to grow these crops, such as those in Kenya and Tanzania as well as Uganda, always makes me uncomfortable, because they remind me of my own role in perpetrating this global injustice.

In the firing line

China's attitude to space debris needs to change, says **Paul Marks**

A SPACE station plummeting back to Earth tends to grab attention. As this article went to press, China's stricken Tiangong-1 was due to re-enter the atmosphere, with a risk, albeit tiny, of bits hitting populated areas.

If this had you fretting during the Easter break, spare a thought for some Chinese citizens, who are repeatedly in the firing line as a result of the nation's approach to debris from its space programme. Examples this year include residents of Xiangdu in southern China, who pointed smartphones skyward at something tumbling from the heavens. It exploded in fields near a town. The object turned out to be a booster from a rocket that had launched satellites from a site 700 kilometres away. The same thing happened again a month later. It was sheer luck no one was killed.

Neither was unforeseen. Both occurred in a designated rocket-stage drop zone, where risking public safety with ditched, fuel-carrying boosters is a price China's totalitarian government is willing to take so it can bask in the glory of space flight.

This attitude extends to orbit, too. China's most infamous act there was obliterating one of its defunct satellites with a missile in 2007. This led to low Earth orbit being polluted with an extra 3500 trackable chunks of fast-moving space debris – and many smaller untrackable fragments.

"China's most infamous act in space was obliterating one of its defunct satellites with a missile in 2007"

In the case of Tiangong-1, if debris mitigation really mattered to Chinese authorities, they would have had a backup plan for getting it down in a controlled fashion.

China will claim it pays due attention to debris risk and will no doubt point to its membership of the Inter-Agency Space Debris Coordination Committee as evidence. But it is in denial on

As an anti-GMO campaigner in the mid to late 1990s, I helped destroy field trials in the UK and spread opposition to progress in modern plant breeding.

Then five years ago, at the UK's Oxford Farming Conference, I publicly apologised for my anti-GMO activism. I had realised that the scientific consensus on GMO safety was akin to that on human-caused climate change. As a writer and environmentalist, I couldn't defend science in one (climate), while denying it in another (GM).

Yet many politicians and environmental organisations are still on the horns of this dilemma. Their continuing refusal to accept overwhelming scientific evidence on genetic engineering puts them in the same camp as climate change deniers.

Change may be slow, but I think it is coming. It is one thing for an individual to change their mind, quite another for political parties or campaign groups to do so. But whether the switch will come fast enough to help subsistence farmers across the planet increase their harvests in the face of many pressures, including climate change, remains to be seen. ■

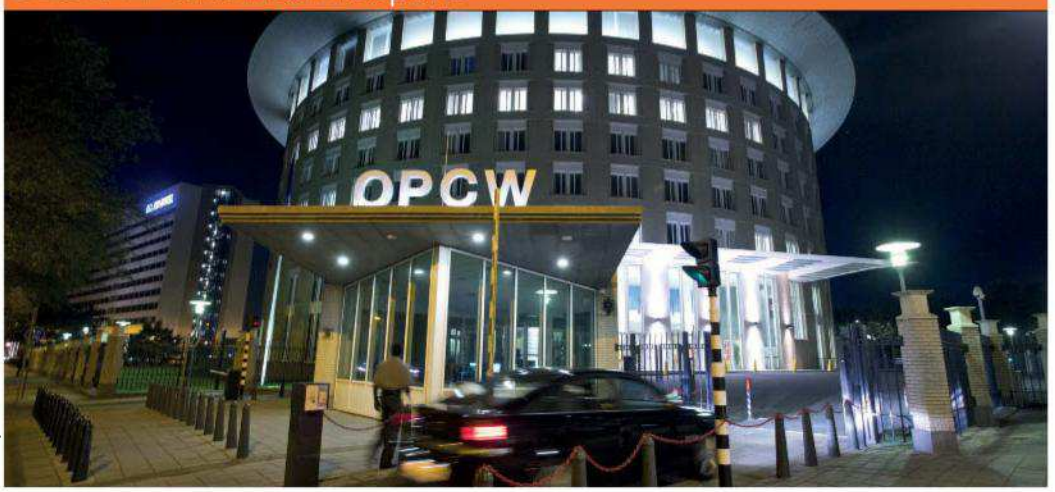
Mark Lynas's latest book *Seeds of Science: Why we got it so wrong on GMOs* (Bloomsbury) is out this month

this: in announcing Tiangong-1's fate, for instance, Beijing's official news agency, Xinhua, claimed that China has always valued the management of space debris. Dumping boosters in populated areas and blowing apart a satellite cannot be reconciled with that.

That is a shame as it detracts from the nation's exciting space projects, such as testing quantum communications in orbit and a plan to land on Mars in 2021. It is time China's deeds matched its words. ■

Paul Marks is a technology, aviation and space-flight writer based in London

INSIGHT Chemical weapons



PETER DEJONG/AP/REX/SHUTTERSTOCK

Testing times for vital international treaty

Debora MacKenzie

THE attempted assassination of Sergei and Yulia Skripal has sparked an international crisis, with UK allies expelling scores of Russian diplomats in solidarity against the apparent use of chemical weapons on British soil. But behind the scenes, another crisis is unfolding: the first ever test of whether the international treaty banning these weapons can be used in a world for which it wasn't designed.

This matters much more than a few diplomats being sent home. Arms agreements backed by science, like the 1997 Chemical Weapons Convention, are a centrepiece of the "rules-based international order" that has governed the world since 1945.

These days, that order is under increasing strain. The chemical weapons treaty was meant to manage military attacks, not assassinations. How well it fares in this standoff could affect whether the world continues to rely on such arms agreements, or falls back on old-fashioned power politics.

UK tests identified the weapon used against the Skripals as a Novichok nerve agent. These were originally developed in the Soviet Union, but have also been synthesised by defence labs elsewhere. So we don't know for sure that Russian Novichok poisoned the Skripals.

Last week, the Organisation for the Prohibition of Chemical Weapons (OPCW), which verifies the treaty, sent samples of the Skripals' blood to two independent, approved labs. The OPCW has never done anything like this before, says Jean Pascal Zanders, a chemical weapons consultant.

These samples will be analysed by gas chromatography and mass spectrometry, with DNA sequencing

"The chemical weapons treaty was meant to manage military attacks, not assassinations"

used to establish whose blood it is. Russia's delegate to the OPCW has called this a "legitimate" approach.

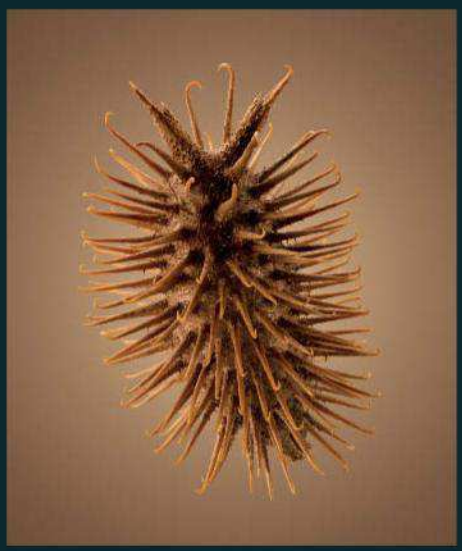
What would really settle the matter would be to compare the samples to Novichok agents synthesised by the Soviet Union. Vladimir Uglev, a chemist who helped develop the agents, told a Russian news site that Novichok agents were only ever made in small batches. If his product had been used in the UK attack, he says, the OPCW's tests could not only identify which agent was involved, but could even match the samples to a specific batch.

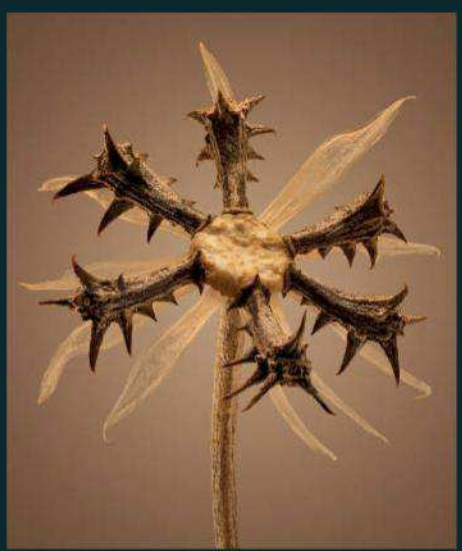
However, such comparisons are only possible if Russia cooperates. The UK has demanded "clarification" from Russia, under article 9 of the treaty, the first time it has ever been invoked. So far, Russia hasn't been forthcoming.

If that continues, says Ralf Trapp, a former expert at the OPCW, the matter could escalate until it reaches the UN Security Council. He fears that will only lead to a Russian veto at the UN.

Other tools are available, says Trapp. For example, treaty member states could vote to add Novichok agents to the lists of chemicals that signatories must declare to the OPCW for inspection, forcing Russia to allow access. They aren't listed now because their existence was only revealed by Russian whistle-blowers after the treaty negotiations concluded.

Under the treaty's ultimate sanction, the UK could demand to inspect locations in Russia suspected of holding Novichoks, at short notice. But Russian officials would manage inspectors' access and may well have cleared these sites already. As things stand, the treaty does provide ways to resolve the latest chemical outrage – but only if all nations continue to see the rules-based international order as something worth preserving. ■





Spiky hitch-hikers

IT IS unwise to walk barefoot through the grass in South Africa. A myriad of tough, spiky seeds lie in wait, hoping to catch a ride to someplace new.

"I have clear and painful memories of stepping barefoot on these thorns," says photographer Dillon Marsh, who grew up on a farm near Stellenbosch. "I regularly have to remove burrs from my socks after taking landscape photos, and recently I looked at one of these up close and realised it had some fascinating features."

Marsh collected these specimens mostly from around Cape Town and along South Africa's west coast. Stacked macrophotography, in which each image is a composite of between five and 50 photos, each focused at a different point, reveals the menacing spikes and hooks in all their glory.

But such weaponry isn't meant to cause pain. Plants evolved these burrs as dispersal devices, and Marsh has named this series of photos "Hitchhikers". By hooking onto a passing animal's fur – or embedding themselves in an animal's foot – these burrs can spread the seeds they contain to new locations. It is such a successful strategy that burrs can cross continents.

Marsh spent months looking for these examples in grassy fields and undergrowth. The pain of stepping on a *duwweltjie* (top left) will be familiar to many South Africans (the name means "little devil" in Afrikaans). It comes from the plant *Tribulus terrestris*, which is particularly well adapted to grow in harsh, dry climates, and has successfully spread throughout Africa and parts of Europe, Asia and Australia.

For humans, these burrs can be more than just a momentary annoyance. Large cockle burrs (top right) are a problem for South Africa's wool industry, as they get stuck in the fleeces of sheep. Contaminated wool has to be cleaned before it can be processed and sold. Penny Sarchet

Photographer
Dillon Marsh
dillonmarsh.com

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CARLO ROVELLI
THE NATURE OF TIME

SARAH-JAYNE BLAKEMORE
THE SECRET LIFE OF THE ADOLESCENT BRAIN

JON COPLEY
BLUE PLANET, UNSEEN

Law and...

We are building machines to undermine nature's most rigid rule, says physicist **Vlatko Vedral**

A FEW years ago, I had an idea that may sound a little crazy: I thought I could see a way to build an engine that works harder than the laws of physics allow.

You would be within your rights to baulk at this proposition. After all, the efficiency of engines is governed by thermodynamics, the most solid pillar of physics. This is one set of natural laws you don't mess with.

Yet if I leave my office at the University of Oxford and stroll down the corridor, I can now see an engine that pays no heed to these laws. It is a machine of considerable power and intricacy, with green lasers and ions instead of oil and pistons. There is a long road ahead, but I believe contraptions like this one will shape the future of technology.

Better, more efficient computers would be just the start. The engine is also a harbinger of a new era in science. To build it, we have had to uncover a field called quantum thermodynamics, one set to retune our ideas about why life, the universe – everything, in fact – are the way they are.

