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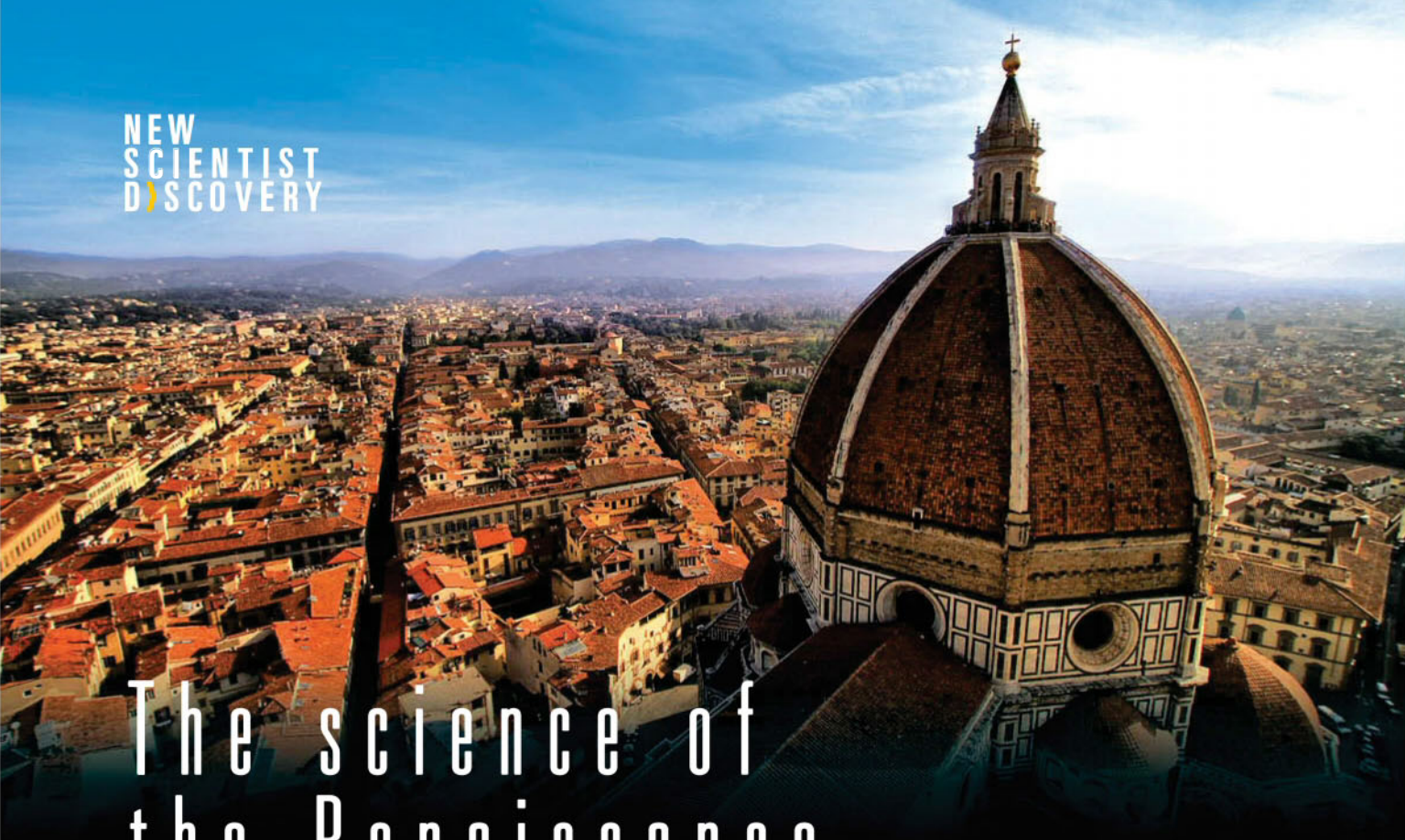