Thermodynamics is the theory that describes the interplay between temperature, heat, energy and work. As such, it touches on pretty much everything, from your brain to your muscles, car engines to kitchen blenders, stars

MARTIN LEON BARRETO

...disorder

to quasars. It provides a base from which we can work out what sorts of things do and don't happen in the universe. If you eat a burger, you must burn off the calories – or get fatter. Coffee never spontaneously warms up when set on a table. As the universe expands, it cools, heading unwaveringly towards heat death in the distant future. All these unavoidable truths spring from thermodynamics. In fact, they come from its two main laws, uncreatively named the first and the second laws.

These laws go back a long way, and one of my favourite episodes relating to their creation involves Julius von Mayer, a German doctor whose real passion was physics. The story goes that in the 1840s, Mayer got a job as a ship's surgeon on a voyage to Jakarta. During this, he noticed something curious: near the tropics, the blood in the sailors' veins wasn't blue as it would be back home in Germany, but deep red.

He hypothesised (wrongly, as it turns out) that the redder blood was due to less food being used to keep the body warm in the hotter climate. But in thinking about the give and take between metabolism, temperature and heat generation in the body, Mayer had alighted on the essence of the first law: energy can't be created or destroyed, merely passed around.

What came to be called the second law had its genesis about 20 years before Mayer boarded his ship. At this time, steam engines were transforming Europe, their furnaces and pistons driving the factories and mills of the industrial revolution. Sadi Carnot, a French engineer, was dissatisfied that no one had a rigorous understanding of how these engines worked, and set out to develop one.

His crucial insight was that, left to their own devices, hot things always spread warmth to their surroundings. When water is heated in steam engines, for example, some of the heat always leaks away to the air outside, so they are never perfectly efficient. In 1824, he published his only book generalising the idea to show that no engine can exceed a certain limit, now known as the Carnot efficiency. This depends on the temperature difference between the heat source (say, a fire) and the heat sink (say, the outside air).

Inescapable entropy

Carnot died a few years later, and his book was ignored for decades until German physicist Rudolf Clausius took notice. Carnot had conceived of heat as a weightless substance called caloric, but Clausius knew it was actually related to how fast atoms or molecules move. That enabled him to reformulate Carnot's ideas in terms of a measure of disorder he called entropy. Imagine you have a hot box of particles that are moving quickly and a cold box of slow-moving ones. That is an orderly arrangement because all the particles with similar energies are together. But the universe doesn't like low entropy states, said Clausius. If you open the boxes, the particles mix. This led him to the second law as we know it: entropy naturally increases unless you put in some work to stop it.

Follow the logic of the two laws and you end up with a cast-iron description of what's possible in the universe. The astrophysicist Arthur Eddington once said: "If your theory is found to be against the second law of thermodynamics I can give you no hope; ›

there is nothing for it but to collapse in deepest humiliation."

What, then, of my idea for an engine that bends the rules? It would seem like pie in the sky. Actually, we have a name for an engine that brushes aside thermodynamics. We call it a perpetual motion machine, a byword for scientific charlatanry. But the machine down the corridor is not one of those. It exploits a sneaky but legitimate loophole: quantum physics.

Thermodynamics predates quantum theory; in fact, it was responsible for its birth. In 1900, the German physicist Max Planck was trying to understand the properties of a hypothetical object called a black body that absorbs all radiation falling on it and then emits it again. The best physics of the time suggested there were an infinite number of wavelengths, so the body would emit an infinite amount of energy. That was nonsensical. Planck solved the problem by supposing that energy can only come in chunks. He called them quanta.

That leap helped explain many niggling questions in physics. But when we began studying objects that perform according to the quantum playbook, we found they do extraordinary things. One of the best-known examples is entanglement, when two particles become intertwined so that interfering with one instantly changes the properties of the other. Another example is that an atom can simultaneously exist in a low and high-energy state, known as a superposition.

These behaviours break all the usual rules of dynamics. Is there any reason to think thermodynamics is exempt? Only in the past five years or so have we had the tools to probe this question. Take the work of Tobias Schaetz at the Freiburg Institute for Advanced Studies, Germany. In 2016, he described an experiment looking at ions inside a crystal. He gave them some energy and watched how they cooled. Unlike a cup of coffee, which cools gradually, the ions seemed to lose energy for a while, but then the energy suddenly bounced back. It is proof of what we had suspected: the rules of classical thermodynamics don't always apply in the quantum world.

Unfortunately, it is tricky to pin down what laws do apply. This is because there are no obvious quantum equivalents of classical thermodynamic concepts like heat or entropy. They are the ultimate product of the motions of many particles; so how do you begin to think of analogues when you are dealing with just one or two particles?

Well, never mind. I thought I would make a quantum version of a heat engine anyway. It is rather a different engine from anything Carnot would have been familiar with, but the principles are the same. The idea was to set up pairs of organic molecules and raise them to a high energy level by shining light on them. Left alone, the molecules will return to a slightly lower energy level, re-emitting light of a different frequency as they do so.

Here's the important part. If we set up the experiment just right, the emitted light won't carry any information that could tell us which of the two molecules it came from. According to quantum theory, this forces them to become entangled, so that when one drops to the lower energy level, the other one automatically does too, with both emitting light in unison in a process called superradiance. I expected that this quantum engine would still be subject to energy leakages in the manner Carnot identified nearly 200 years ago. But because of the superradiance, it should transfer energy faster, making it more efficient than a non-quantum engine.

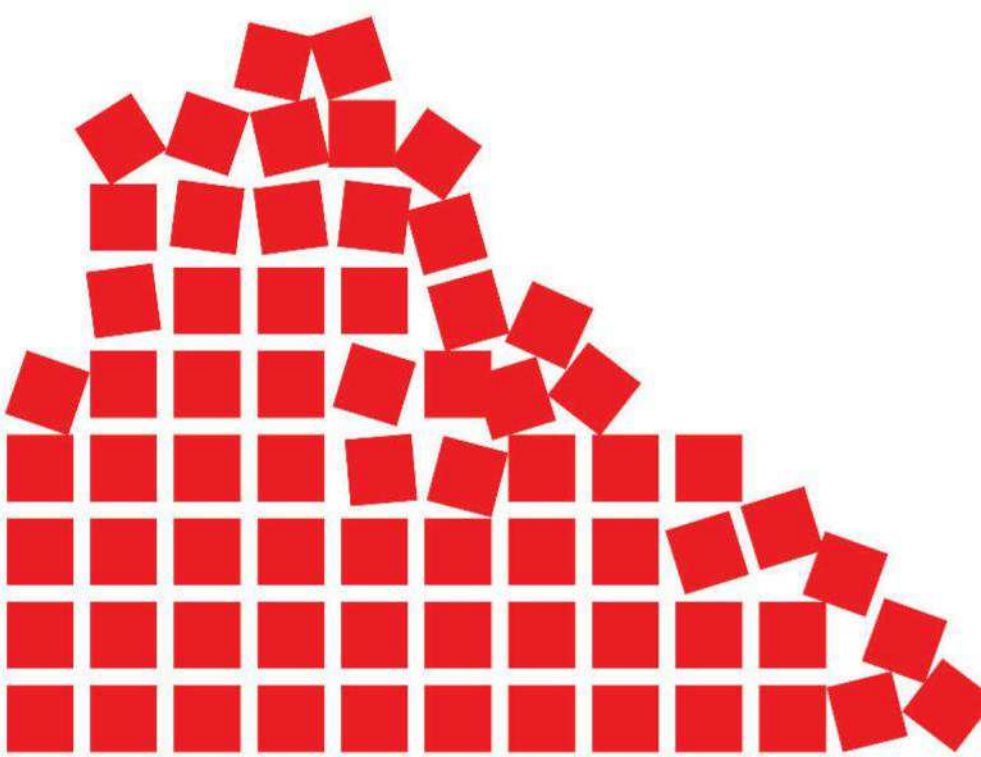
> "Quantum thermodynamics may mean time can tick in two directions"

Working with my two experimentalist colleagues, Tristan Farrow and Robert Taylor, I completed a control experiment last year in which the molecules weren't entangled. But just as we were putting the finishing touches to the interesting version, we were scooped.

In October 2017, my Oxford colleague Ian Walmsley and his team described an experiment similar to the one we had envisaged. In this engine, it was not organic molecules doing the absorbing and emitting, but atoms trapped inside special cavities in a diamond. The atoms weren't entangled, but were in a superposition of a high and low-energy state. And sure enough, Walmsley and his team saw that light was produced quicker than the classical rules of thermodynamics predict.

It isn't yet entirely clear why this is so. And admittedly, the degree of violation is tiny and wouldn't be useful in practice. Nonetheless, it is crucial first proof that quantum heat engines can bend those cast-iron rules.

I expect this machine can be improved upon and I am excited about the future of quantum heat engines. The thing that first drew me into this game is my work on quantum computers. There is plenty of talk about these futuristic machines, which operate using quantum bits, or qubits, and



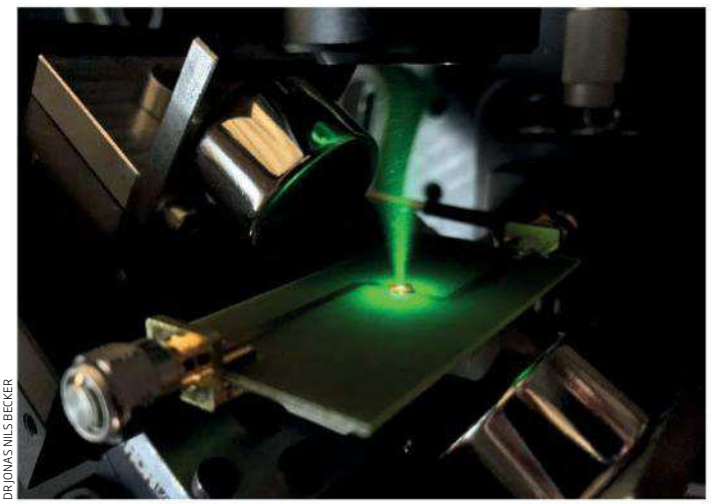
should be able to crack all sorts of intractable calculations. But getting them to work involves cooling the hardware to extremely low temperatures, which demands vast amounts of energy.

Descendants of Walmsley's machine could help. After all, a heat engine converts heat into directed work, for example to move a steam engine's piston. If you reverse that, you can use directed work to pump heat away. The result is a quantum fridge. Gleb Maslennikov at the National University of Singapore and his colleagues are already experimenting with quantum fridges, with promising indications that they too might be more efficient than their classical counterparts.

It's not just quantum computers that could benefit. One major obstacle to further miniaturising normal circuits is that they would overheat if we tried to cram components any closer. Better refrigeration is exactly what we need.

If you think quantum fridges sound handy, allow me to introduce the quantum battery. A former student of mine, Felix Binder, now at Nanyang Technological University in Singapore, has shown that quantum batteries can charge more quickly than normal ones.

Instead of moving ions around, as traditional batteries do, these devices would have electronic bits akin to a computer bit that can be either charged or not. Under classical thermodynamics, the amount of energy used to charge the battery increases linearly with the number of bits. But Binder has shown that if we entangle the bits, the amount of energy needed for a full charge scales with the square root of their number. This means that a quantum battery with 1 million bits would be fully charged in the time it would take to charge a 1000-bit classical battery. Vittorio Pellegrini at the Italian Institute of Technology in Genoa is one researcher hoping to build such a super-battery within a few years.



DR JONAS NILS BECKER

Rule breaker: A diamond-based quantum heat engine at the University of Oxford

The untidiest room

But we shouldn't think that quantum thermodynamics is only about creating gizmos. It also touches the most profound distinction there is: life and death. Living things constantly strive against the second law of thermodynamics, sucking in energy to maintain the order within their cells. Powering all this are our bodies' equivalent of heat engines: mitochondria. So here's an intriguing question: given that natural selection tends to encourage efficiency, has biology evolved quantum heat engines? There is a hot debate about whether any quantum effects are important in biology, but in my opinion it's not crazy to think that evolution would produce the most efficient engines possible.

Even the flow of time might be recast by quantum thermodynamics. No physical law provides a reason why any natural processes can't go backwards – except the second law of thermodynamics. Its insistence that entropy must increase leads many physicists to suspect that time somehow arises from entropy changes.

In classical terms, entropy makes intuitive sense. For example, classical thermodynamics says the universe must be at least as disordered as its parts are. This is like saying that the overall messiness of a house, perhaps quantified as the amount of energy needed to tidy it up, can't be less than the messiness of the untidiest room.

The picture would be radically different if the universe obeys the laws of quantum thermodynamics. True, we don't know exactly what these are yet. But we do know from the equations of quantum theory that the overall amount of disorder in the universe must remain constant. What's more, quantum uncertainty forbids us from gaining full information about the states of individual parts of the universe, meaning that some parts can be more disordered than the whole.

This could mean that if you look at the universe as a whole, entropy doesn't change and so there is no time. But look at small patches where entropy is changing and time starts ticking. Because things don't have to add up everywhere, all the time, it is even possible that the arrows of time flow in different directions in different parts of the universe.

It is only by carefully probing the quantum foundations of thermodynamics that we will discern whether any of this is an accurate picture of reality. That's why quantum heat engines are so interesting. I can't wait to put mine through its paces. ■

Vlatko Vedral is a physicist at the University of Oxford, UK, and the National University of Singapore

RICHARD BAKER/IN PICTURES LTD./CORBIS VIA GETTY IMAGES

Culture clash

Why are some societies strict and others laissez-faire, wonders **Laura Spinney**

I'M BRITISH. Soon after moving to Switzerland, where I lived for six years, I threw a house-warming party and was taken aback when all 30 guests arrived exactly on time. Years later, having moved to France, I turned up at the appointed hour for a dinner, only to find that no other guest had arrived and my hostess was still in her bathrobe.

Every culture is riddled with unwritten rules, such as ones on punctuality. They are the invisible scaffold that frames the behaviour of individuals so that the collective can function in a frictionless and productive way. But the rigour of these rules and the exactitude with which they are enforced varies dramatically. Some nations tolerate singing in an elevator, swearing during an interview or entering a bank barefoot, for example, while others frown upon such behaviours. Perhaps these aren't mere quirks. Perhaps the best way to understand societies is to look at their social norms.

That is the argument being made by cultural psychologist Michele Gelfand at the University of Maryland in College Park. She and her colleagues describe societies with strict, rigorously enforced norms as "tight" and those with more laissez-faire cultures as "loose". They argue that this key difference underpins all sorts of others, from creativity and divorce rates to the synchronicity of public clocks. What's more, they believe they know why some nations are tighter than others – and how to influence social norms. If they are right, this could clear up many cross-cultural misunderstandings, not just between nations, but also within countries, corporations and households.

Ever since 1961, when Stanley Milgram started persuading people to obey his commands to give others electric shocks, experimenters have manipulated social rules and observed the pressure people feel to conform. However, researchers tended to study norms within societies – Western ones, mainly – rather than between them. One person to buck the trend was Dutch social psychologist Geert Hofstede.

Starting in the 1960s, he developed a model for understanding cross-cultural differences based on six dimensions (see "Six degrees of separation", right). Since then, one of his metrics, individualism/collectivism, has attracted considerable interest and proved useful in explaining cultural differences, especially those epitomised by typically Western or Eastern modes of thought. But Gelfand believes the focus has been too narrow, and that tightness/looseness is a neglected source of cultural variation that has a huge influence on our behaviour – "a Rosetta stone for human groups", she says.

The fear factor

In fact, the idea of cultural tightness also dates back to the 1960s, when anthropologist Pertti Pelto studied 21 traditional societies and found big differences in the rigour of their social norms and how these were enforced. The tightest included the Hutterites, while the !Kung people of southern Africa came at the other end of the scale. Pelto's insight was to suggest that tightness was connected to ecological factors such as high population density and dependence on crops for survival.

Gelfand wondered how this might apply to modern societies. She suspected that tightness is determined by the level of external threat to which a society was exposed historically – whether ecological, such as earthquakes or scarce natural resources, or human-made, ›

SIX DEGREES OF SEPARATION

Differences between cultures can be understood in terms of six factors, according to a model developed from the 1960s, which is now being challenged (see main story).

Individualism
The degree of personal independence as opposed to mutual interdependence.

Power distance
The extent to which citizens expect and accept an unequal distribution of power.

Masculinity
The extent to which the use of force is endorsed socially.

Uncertainty avoidance
The level of anxiety and distrust in the face of the unknown.

Long-term orientation
The degree of belief that the world is in flux as opposed to seeing the past as providing a moral compass for the future.

Indulgence
The tendency to value freedom, impulsiveness and friendship rather than seeing life in terms of struggle and duty.

UPTIGHT IN ICELAND

Social engineering has a terrible reputation: think China's Cultural Revolution, or the atrocities of Cambodia's Khmer Rouge. Nevertheless, it can have positive results. Take Iceland.

In the early 1990s, the country had a problem: its young people were abusing drugs and alcohol, and becoming a social menace. When the authorities consulted addiction expert Harvey Milkman at the Metropolitan State University of Denver, Colorado, he proposed a seemingly simple solution. They should give teens the high they craved in a healthier form – sports.

It sounded promising, on paper. The challenge was to get the kids to comply. A night-time curfew was imposed on 13 to 16-year-olds, and the state invested in sports, dance and arts programmes. Meanwhile, teachers, parents, journalists and politicians all took part in a concerted campaign to enforce a new social norm: excessive use of drugs and alcohol was no longer acceptable, and participation in sport and arts programmes was the expected standard.

It worked. By 1998, substance abuse was in decline, and today the campaign is regarded as an unqualified success. The curfew is still in place. "Everybody's proud of it," says Milkman. Icelanders even credit the new norm with contributing to their victory over England in the 2016 European football championship.

such as war. "Tightness is about the need for coordination," she says. "The idea is that if you are chronically faced with these kinds of threats, you develop strong rules in order to coordinate for survival."

To test the idea, Gelfand teamed up with colleagues from 43 institutions around the world, and compared 33 nations in a study published in *Science* in 2011. First they asked nearly 7000 people from diverse backgrounds to shed light on the tightness of their national culture by rating their agreement with statements such as: "There are many social norms that people are supposed to abide by in this country" and "People in this country almost always comply with social norms". The volunteers also revealed how constrained they felt in everyday situations by rating the appropriateness of 12 behaviours, including eating, crying and flirting, in 15 contexts ranging from a bank to a funeral to the movies. There was high agreement among people from different walks of life within nations.

> "Understanding what makes other cultures tick is at a premium"

Next, the team calculated national averages for tightness (see "A world of difference", right) and compared these with past threats to each country, as gauged by a battery of measures including natural disasters, exposure to pathogens, territorial conflict, lack of access to clean water and high population density. Sure enough, there was a correlation. Societies that had faced a high level of threat, such as Pakistan and Malaysia, did more to regulate social behaviour and punish deviance than loose countries, which included the Netherlands, Brazil and Australia. Israel, which is also loose, was a notable exception. The UK came out slightly tighter than average, and the US looser.

But it doesn't end there. Gelfand and her colleagues found that the degree of tightness was reflected in all sorts of societal institutions and practices – even after taking national wealth into consideration. Tight societies tend to be more autocratic, with greater media censorship and fewer collective actions such as demonstrations. They are also more conformist and religious, and have more police, lower crime and divorce rates, and cleaner public spaces. "Tightness brings with it a lot of order and social control," says Gelfand. "Even stock markets are more synchronised."

Loose societies tend to be more disorganised, but also more creative, innovative and tolerant of diversity.

Three years later, Gelfand and her doctoral student Jesse Harrington carried out a similar comparison across all 50 US states. This time they assessed tightness using factors including legality of same-sex marriage, percentage of foreign-born inhabitants and strength of religious institutions. Again, they found a correlation between tightness and threats such as tornado risk and exposure to hazardous waste. And again, they found that tightness corresponded with lots of other aspects of society. Tighter states, such as Kentucky and Alabama, had lower rates of drug abuse and homelessness than loose states such as Oregon and Vermont, for example. They also had higher rates of incarceration and discrimination and, interestingly, lower happiness.

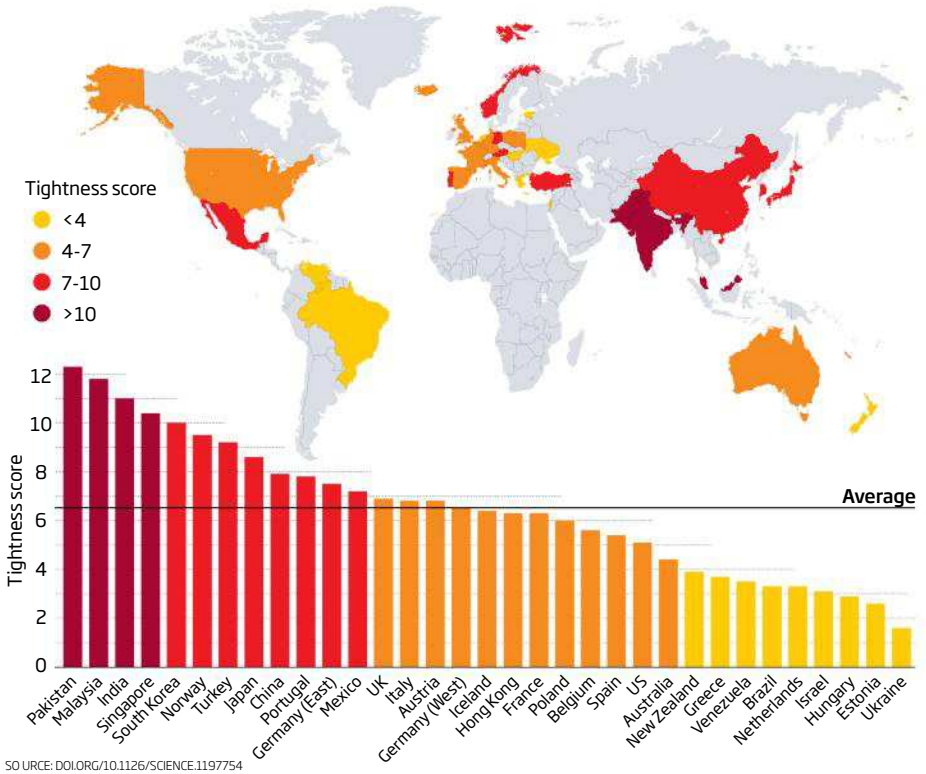
The researchers acknowledged that their map resembled those showing voting preferences, with tight states corresponding to Republican inclinations and loose to Democrat leanings. But, they argued, there is a crucial difference: political affiliations indicate individual beliefs, whereas tightness and looseness describe "an external social reality that exists independently of any one individual". More evidence, it appears, that we aren't entirely free agents at the ballot box.

Not surprisingly, Gelfand's research has attracted attention. In our globalised world, understanding what makes other cultures tick is at a premium. With nations in ever-greater contact with one another, misunderstandings can have profound consequences in all sorts of areas, from trade to diplomacy to war. Furthermore, some of our most-pressing problems – notably climate change and nuclear proliferation – require different cultures to cooperate to find solutions.

Of course, dividing the world's cultures into tight and loose isn't going to bring prosperity and peace, but it does have some advantages. "For one thing, it breaks up our ideas about East Asia," says Dov Cohen at the University of Illinois at Urbana-Champaign. All East Asian countries score highly for collectivism, but some are tighter than others – South Korea and Singapore, for example, compared with China. "Tightness/looseness allows you to look at much higher resolution," he adds. We might also be more sympathetic to different social norms if we accept that the way nations function is connected to levels of threat. "[Tightness/looseness] may sound like a rather specific difference," says Gerben van

A WORLD OF DIFFERENCE

A study of 33 nations quantified how strict or laissez-faire each culture is. "Tighter" societies tend to be more conformist, law-abiding and religious, while "looser" ones are more creative, tolerant and disorganised



SOURCE: DOI.ORG/10.1126/SCIENCE.1197754

Kleef at the University of Amsterdam in the Netherlands, "but I'm now convinced that it explains a lot of the variance in behaviour and perceptions across cultures."

Simon Levin at Princeton University is more circumspect. He points out that tightness is conceptually similar to cultural "stickiness", something he and others have been talking about for years. "What is new is trying to associate the degree of stickiness or tightness to driving factors in terms of threat," he says. But he also points out that the link may be more complex than it seems. For example, a norm that says you shouldn't marry outside your group could ultimately enhance threat as a result of inbreeding.