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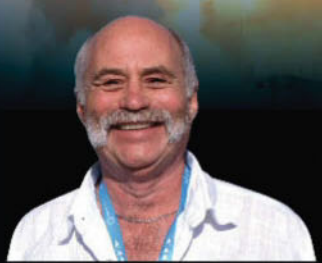
Space flight: A history

A two-week, action-packed tour in the US with astronomy and space experts



Nigel Henbest

DEPARTURE:

25 SEPTEMBER 2017

VISIT THE TRINITY SITE

Join a small group *New Scientist* readers and local experts on 7 October at the Trinity site in New Mexico, the desolate spot where the first atomic bomb was tested. Seldom open to the public, it will be a rare opportunity to get close to some of the key science behind space flight engineering.

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FELIX CLAY / EYEVINE

Trust me, I'm an algorithm

AI doctors should improve healthcare, but not at any cost

ANYONE phoning a customer service department is likely to be warned that "your call may be recorded for training purposes". It sounds banal until you realise that the trainee might be an artificially intelligent voice-recognition system that requires real-world data to learn its trade.

Now imagine visiting the doctor and being told "your medical records may be used for training purposes". Again, it sounds innocuous – but what if the entity being trained is not a human student but a diagnostic algorithm?

The use of AI in medicine is in its infancy, but looks set to become a routine part of healthcare (see page 36). That raises important questions for patients and providers alike – although perhaps not the ones you might think of at first.

Consider, for example, safety and accuracy. Both are likely to be prominent patient concerns, but algorithms trained on existing medical data already outperform specialists. Misdiagnosis contributes to tens of thousands of preventable deaths every year. AI could slash that failure rate.

A more troublesome issue is the question of who controls and owns the data. To make AI diagnosis work will require access to vast quantities of data about symptoms, diagnoses, treatments and outcomes: in other words, medical records.

From an individual perspective, this may seem a non-issue. Most people diagnosed with, say, skin cancer would be happy to donate their data to help others. But what if it were subsequently reused for another purpose? What if their privacy were voided by a leak, a hack or a failure to anonymise it? What if it were used to build a commercial product or service?

"Data collection and analysis is changing so rapidly that systems of governance can't keep up"

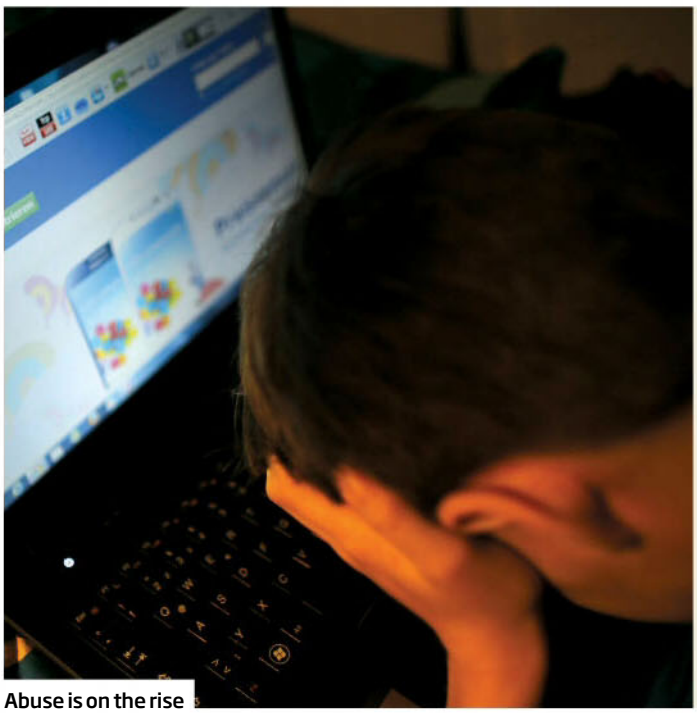
Such questions of propriety and custodianship have been asked about data before – but medical information is uniquely valuable and sensitive. Last week, the UK Information Commissioner's Office (ICO) reprimanded the Royal Free Foundation NHS Trust over an agreement struck with Google DeepMind (see page 24). As revealed by *New Scientist*, the deal gave the AI company access to 1.6 million people's medical records to develop a monitoring tool for kidney patients: the ICO ruled that they were not properly informed about the use of their data, among other shortcomings.