What's more, social norms shape some behaviours and perceptions more than others, according to research by Hofstede and his colleagues. They found that people's views on abortion, homosexuality and euthanasia – issues relating to basic concerns about survival and reproduction, in other words – were powerfully shaped by culture. But views on matters relating to honesty and respect for the law were influenced more by individual beliefs. In addition, the culturally shaped views correlated strongly with a nation's rating for individualism – with individualist societies tending to have more liberal attitudes – and not at all with tightness scores.

Nevertheless, Gelfand's model appeals to many, not least because it might help explain some of the sweeping social changes happening in the world today. Her computer modelling experiments with virtual agents show that upping an external threat pushes a group to enforce its norms more strictly, while lowering it does the opposite. She notes that populist leaders including Donald Trump and Marine Le Pen direct their messages at groups who feel particularly threatened by the economic situation, and who are therefore likely to favour a tightening of norms. And certain politicians may not be above exaggerating the real threat to persuade people to vote for them.

There could also be a backlash effect. Too much looseness can invite what Gelfand calls "autocratic recidivism". "We can see that the places where ISIS was able to take over are places where people felt there was no security or infrastructure," she says. Conversely, the fact that Ukraine was the highest scoring country for looseness in 2011 could be partly explained as a reaction against the tight Soviet culture it was formerly in thrall to.

The best way to be

Preventing such pendulum swings may be neither feasible nor desirable. However, politicians and voters might want to heed the results of another study explicitly addressing the question of whether societies should emphasise freedom or constraint. On a range of measures, including health, wealth, happiness and political stability, moderate cultures came out best. "The most successful societies balance tightness and looseness," says Gelfand. Extremes can cause problems in any type of group. For example, she argues that a series of scandals concerning United Airlines last year – one involving a passenger being dragged off a plane – were the product of an overly tight organisational structure.

Although many would baulk at the mere suggestion of social engineering, nations can consciously change their social norms (see "Uptight in Iceland", left). They can also underscore unwritten social rules through their choice of more formal ones. In New York state, for instance, the fine for a first-time littering offence is $250, whereas in Singapore it is the equivalent of $1500. No prizes for guessing which has the cleanest streets. Simple things can make a big difference, too. Gelfand has suggested that part of the solution for United Airlines could be to empower low-level personnel to resolve problems with passengers as they see fit.

In their pioneering global study on tightness, Gelfand and her colleagues concluded: "From either system's vantage point, the 'other system' could appear to be dysfunctional, unjust, and fundamentally immoral, and such divergent beliefs could become the collective fuel for cultural conflicts." If they are correct, simply understanding why societies differ in this way could be the first step towards greater global harmony. "Some of our biggest messes in US foreign policy happened because we really did not understand the cultures we were dealing with," says Cohen. "The more armed policy-makers are with cultural information, the better off we will all be." ■

Laura Spinney is a writer based in Paris, France

Reading the book of life

We can unlock a wealth of secrets by sequencing every species on Earth, says Alice Klein

BOB MURPHY has had some close shaves. He once found a deadly viper slithering into his sleeping bag in a Southeast Asian jungle. He was in a four-wheel drive that rolled over on a dirt trail in the Australian desert. He nearly plummeted to his death when a cliff he was standing on in Vietnam collapsed. And last year, he found himself in the middle of a war zone in Armenia. "I'm like a cat with nine lives," he says.

Murphy is a "hunter-gatherer" – a biologist charged with cataloguing Earth's rich array of plants and animals. For decades, he has plunged into the farthest-flung corners of the globe to find and collect new species. "It's not for everyone," he says. "People can end up with broken bones or malaria or puff up with insect bites, and the days are long and tough." Indeed, the dangers can be life threatening. In 2001, Murphy's friend and fellow collector Joe Slowinski died after being bitten by a venomous snake he had caught in Myanmar.

Despite the risks, hunter-gatherers will soon be in high demand as an audacious scheme gets under way. This biological "moonshot", known as the Earth BioGenome Project, is scheduled to launch in June. Its mission is to sequence the genomes of all known species of flora and fauna on Earth. Nature's recipe books could hold clues to making far superior medicines, materials, biofuels and crops, unravelling our evolutionary past and help us to be better custodians of our planet.

The first challenge, however, will be collecting specimens from the wild. Then comes the sequencing itself, which will require Herculean amounts of human labour and computing power. Can it be done?

The Human Genome Project seemed equally far-fetched when it was proposed in the late 1980s. "There were many people who told us, 'This is a waste of money, it's way too costly'," says David Haussler at the University of California, Santa Cruz. It cost $2.7 billion – or about $4.8 billion at today's prices – and took over a decade to complete, but the treasure trove of information it unlocked has wildly exceeded expectations. Not only did it give birth to the personalised medicine revolution, it also propelled advances in diverse fields including forensics, archaeology and bioinformatics. Not to mention, every $1 of public money invested has since generated $141 in economic activity. "It's paid for itself many times over," says Haussler.

> "The plan is to decode the genomes of 1.5 million species in just 10 years"

It was this success that inspired biologist Harris Lewin at the University of California, Davis, to start pondering an Earth-scale genome project three years ago. "Everybody's first expression is like, 'He's gone insane'," he chuckles. But his initial rough calculations suggested it was doable. "I saw that with today's technology, the time and cost would basically be the same as for the Human Genome Project," he says. "The insights we've gained from just one genome have been incredible, so imagine what could be revealed by sequencing the rest of life?"

At the time, Lewin was a member of Genome 10K – a scheme launched in 2009 with the goal of sequencing 10,000 vertebrate genomes. Similar projects soon popped up aiming to sequence 10,000 bird genomes (B10K), 5000 insect genomes (i5K), 10,000 dog genomes (Dog 10K), 7000 marine invertebrate genomes (GIGA) and 1000 plant genomes (1KP). "It just seemed like the logical next step to sequence everything," he says.

In November 2015, at a meeting of 23 biologists at the Smithsonian Institution in Washington DC, Lewin floated his idea: to sequence, over a 10-year period, every eukaryote known to exist on Earth. These are organisms with cell nuclei, including animals, plants and fungi – of which there are about 1.5 million. "There were some very sober people there, but by the end of the meeting, enough ›

TIM MCDONAGH

were convinced," he says. A framework for the Earth BioGenome project was teased out over several follow-up meetings, and partnerships were forged with research powerhouses including the Smithsonian Institution, the Wellcome Sanger Institute in the UK,

"Indigenous people may be hired to help find specimens of rare plants"

BGI in China, and the São Paulo Research Foundation (FAPESP) in Brazil.

Just 2500 eukaryotes have been sequenced to date, so it will be a gargantuan endeavour. The goal for the first three years is to produce a high-quality genome for one member of each of the 9000 eukaryotic families. Then, over the following three years, a draft genome for one member of each of the 150,000 genera – the taxonomic group below families – will be assembled. And the last four years will be spent compiling drafts for the remaining species, which can be refined later on.

These lofty targets mean sequencing eight high-quality genomes per day during the first phase, more than 100 drafts daily in the second, and in excess of 1000 every day in the third. With current technology, a high-quality genome takes about a week to sequence and costs between $1000 and $30,000, depending on its size. A draft takes a few hours and cost about $800. But costs and sequencing times are likely to fall as technology improves, says Lewin. And, despite the enormity of the task, Guojie Zhang, a biologist at BGI, thinks it can be done. "With the sequencing power we can access now, it would actually be possible to finish the sequencing for all 1.5 million eukaryotic species within a year," he says.

In fact, the main difficulties will be in logistics, including getting permission from governments to sequence native species, and collecting and preparing samples. Some specimens will come from museum collections, but they are only suitable for draft genomes because high-quality sequences require fresh tissue from multiple organs – hence the need for hunter-gatherers like Murphy, who is based at the University of Toronto in Canada and collects specimens for Genome 10K. Finding rare species – particularly in difficult-to-access areas like the deep sea or dense forest – will be challenging. Murphy's speciality is frogs and snakes. Sometimes he travels by plane or boat to reach remote places, but mostly he treks on foot into the wilderness with local porters or elephants carrying his supplies. The investment of time and effort can be huge. "We expect one of the legless lizards we want for Genome 10K may take six months of fieldwork to find, if we're lucky," he says.

Lewin hopes that the demand for specimens to sequence will drive technological innovation. Drones or underwater vehicles could potentially roam remote areas and automatically sample different species, provided they were minimally invasive, he says. Indigenous people could also be hired to help find rare plants and use newly available handheld DNA sequencers to obtain rough sequences of specimens in the field. These devices, which cost as little as $1000, are already being used in the jungle and the Arctic.

MEGAPROJECTS FOR MICROORGANISMS

If you thought 1.5 million eukaryotes was a lot of genomes to sequence, the number of prokaryotes will blow your mind. It is estimated that there are up to 1 trillion species of these microorganisms, which include bacteria and archaea, and we have only classified a few thousand so far. The reason for this slow progress is that prokaryotes are hard to isolate. Most can survive only in the precise conditions of their natural habitat – be it a hydrothermal vent or a cow's gut – so cannot be grown and studied in the lab.

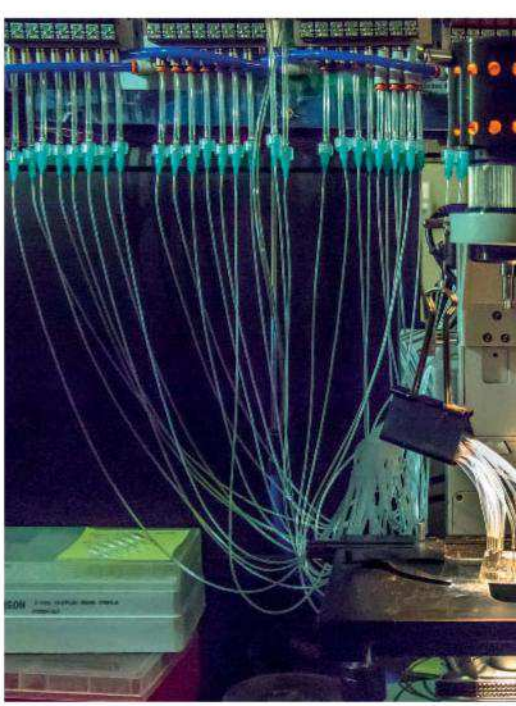
The game changer is metagenomics. This technique allows us to sequence all the DNA in a sample taken from an environment such as seawater, soil or faeces, and then pull it apart to identify the individual species. The biggest metagenomics project yet is currently under way at the US Department of Energy's Joint Genome Institute. It is set to publish the genomes of more than 100,000 species of bacteria and archaea from a range of different environments this year.

The information contained in prokaryotic genomes could help us develop novel antibiotics, because bacterial DNA contains blueprints for chemicals to fight off other bacteria. It may also contain instructions on how to break down pollution, produce industrial chemicals, improve food production and much more.

Another challenge is how to store the whopping amounts of data. It is estimated that the project will generate several thousand petabytes per year – more than all the videos uploaded to YouTube annually. Again, this could be a spur for innovation, this time in bioinformatics. One option may be to store DNA data in… DNA. The code's letters A, T, C and G can be used like the 0s and 1s in regular computing, and researchers at Columbia University recently showed that a gram of DNA can encode 215 petabytes of digital data.

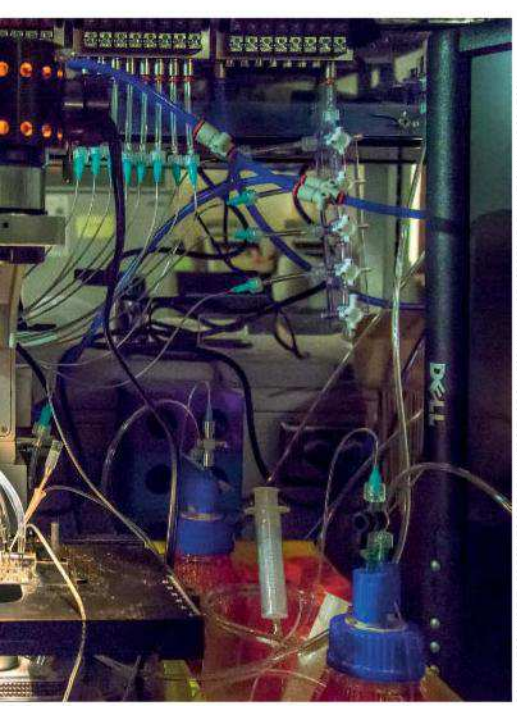
Finally, the project's founders want to make sure it benefits all involved fairly. To do this, they have signed up Peruvian entrepreneur Juan Carlos Castilla-Rubio to build the Earth Bank of Codes. This open-access database will record the genomic sequence, appearance, location and associated indigenous knowledge for each species. The data will go on a blockchain – a type of ledger used in cryptocurrency – that traces where and how the information is used. Any commercial benefits can then be shared appropriately with all contributors, including local people who provide traditional know-how.

Castilla-Rubio came up with the idea when he was looking for ways to shift the Amazon's economy away from destructive industries like farming, logging and mining towards more knowledge-based enterprises that preserve the environment. He recognised the huge economic potential of the genomic



information tied up in the Amazon – which is home to 15 per cent of Earth's land biodiversity – but also the problem of exploitation. In the past, large corporations have tapped the region's natural resources and indigenous knowledge without paying their dues, for example, when a blood-pressure medication was developed from snake venom traditionally used by Amazon people on their arrow tips. The blockchain approach should prevent this type of biopiracy and ensure that the Earth BioGenome Project sticks to the Nagoya Protocol – an international agreement made in 2010 to recognise the rights of countries over their genetic resources and traditional knowledge.

Of course, all this must be paid for – the total cost is estimated at $4.7 billion. As yet, the project has no dedicated funding, although publicity at this year's World Economic Forum in Davos, Switzerland, has sparked enthusiasm. "Many individual countries are now expressing interest or are close to making large commitments, and we're talking to some prominent people," says Lewin. But existing sequencing drives such as Genome 10K do have funding, and when the project is officially launched in June, it will begin by building on these. Lewin and fellow project leaders Gene Robinson at the University of Illinois and John Kress at the Smithsonian Institution plan to start by coordinating the activities of the various schemes to make sure enough genomes are sequenced each year to meet overall targets.



ROY KALTSCHMIDT/THE REGENTS OF THE UNIVERSITY OF CALIFORNIA, LAWRENCE BERKELEY NATIONAL LABORATORY

We already have the sequencing power (below, left) to decode the DNA of every eukaryote from fungi to frogs (right) in one year

PHIL SAVOIE/NATUREPL.COM

Given all the expense and effort, what pay-off can we expect? Lewin is confident that the open nature of the Earth Bank of Codes will lead to discoveries and innovations all around the world. One area with huge potential is pharmaceuticals. Already, about half the world's drugs are natural products or derivatives – including aspirin and Botox – and we have only just scratched the surface. Genome sequencing can inspire new medicines by revealing how plants and animals have evolved their sophisticated defences against predators and disease. Guilherme Oliveira at the Vale Institute of Technology in Brazil, for example, is sequencing the Amazon's jaborandi tree, which produces pilocarpine, a drug used to treat the eye disease glaucoma. Once his team has done this, they will be able to work out the pathway that produces the valuable chemical. It may be possible to replicate this process synthetically or tweak it to make even more potent medicines.

Another major beneficiary will be conservation, says Haussler. He believes sequencing endangered species will give us clues about which are most vulnerable to climate change and need the most attention. This knowledge will help caretakers manage remaining populations too. For example, when researchers sequenced the genome of the critically endangered Californian condor, they found a recessive gene that was causing fatal skeletal abnormalities in some of the 400 remaining birds. Breeders are now using this information to selectively match up individuals without this gene to improve the health of the population.

Sequencing all life will also let us retrace evolution and see where each species sits in the family tree, says Susan Brown, a biologist at Kansas State University. This will answer long-standing questions such as whether vocal learning evolved once or multiple times in birds. Already, DNA sequencing has revealed unexpected relationships in our family tree. For instance, we have discovered that the same genes regulate circadian rhythms in both plants and animals. "In the same way that the periodic table shows you how the different elements are related, the tree of life reveals relationships between different species," says Brown.

"Potential applications range from engineering and renewable energy to AI"

Lewin believes the potential benefits of the project go far beyond biology. The wealth of genomic information is likely to find applications in all sorts of fields from renewable energy and engineering to agriculture and artificial intelligence, he says. There could also be benefits we can't even conceive of yet. In the same way we couldn't predict all the innovations that came out of the Human Genome Project, "we don't know what we don't know", he says.

Such enthusiasm is what keeps Lewin criss-crossing the globe to promote the Earth BioGenome Project. He is well aware there are vast challenges ahead, but he is also certain they will be worth it. "Sometimes, you just have to go for these things," he says. "We've got the technology, we've got the expertise, now we just need the will." ■

Alice Klein is a reporter for *New Scientist*

Look too close and we're all sick

Diagnostic tests are becoming too good for our own good, warns **H. Gilbert Welch**, who believes it is time to reassess what medicine is for

IN THE 1970s, H. Gilbert Welch drove an ambulance as a college job in Boulder, Colorado, often blaring out Elton John's *Someone Saved My Life Tonight*. Wanting to save lives led him to study medicine, but he came to realise that saving lives wasn't as clear cut as he thought. Sometimes, he found, it can be better to do nothing.

Welch became a physician and academic researcher, and he has spent the last 25 years warning of the dangers of overzealous medicine. He worries that doctors are detecting problems too early, convincing healthy people they are sick, and treating them too aggressively.

His latest research, published in December in the *Journal of the American Medical Association*, is a case in point. He has found that in US hospital regions with high rates of CT scans – which are typically ordered to check the lungs and abdomen – many more kidneys are removed. So what is going on? When doctors look at the images, they can see the kidneys too, and often stumble on innocuous cancers, says Welch. "It's leading some people to be treated for disease that was never going to bother them." And at significant risk: 1 in 50 of those who underwent the surgery died within a month.

A professor at the Dartmouth Geisel School of Medicine who only stopped practising medicine five years ago, Welch has written three books highlighting unnecessary medical care, as well as dozens of journal articles and call-to-arms pieces in newspapers such as *The New York Times*. He travels the globe to speak to fellow doctors and researchers. With biomedical companies designing ever more tests, such as breath-tests for cancer, the problem seems poised to worsen. "It's a very frothy industry right now," says Welch.

The *JAMA* study was inspired by a patient we will call Robert, who came to Welch at a Veterans Affairs medical centre in Vermont, complaining of lingering hoarseness. Welch referred him to a specialist, who found a small tumour on his vocal chord. The tumour was removed and his hoarseness went away. Then Welch had to call Robert back. Somewhere along the line, a CT scan had been taken of Robert's lungs, which showed his chest was fine but revealed a cancer in his kidney. This was, in medical terms, an incidentaloma. "He was just so funny about it," Welch recalls. The urologist wanted the kidney out, and Robert said to Welch, "C'mon, you're kidding me, doc. You just did surgery in my throat and now you're going after my kidney? Let's you and I talk about this." So Welch challenged the urologist. He followed the cancer for 10 years with imaging; it stayed the same size. Robert eventually died of pneumonia.

Vanishing cancers

"I was taught in medical school that once a cancer was formed, it was going to relentlessly progress to metastatic cancer," says Welch. "We now know it's a whole lot more complex than that." Cancers can grow quickly and slowly; some even vanish on their own. There are the bird cancers, which have already spread before tests notice them; the rabbit cancers, which can be treated before they spread if caught early; and the turtle cancers, which never spread. The problem, says Welch, is "there's a whole lot of turtles out there", but doctors and patients alike want to treat all cancers.

A new test that worries Welch is liquid biopsy, which identifies pieces of "cell-free DNA" in the blood to determine whether someone has cancer, and how bad that cancer is. "You think, 'How could you possibly argue with that?' until you look under the hood," says Welch. We all have cell-free DNA in our blood, and liquid biopsy analyses about 2000 different mutations in this DNA. An algorithm then determines what thresholds and combinations of mutations equal cancer. Welch worries about a future in which people are told: "You have a positive liquid biopsy, but we don't know where the tumour is, so we're gonna have to start looking."

Richard Baker, a radiologist in Madison, Wisconsin, worked with Welch at the Veterans Affairs centre. As a result of Welch's influence, and against his own financial interest, Baker often dissuades his patients from getting a biopsy on their thyroids after imaging

Photographed for *New Scientist* by Ken Richardson

has found a nodule, even though that is why they are seeing him. "Thyroid biopsies are skyrocketing in this country," says Baker, yet deaths from thyroid cancer have always been rare in the US, and treatment carries risks of its own. "These are difficult ideas for both patients and physicians to accept," he says.

In 2016, Welch reported that screening in the US had found many more non-progressing breast cancers in the 20 years up until then, but helped very little in catching fast-progressing cancers early on. In earlier work looking at women who were screened every year for a decade from the age of 50, he found that for every 1000 of those women, roughly one will avoid death through breast cancer, more than 500 will have at least one false alarm and 10 will be treated needlessly.

Welch advocates for reductions in screening mammography. Taking this sort of position doesn't win popularity contests, and Welch decided early on to direct all profits from his books to charity to avoid the criticism that he is making provocative arguments to cash in.

"[Welch] has had an enormous negative impact on the practice of medicine," says Daniel Kopans, a professor of radiology at Harvard University. He disagrees with Welch's research on a number of methodological points, and on his larger conclusions as well. "Addressing overtreatment by stopping screening is like removing the engines from our cars to stop automobile accidents."

> "You just did surgery in my throat and now you're going after my kidney?"

Kopans believes in the life-saving good of mammography, and he isn't alone. Likewise, many healthcare providers stand in Welch's camp. One side emphasises the lives saved by mammography. The other side puts more weight on the very common post-mammography anxiety women experience as they wait for a biopsy of a suspect mass, and on the risk of undergoing chemotherapy for a cancer that would have gone forever unnoticed. Welch thinks women should have mammography's risks and benefits explained, then be encouraged to choose for themselves.

When Welch began practising 30 years ago, the suggestion that screening was responsible for overdiagnosis was a radical one. Now, thanks to the work of Welch and his ilk, the debate isn't whether overdiagnosis occurs, but how big a problem it is.

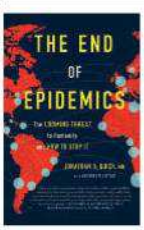
Welch suggests it is time we reassessed what medicine is for. "Do people want medical care as a way to deal with acute problems; things that are bothering them? Or do they want to take the power of medicine to look hard to try to find things wrong with them?" he says. Because in this age of super-sensitive diagnostics, seek and ye shall find. ■

Wendy Glauser is a science writer based in Toronto

The disease machine

Creating an ambitious plan to stop outbreaks becoming global epidemics is fine, says **Debora MacKenzie**, but governments must show willing and fund a real scheme to do just that

The End of Epidemics: The looming threat to humanity and how to stop it by Jonathan D. Quick with Bronwyn Fryer, Scribe



INFECTIOUS disease is humanity's oldest and deadliest enemy. Epidemics from HIV to flu remind us that it is far from defeated. As the human population grows, factory farming expands and climate change upends the ecology of infections and their hosts, new pathogens are invading – and every time one does, it is clear that we aren't prepared. Public health experts seethe with the knowledge that this just isn't good enough.

So Jonathan Quick, a veteran of the World Health Organization and of efforts to get good business practice into public health, has written a book about how best we can face this threat. After all, outbreaks of new and nasty pathogens won't stop happening as they are part of human ecology.

In *The End of Epidemics*, Quick and co-author Bronwyn Fryer spell out the seven biggest things we need to stop those outbreaks becoming epidemics. It is an impressive wish list. Top of the pile is urgent, aggressive leadership on public health. Then there is the development of strong national health systems to spot and pounce on new diseases. Global programmes for disease prevention is next, from promoting handwashing to killing mosquitoes. Good communications between authorities and people at risk is vital too, as is better research and development on diagnostics, treatments and vaccines. There is also a need for popular advocacy to push governments to invest more in epidemic preparedness.

"The WHO has launched a field investigation of a disease outbreak at a rate of nearly one per day"

Finally, of course, we need an awful lot more money and investment.

Few disease experts would disagree that we need all of the above. Quick gives success stories from when some elements of the wish list were present: the leadership that banished smallpox and SARS, the R&D that led to an effective Ebola vaccine, the advocacy that led to HIV treatment. And he recounts how badly things can go when they weren't, most notably the disastrous failures in communication during West Africa's 2014 Ebola epidemic.

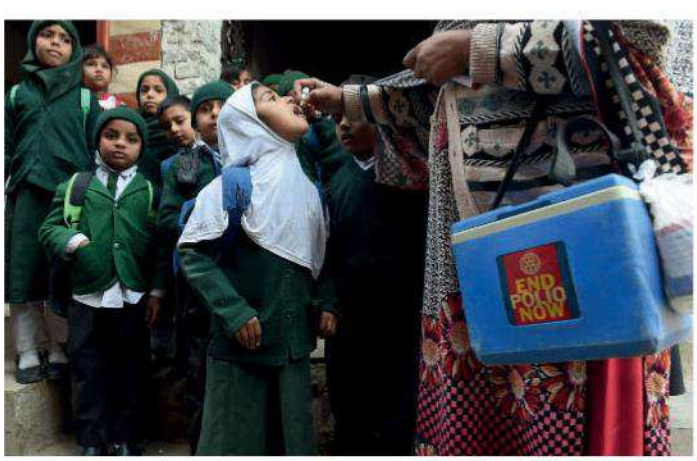
But how do we ensure that Quick's list – or most of it – is in place? In a 1972 parody of a children's television show, the classic British comedy Monty Python advised that "to rid the world of all known diseases", one merely had to "discover a marvellous cure" then "jolly well tell them what to do and make sure they get everything right so there will never be any diseases ever again".

Quick's seven priorities can seem a bit like that: telling us where we need to go while not quite telling us how to get there. For example, he calculates that if the poor countries that harbour many worrying pathogens were able to collect even 20 per cent of their GDP as taxes – instead of losing so much of it to tax havens – and then spent 15 per cent of that on healthcare, they would have healthy citizens, and could spot and stop the next pandemic to boot.

Yes, that would be good. But he offers few clues to how we make it happen. It has eluded Greece, never mind Guinea. Imagine the impossible, then make it happen, Quick urges. It is true we have to imagine what we want before doing anything. But we cannot just imagine how to approach that tricky, second bit.

If anyone does know, it should be Peter Salama, who heads the WHO's Health Emergencies Programme. "For the first 18 months that we've existed, we've been trying to answer exactly that question," he told me recently.

The WHO underwent a major restructuring to put the emergencies programme in place, after being widely criticised for



ARIF ALI/AFP/GETTY IMAGES

Polio vaccination programmes are cheaper than treating the disease

DANIEL BEREHULAK/NYT/EYEVINE

The 2014 Ebola outbreak claimed thousands of lives in Liberia

its slow response to Ebola in West Africa. Six of Quick's seven suggestions are now on Salama's plate. But spending is still within the control of individual governments.

Quick doubts the WHO's traditional command and control approach could achieve global health security. But while his book was in press, a lot has changed; the emerging culture of the emergencies programme is more about coordination instead.

"SARS was contained after it had killed 774 people, but it cost the world some $40 billlion"

Certainly, the 300 people at its headquarters in Geneva, Switzerland, can't be a global fire department for disease on their own. But as a UN agency, the WHO's global mandate means it can pull hundreds of outside experts and institutions together as and when they are needed, says Salama. After reaching fighting strength some six months ago, the programme has launched a field investigation of a worrying disease outbreak somewhere in the world at a rate of nearly one per day.

For the first time, Salama says, one agency is systematically trying to keep tabs on all the potentially severe health risks arising across the world, in real time, using input ranging from press reports to government requests for help. That has led to earlier responses to outbreaks and, he says, "a real sense of urgency".

The programme is also helping poor countries monitor their population's health and boost disease prevention. It is running an ambitious R&D "roadmap" and incorporating R&D and risk communication into outbreak response. "For the first time, the WHO can articulate the health needs of the world," says Salama.

That at least starts to address six of Quick's seven targets. But as always in public health, the seventh is the rub: money.

After the slow international response to Ebola, the WHO's member nations approved of its shift to emergency surveillance and response. In its first 18 months, the emergencies programme received more than 90 per cent of the $1 billion or so it needed. But it was all earmarked by the donating countries for specific projects, and was all very short term.

In January, the WHO started a new two-year financial cycle – and the emergencies programme will now have to start from scratch to find its funding again. Salama is optimistic that he will have his budget again within two years. In the meantime, he is running on a tiny pot of emergency funds. If there is a big outbreak tomorrow, "the picture isn't pretty", he says.

To be safe from nasty new diseases, we have to spot them and slam the lid down when they first emerge, not chase them after they spread. We need money upfront to do that. "To do what we need to be safe, we need to be proactive, not reactive," says Salama.

Quick is "furious" we aren't already doing that, not only because of the suffering and social collapse that could follow a pandemic, but also because prevention really is so much cheaper than cure.

He reckons that global spending of $7.5 billion per year for the next decade – around a dollar for each person on the planet each year – would do the trick. This would be enough to fund the WHO and its far-flung collaborators, from new public health agencies in the poorest countries to cutting-edge vaccine research in rich countries.

Looking back to the SARS virus, the point couldn't be clearer. The virus emerged unexpectedly and reached 37 countries in 2003. It was contained after it had killed 774 people, but that extraordinary effort cost the world economy some $40 billion.

Quick calls investment to spot and stop such surprises, instead of dealing with them once they cause havoc, a no-brainer. Yet in another kind of no-brainer, the world's richest nation, the US, is threatening to withhold funding from the WHO, and even from its own Centers for Disease Control, a key global player.

We know where we need to go. Salama and his team are trying to find the way. The pathogens are out there. We could certainly use some of the advocacy for public health spending Quick calls for – and soon. ■

Debora MacKenzie is a *New Scientist* correspondent based in Geneva, Switzerland

Monkeying around

You have morphed into a chimp. **Stewart Pringle** on a timely satire

Great Apes by Will Self, adapted by Patrick Marmion, Arcola Theatre, London, to 21 April

IT IS rare that a year goes by without Will Self, that sardonic chronicler of the broken and the bizarre, declaring that the novel is dead, or doomed. His first theatrical venture, *Great Apes*, is itself a kind of goodbye, though in this case he is waving off the entire human species.

This wildly alternate reality, where the development of *Homo sapiens* took a different fork in the Darwinian road, is based on one of Self's best novels, published in 1997. It combines a germ of Kafka's *Metamorphosis*, a snatch of *Planet of the Apes* and a whole island's-worth of Swiftian satire, to prick the preposterous commonplaces of the 1990s, and through them, our abiding penchant for posturing anthropocentrism.

At London's Arcola Theatre it has been given a wild, whirling adaptation by playwright Patrick Marmion. A ferocious, talented cast switch roles and flick through scenes with abandon.

Simon Dykes is an artist, played by Bryan Dick, who wakes up after an evening of exuberant drug-taking and sex to find that he and everyone he knows have morphed into up-scaled chimps. London is now a swarming ape metropolis, social norms have collapsed, and the preface to social encounters is rampant Bonobo-like copulation rather than polite human greetings.

Self's work has always been a freewheeling mishmash of whimsy, bar-room philosophy and bum jokes, giving his work great energy and exuberance. There is also a less appealing note: a queasy "appreciation" of the louche excesses of London's arts scene. Marmion has nailed that perfectly.

In Oscar Pearce's high-energy production, chimp puns tumble over lofty reflections, and existential crises jostle for space with the sheer slapstick joy of actors pretending to be monkeys pretending to be 1990s urbanites.

The cast is uniformly strong, with Bryan Dick and Donna Berlin the standouts. Sarah Beaton's design is minimal, but that is for the best as this seven-strong company barrels across the stage under Jonnie Riordan's witty movement direction.

The original novel had plenty to say about the state of the world, and depressingly many targets have survived the passage of the years. Care for the unwell and the elderly, the glass ceiling and the patriarchy are held up to alien, ape-ish standards.

There are lessons to be learned among the primates and, barring a slightly mawkish penultimate scene, Marmion retains enough of Self's acidity to pose them clearly.

"London is now a swarming ape metropolis, and all social norms have collapsed"

The play is at its best when it uses the apparently shocking social codes of the apes to reframe our own standards of care and community. As Simon's journey progresses, in fact, the grooming and sex lose their power to affront and become symbols of something kinder, or at least more honest.

There is an intriguing thread running through *Great Apes* that has only become more relevant with the passing of time: in a world where social media profiles are the front-line of interaction, how relevant is it whether a chimp or a human is at the controls?

Sadly, the conceit begins to wear thin before the end. Perhaps that is inevitable in a play lasting just under 2 hours.

For sure the cast's energy never flags, there is no shortage of ideas, and the play's balancing of smarts and humanity is engaging to the last. But time is the enemy of some satire: however deftly Self's thought experiments are spun, it did feel like an awfully long time to be monkeying around. ■

Stewart Pringle is a playwright, critic and theatre producer

The cast goes ape to highlight the norms of human society

ALASTAIR MUIR/REX/SHUTTERSTOCK

Brexit batters science job market

Confidence is at rock-bottom in the UK's ability to attract and retain the best scientific and engineering talent from Europe

THE uncertainties caused by Brexit are set to dramatically influence the UK's ability to attract and retain top scientists and engineers. That's the conclusion from a survey of over 4000 people working in science and engineering, carried out by *New Scientist* and science recruitment firm SRG.

The survey gathered data from around 4300 individuals working as scientists, engineers, academics, and in clinical trials. More than 2500 were based in the UK and almost 900 in continental Europe. The remainder, based in the US, were not asked about Brexit.

Almost two-thirds of managers who recruit scientists and engineers in the UK believe Brexit will affect their ability to attract top talent from within the European Union. Many also think the referendum result will make it more difficult to retain existing staff.

That's despite the UK government's declaration in December that around 3 million EU citizens living in the UK will be able to apply for the right to stay indefinitely following Brexit.

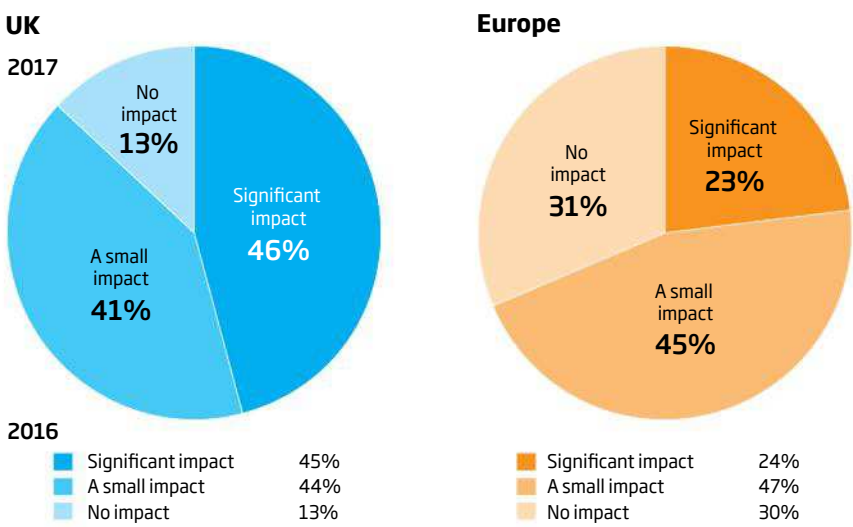
"Science is incredibly international and our labs are full of people from Europe and elsewhere," says Jennifer Rohn, a cell biologist at University College London, and founder of the campaign group Science is Vital. "Even if people are allowed to stay, they quite rightly feel a sense of uneasiness at the idea they are not wanted and don't want to be in a place that's closing its doors to the rest of the world."

Some 63 per cent of UK-based participants responsible for hiring staff thought Brexit would affect their recruitment activities during 2018-19. Four in 10 said it would make it harder to retain existing staff, and 30 per cent believed it would mean they would have to recruit more staff from within the UK. The worries are less pronounced in mainland Europe where a third thought Brexit would have an impact on their recruitment efforts.

"Brexit will have an impact on scientists, but at the moment we do not know what the impact will be, and that is creating great uncertainty," said Venkatraman Ramakrishnan, president of the Royal Society, the UK science academy. "National polling has shown the public support migration of highly skilled people. Our government should listen to that and ensure we do not create a system that pushes people away from the UK as a place to come, live and work."

Impact of Brexit

What impact do you believe the results of the UK referendum (Brexit) will have on your business?



SOURCE: NEW SCIENTIST/SRG 2017 SALARY SURVEY

Much of the uncertainty is linked to future funding for science. The UK government has said that UK-based researchers can continue to apply for funding under Horizon 2020, the EU's pooled research funding scheme, until it ends in 2020. After that the UK may be able to pay to participate, like other non-EU members such as Switzerland, Norway and Israel. However, that idea remains under discussion.

"I don't want to live in a narrow-minded, Brexit-voting Little England"

Anecdotal reports suggest uncertainties over future funding and the ability to participate in and lead EU-funded collaborations are already making the UK less attractive to foreign scientists.

Among UK-based respondents to the *New Scientist*/SRG survey who said they would consider relocating for work, 32 per cent said Brexit would affect where they would consider moving to. One wrote, "I don't want to live in a narrow-minded, Brexit-voting 'Little England'." Another wrote, "I find the atmosphere pessimistic and I'm sorry to see less cross-border projects with the EC in the future."

Of those based in continental Europe and willing to move for work, 38 per cent said Brexit would affect their choice of location. One wrote: "As a European, I might not be able to go to the UK in the future. I also feel less welcome there now."

A UK government spokesperson told *New Scientist*: "It is important that Britain and the EU ensure that their research communities can continue to access the high-level skills that support innovation in science and technology. We are carefully considering the options for a future immigration system but are clear that the UK will remain an open country that attracts the brightest and the best researchers." **Nic Fleming** ■

This article was written and edited independently by *New Scientist*

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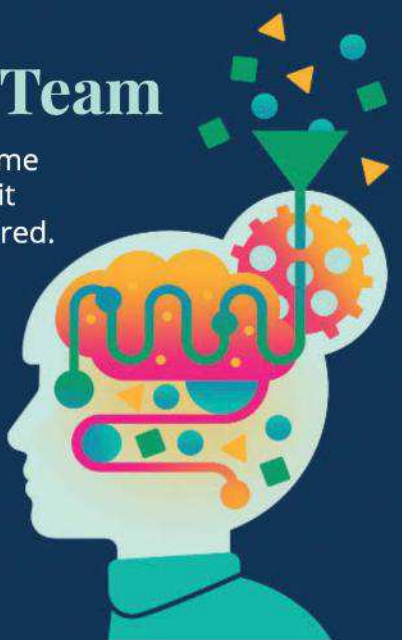

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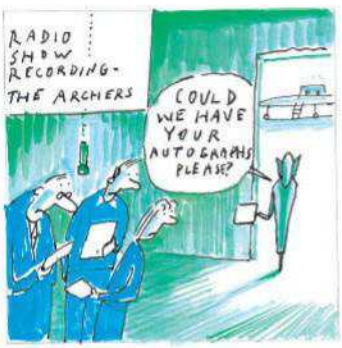
METROPOLITAN POLICE

EDITOR'S PICK

Listen for radio signals to find alien worlds



From Richard Keyworth, Over, Cambridgeshire, UK

Leah Crane reported on Hector Socas-Navarro's work on using geostationary satellites as a means to detect potential civilisations across the galaxy (17 March, p 16). He calculated there needed to be between 10 billion and a trillion in orbit to be observable.

This had me reaching for an envelope to write on. Earth's geostationary orbit is approximately 250,000 kilometres in circumference. A trillion satellites, each with a 1-metre radius, will result in about 8000 in any cross section of the orbit. Packed solid, this cross section would be 200 metres in diameter. Of course, each satellite must be free to move up and down and from side to side. If allowed a bit more elbow room, the size of the cross section would increase further.

Scaling back a bit, the (geometric) mean of Socas-Navarro's range is 100 billion satellites. Assuming each is 100 kilograms and a launch can lift 10 tonnes, that is a launch a day for over 2.7 million years.

Perhaps we should stick to trying to listen for radio shows like *The Archers* coming from Alpha Centuari.

Schools still need to test for colour blindness

From John Butler, Lasswade, Midlothian, UK

Following on from your article on colour blindness (17 March, p 38) and as someone with fairly severe protanopia (a reduced sensitivity to red light), I was dismayed to read elsewhere that screening for colour blindness in UK schools is at best patchy.

Affected children will be unable to create or understand a normal colour scheme, may be unable to tell red text from black on a computer screen, and when presented with concepts like blue vs purple, pink vs grey, green vs red vs brown vs orange could well have no idea what the teacher is talking about. They probably don't understand the fuss about autumn or pre-Raphaelite art.

They would have no idea that colour is an aspect of food preparation or presentation. They can't deal with status lights that go from red to yellow to green and could be totally at sea with colour-cued teaching aids and apps.

Most teachers will be in contact with pupils who are significantly colour blind even if they don't realise it. They need to know who these children are and understand the world from their perspective to avoid letting them down.

From Toby Pereira, Rayne, Essex, UK

It is worth noting that what you describe as "full colour vision" in humans is nothing of the sort, and that colour blindness is a relative concept. Humans usually have three types of colour cone, so are trichromatic. But some species have four colour cones, making them tetrachromatic. In a world of tetrachromats, trichromats

"Mmm! Can't be any stranger than that found on Earth"

@HeslingLaolcom reacts to discussion of the weird life that alien seas on Titan could host (24 March, p 40).

would be considered colour blind.

Computer screens are able to use the three primary colours of red, green and blue to cover the range of human colour vision, but this would be insufficient for tetrachromats, for whom a fourth would be needed. We see a mix of red and green light as yellow, but this isn't objectively the same as pure yellow light. It is an example of our own "colour blindness".

Sharing renewables on the back burner

From Garry Trethewey, Cherryville, South Australia
Alice Klein's look at the use of batteries for storing renewable energy and sharing it in South Australia is full of hope, but premature (10 March, p 22). A week later, an election put a conservative government in power.

We have had two major power failures here recently – one when pylons blew down, the other when the regulator decided not to start a spare generator, explaining that a "state of emergency" hadn't been declared. Federal and state conservatives blamed both on renewables. So the state will get a new interconnector to bring in electricity from elsewhere, solidifying our dependence on polluting energy sources.

Are chimps born with a sense of morality?

From Dudley Miles, London, UK
Anil Ananthaswamy reports that 4-month-old infants expect adults to comfort crying babies, suggesting that we may be born with a foundation of morality (17 March, p 15). It would be very interesting if similar experiments were done on infants of other primates, such as chimpanzees, bonobos and macaques, as this could throw light on whether such instincts predate humans, as ethologist Frans de Waal suggests in *The Bonobo and the Atheist*.

Worrying message on antidepressant use

From Jim Alexander, Holmfirth, West Yorkshire, UK
Clare Wilson took a look behind recent headlines declaring that antidepressants really do work (3 March, p 27). Those headlines, based on a study of hundreds of trials of these drugs, seemed to add up to a call for an increase in the use of antidepressants. Up until then I had been hearing a lot about their overuse and that doctors were seeking to cut back.

This is especially bad when we consider the current emphasis on mental well-being. It worries me that there may be a push to suppress symptoms with more drugs rather than to seek cures for the problems people experience.

A weekend lie-in may leave you feeling groggy

From Brian Horton, West Launceston, Tasmania
Your leader advised us to have a good lie-in on the weekend (24 March, p 5). This was also a minor option in your look at dreams, suggested as part of point one in "Can you boost your dream power?" (p 34). But point five emphasised the need to maintain a regular sleep schedule. Sleeping in on the weekend resets your biological clock, so on Monday you wake up groggy, accident prone and more dream-deprived.

The editor writes:
You shouldn't regularly sleep in ›

longer at the weekend than you do during the week – but an unexpected upside of doing it every now and again is the boost of dream sleep.

Milgram's findings have long been questioned

From Nicholas Humphrey, Great Shelford, Cambridgeshire, UK
Gina Perry describes how Stanley Milgram's flawed research on obedience "has been absorbed into our culture" (17 March, p 43).

Still, *New Scientist* can be proud that 40 years ago it did its bit to question it. In 1974, it published my review of his book, *Obedience to Authority* (13 June 1974, p 710). I wrote: "Anyone who presumes that a social psychologist can in an hour's experiment turn a person into an automaton betrays either extraordinary arrogance, or insensitivity to the complexities of human action… Much of the experimental evidence could be explained in terms of the subjects' (justified) belief in the superior knowledge and experience of the experimenter – the belief even if unformulated, that the experimenter knew something that they did not. As Milgram himself confirmed… almost nobody to whom the experiment was described was prepared to credit that ordinary people would behave so brutally. How much better reason was there for the subjects themselves to doubt that torture is a routine part of Yale's psychology programme."

Time to rethink our industrial civilisation

From Daniel Hackett, London UK
The prospects of meaningfully tackling climate change by capturing and using carbon dioxide seem slim, as Michael Marshall states (17 March, p 34). He quotes Peter Styring as bluntly stating that stopping burning fossil oil is the only solution.

In addition, a participant from the Sackler Forum is quoted as saying "Carbon dioxide is the only gas we can emit into the atmosphere with impunity". Maybe no tax currently applies, but we are paying with ocean warming and acidification, climate chaos that may swamp our resources, mass human migration from uninhabitable zones, loss of food production… need I go on? There are no free lunches on this planet. The whole basis of industrial civilisation has to be reconsidered.

From Richard Mellish, London, UK
You quote Peter Styring on possible uses of carbon dioxide, saying: "I can take a slurry of calcium oxide, put CO_2 into a bottle, shake it up and it'll react very quickly [to make calcium carbonate]." Yes; but how does he get his calcium oxide? It's made by heating calcium carbonate. This looks like a chemistry version of perpetual motion.

Minds greater than ours are watching us like bugs

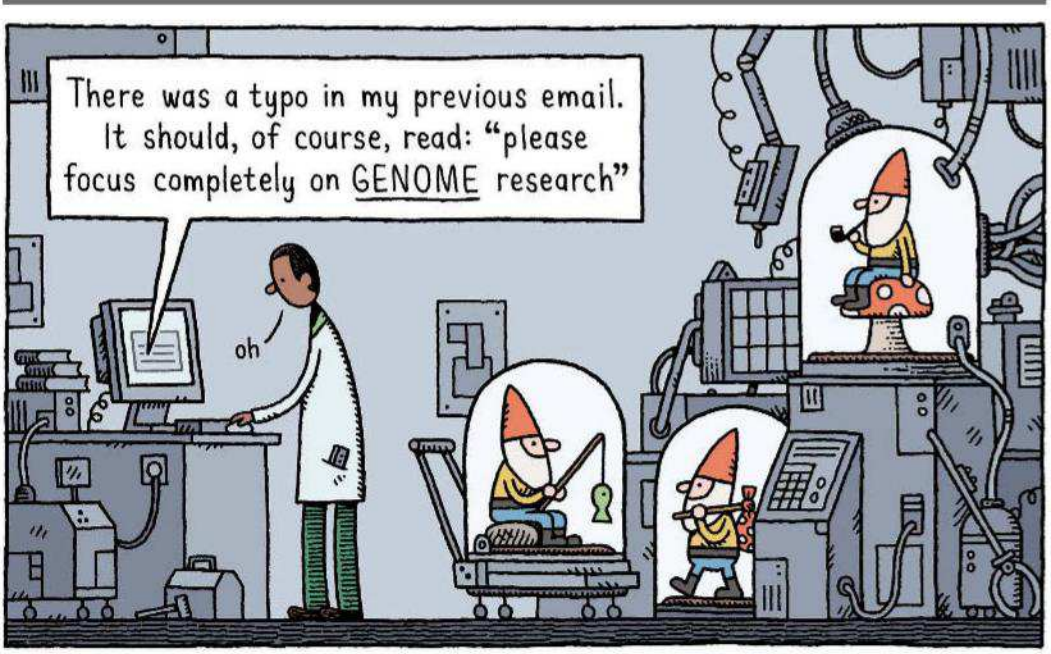
From Eric Dabbs, Rosebank, South Africa
Alastair Malcolm says extraterrestrials may be shy of contact with us out of fear of another technological civilisation (Letters, 3 February). Equally, perhaps Earth is nothing special. Life forms inconceivably more advanced certainly exist and perhaps observe us. But why should they wish to engage in two-way communication, any more than we do with ants or social bacteria?

Lots to do before a fluid universe gets my vote

From Niall Finn, Lethbridge, Victoria, Australia
The idea of describing space-time as a fluid undergoing phase transitions (17 March, p 30) sounds suspiciously like a "luminiferous ether", the all-pervasive medium on which electromagnetic fields were once believed to depend.

As I understand it, the concept was dismissed early in the last century in favour of relativity. And so there are plenty of experimental tests, whose existing results support relativity and contradict the ether hypothesis, that the new space-time fluid idea needs to explain before it is extrapolated to the beginnings of the universe.

TOM GAULD



In this case, less may well mean more

From Eric Kvaalen, Les Essarts-le-Roi, France
Further to your story on lowering the amount of nicotine in US cigarettes by a third (24 March, p 6). I would think, as a first approximation, that would raise the number of cigarettes smoked by 50 per cent. That would increase the amount of tar inhaled by 50 per cent, which is what causes the harm.

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OLD SCIENTIST

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

GREENPEACE/HIROKO KUMADAE

"IS IT safe?" Laurence Olivier's Nazi torturer cryptically asked Dustin Hoffman's "marathon man" in the 1976 movie of that name. The hero couldn't answer the question, much like *New Scientist* on many occasions down the years. But we have often posed it nevertheless.

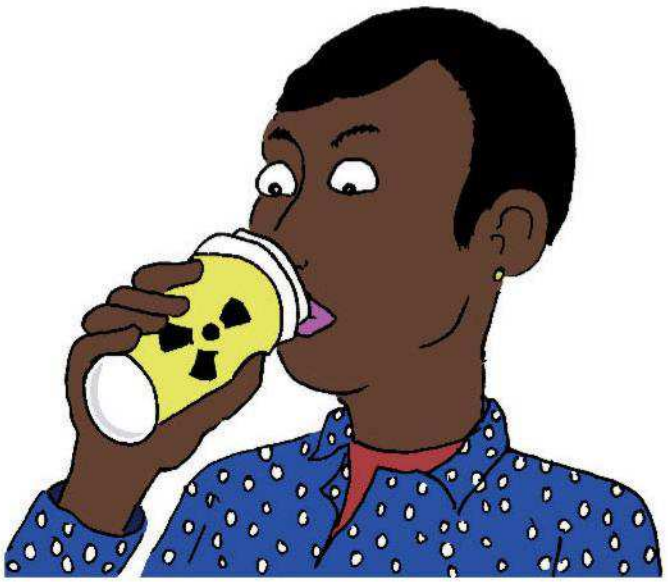
In our 24 April 1975 issue we queried whether DDVP, aka dichlorvos or 2,2-dichlorovinyl dimethyl phosphate, was safe for use in homes. DDVP was the active ingredient in Vapona, then the most popular fly killer in the UK. "If flies were really dangerous, it might make sense to insist we killed every one that flew in the window," we wrote. "But in parts of the world where flies are no more than a nuisance over-dramatised by the chemical companies and their admen… a product like Vapona should only be allowed if it has been proven to be totally, completely safe." Dichlorvos sales were suspended in the UK in 2002 and banned by the EU in 2012.

We are pretty sure plutonium isn't safe, but in 1992 we were concerned with a dispute over the best way to transport it. The US government had vetoed a UN plan to send it by air, so, as we reported in our 18 April issue, a ship was set to leave France for Japan carrying enough material for 120 nuclear bombs. But was this any safer? We weren't sure. We quoted a report by environmental consultants that drily noted: "Marine accidents involve significant forces." It concluded that the plutonium flasks might not withstand shipboard fires or deep-sea sinking.

In 2000, we were more worried about pigs than plutonium. A US company had been trying to cure brain damage by injecting fetal brain cells from pigs into humans, but some patients had reacted badly, as we reported in our 29 April issue. The company halted its trial while it investigated what had gone wrong.

Olivier's character found out the hard way that it wasn't safe to collect his stash of diamonds from a Manhattan bank. *New Scientist* was, and of course still is, far more cautious. Perhaps that's why we're still here. **Mick O'Hare** ■

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



PAUL MCDEVITT

TURKISH police raised eyebrows when they announced the seizure of 1.4 kilograms of the radioactive element californium last month. Four men were arrested, who had allegedly hoped to sell the material for $70 million. Almost non-existent in the wild, the most common isotope, californium-252, can be produced only in nuclear research laboratories, which currently churn out a meagre 35 milligrams per year.

That made the Turkish haul about 40,000 years' worth of production – a tall order for an element with a half-life of less than three years.

The Turkish Atomic Energy Authority soon declared that, on closer inspection, the substance was in fact a type of polystyrene, with no radioactive properties. Police are bound to be disappointed: with a street value of $27 million per gram, that much californium would have been worth $37.8 billion. Enough to afford a few Geiger counters?

YOU'VE heard of tiger mums, but what about doggie dads? Researchers at Wageningen University in the Netherlands have investigated parenting styles for pet owners.

Writing in *PLoS One*, Ineke van Herwijnen and her colleagues note that "parenting styles are relevant because of their effects on the development and well-being of children", and a similar diagnostic could inform animal welfare.

Drawing from questionnaires that sort parenting style into one of four categories (authoritarian, authoritative, permissive and uninterested), the team created a new series of prompts such as "I lure my dog with reward to solicit certain behaviour, even when it is misbehaving at that moment." A trick familiar to many parents, Feedback suspects.

The results from 518 dog-owning parents revealed that most opted for authoritative styles for both two- and four-legged babies, involving both corrective behaviours and consideration of the dog or child's needs. However, adults were twice as likely to follow a rigid authoritarian style with dogs as they were with their own children.

The researchers note that "we did not find a dog-directed parenting style of being permissive or uninvolved, which we attribute to a study population of devoted dog owners". It seems for dogs in the Netherlands, tough love is all that's on offer.

A COURT in Romania has ruled that a man is dead – even though he was standing alive in front of them. Sixty-three-year-old Constantin Reliu brought the case after discovering he had been declared dead by his wife. This was somewhat understandable, as he had left for Turkey in 1999 and not contacted her since.

Now returned home, he protested the decision, but the court ruled that as the time for appeals had elapsed, he must remain dead. Still, a political career might be open to Reliu. In 2008, the residents of the Romanian village Voinesti elected Neculai Ivascu as their mayor, although he had passed away before the vote. A villager told reporters: "I know he died, but I don't want change."

A COLD wind is blowing in the Welsh valleys, where Monmouth MP David Davies sees foul play afoot, reports Larry Stoter. He draws our attention to Davies's regular column in the *South Wales Argus*, in which the MP says the recent cold weather serves as "a reminder of the importance of a cheap and reliable electricity supply", which is under threat from an "unholy coalition of environmentalists working with big business".

We are told the "alarmists" at the Intergovernmental Panel on Climate Change have led the UK down a dark path of fossil fuel divestment. This in turn has led us to buying power from France, whose energy is far cheaper than ours "because their generators do not levy carbon taxes".

What Davies neglects to mention is the reason for this: France's energy portfolio contains far more nuclear power, which doesn't produce carbon emissions and therefore doesn't attract such taxes. Had the UK invested similarly in the 1970s, we might be enjoying the same cheap energy ourselves.

This may have been prudent given the UK's reliance on imported fossil fuels from Russia, which is proving neither cheap nor reliable, and with whom the UK's relations are currently a rather chilly -23.

THE recent crop of tobacco-based anecdotes suggests there is no more measured way to pass the time when travelling than with a smoke (31 March). The habit seems universal.

Anton Fletcher recalls "reading of Australians in Papua New Guinea searching for some lost explorers. They obtained the help of indigenous tribespeople, who spoke pidgin English." Anton says that when the

locals were questioned on the possible whereabouts of the missing men, a direction was indicated with a wave of the arm, "but the distance was, 'him longtime 2, 3, maybe 4 cigarette'".

Exactly how this related to a kilometre measure is not explained, says Anton. Feedback wonders how we measured distance before the advent of smoking.

More infant intuition: "As a very small child I came down with chicken pox while on a farm holiday," writes Ben Crossley. "I still believe I caught my pox off real chickens"

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.

Hair shadows

During the recent total solar eclipse in the US, I overlapped my hands, using the gaps between my fingers to form "pinholes". Just before the start of totality, someone noticed that the shadows formed through this "pinhole camera" onto a whiteboard were so sharp that the individual hairs on my arms were visible. How thin must the solar crescent be for the shadows to be this sharp, and how soon before totality would this occur?

■ The size of the light source doesn't actually determine the sharpness of the pinhole image. The major factors are the size of the pinhole and the amount of ambient light "noise". In effect, the pinhole allows through rays of light, each one connecting just one pixel of the scene onto a matching pixel on the whiteboard. Of course, a small pinhole and minimal diffraction (scattering of light by the edges of the hole) will give fine light rays, with sharp distinction between adjacent light sources and high resolution. But small pinholes also mean dim images.

The diameter of the ideal pinhole is roughly the wavelength of the light. Any object with a larger diameter will block at least one ray and remove that pixel from the image no matter how large the light source behind the pinhole. It is unrealistic to expect to have a perfect pinhole, but objects such as human hairs or dust particles are typically about 100 times the wavelength of visible light, so they can block pixels from "realistic" pinholes or blur pixels with the light they scatter.

You don't see hair shadows in full sunlight because light scattered from a sunlit sky washes out fine detail in the faint pinhole image. But they would show up in a pinhole image projected into a darkened chamber.

Jon Richfield
Somerset West, South Africa

Snap, crackle, pop

I can usually make sense of my kitchen radio, even if someone else is talking or the phone is ringing. This isolation of a single noise among others is known as the "cocktail party effect". However, just crumpling the bag inside a cereal packet renders any other sound unintelligible. Why?

■ The term "cocktail party effect" was coined by British cognitive scientist Colin Cherry in 1953, although his research was actually prompted by the difficulty air traffic controllers had in keeping track of certain pilots when all their voices were broadcast over a single loudspeaker. Researchers wanted to know how people could tune into a single voice and what prompted their attention to switch to another voice.

While focusing on one source of sound, like someone speaking to you, other conversations form part of the "unattended stream", which is being unconsciously interrogated for any meaningful patterns. If such a pattern is recognised in that stream – such as your name – your attention switches.

You can think of attention as being like computer bandwidth. A person's attention (or bandwidth) is increased if they are interested in the conversation (or signal). However, some of this bandwidth is "noise", reducing what is available for the signal. When the noise isn't continuous, such as when other conversations are taking place, we can fill in the missing bits of the conversation.

Crumpling a cereal bag is similar to white noise, which is continuous and extends across all frequencies, making it impossible to "fill in" the missing snippets on the radio.

The ability to separate sounds from background noise varies according to the rate of speaking and the pitch of the sound, which can depend on the speaker's sex. Apparently, the cocktail party effect is enhanced if you can localise the source, which requires both ears, but this ability declines with age.

Mike Follows
Sutton Coldfield, West Midlands, UK

■ Recognising a spoken word frequently depends on its initial sound, which is over in a fraction of a second and is usually spoken at a softer and higher pitch than the rest of the word. Try saying any word with the first letter missing to get an idea of how unidentifiable many become without this initial clue.

People like me who have lost much of their higher frequency hearing have no trouble understanding companions in a quiet situation, but are lost in a crowded one. We can hear that our friends are speaking, but we can't understand what they are saying because we can no longer hear the beginning of their words above the background noise.

Your questioner obviously hasn't lost their higher pitch hearing, so can isolate one voice among many. A telephone ring is different enough from the subtle beginning of words that it causes no problem. But to some extent, the crumpling of a cereal packet mimics these initial word sounds, rendering speech unintelligible. Your questioner is, in fact, having a sneak preview of what life may be like should they ever lose their higher frequency hearing.

Geoffrey Cox
Rotorua, New Zealand

This week's question

BREATHE SLOWLY

London pea-soupers and the "great smog" of 1952 led to the UK's Clean Air Act of 1956. In the 1980s, Mexico City was talked about as the place with the most polluted air. In recent years, Beijing and Delhi have often had terrible air quality. How do the levels of pollution in these different cities at these different times compare? Were any clearly more dangerous than the others?

Paul Singer
London, UK

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