So how should the hospital have proceeded in its dealings with DeepMind? The problem is that no one is entirely sure – and not just in medicine. A report by the Royal Society and the British Academy recently concluded that the collection and analysis of data is changing so rapidly that the UK's systems of governance cannot keep up. It concluded that a new body is needed to safeguard trustworthiness and trust.

If such a body is created, it will have a tightrope to walk. Some argue that medical data should be sacrosanct, asking for implausibly tough safeguards around sharing and reuse. Others say patients should be compelled to share their data for the greater good, with refuseniks being excluded from any resulting improvements in diagnosis and treatment.

The middle ground is worth seeking out. Nobody should want data to be appropriated by third parties, but nor should anyone want innovation that could advance medical care to be stifled. The best way to ensure neither happens is to provide a clear framework that lets healthcare providers, innovators and investors and, above all, patients have confidence that AI doctors will do no harm, of any kind. ■

OLIVER BERG/DPA/PA IMAGES



Abuse is on the rise

What is harassment?

ONLINE harassment is on the rise, but no one can agree on what exactly it is.

That's according to the results of a survey of 4248 people in the US, released on Tuesday by the Pew Internet Survey. It found that 41 per cent had experienced harassment online, up by 6 per cent since 2014.

The rise may seem small, but given the long search for solutions, it's surprising that the numbers are still going up, says survey author Maeve Duggan at the Pew Research Center in Washington DC.

What's more surprising is that people can't agree on a definition. That may be related to the finding that different groups experience online harassment in different ways. For example, men are twice as likely as women to be targeted for their political views, but women are more likely to report abuse that targets them for their gender alone.

However, people's ideas of what constitutes harassment was inconsistent. Roughly a third of participants who had had an experience that met the survey's definition considered it to be online harassment, whereas a third didn't. The remaining participants weren't sure.

This may explain why people are divided on what solutions, if any, are needed. Fifty-six per cent of respondents feel that offensive content is taken too seriously, including 73 per cent of young men.

Most respondents did agree that law enforcement should play a "major role" in addressing the issues.

Stop gonorrhoea

A VACCINE for meningitis B may be a weapon against antibiotic-resistant super-gonorrhoea.

Last week, the World Health Organization reported that 81 per cent of the 77 nations that have looked for antibiotic-resistant gonorrhoea found strains resistant to azithromycin, the main antibiotic used to fight the disease. According to the WHO, a vaccine "will ultimately be the only sustainable way to achieve control" of gonorrhoea.

"That an existing, licensed vaccine may control gonorrhoea is incredible news"

So far, all experimental vaccines have failed. But an existing vaccine may do the trick – a finding David Fisman at the University of Toronto, Canada, describes as "incredible news".

Gonorrhoea is caused by a bacterium that is closely related to the one that causes meningitis B. When Steven Black of Cincinnati Children's Hospital in Ohio and his team analysed data from 15,000 people in New Zealand who would have been offered a meningitis B vaccine around 12 years ago, they found that those vaccinated were 31 per cent less likely to get gonorrhoea (*The Lancet*, doi.org/b9jr).

A vaccine wouldn't need to be hugely protective to have a big impact. Modelling has suggested that if all 13-year-olds were given a vaccine that only protected half of them, the prevalence of gonorrhoea in the population would fall by 90 per cent in only 20 years.

Particle discovery

THERE is a new member of the particle family and it's a real heavyweight. The so-called Xi_{cc}^{++} is a baryon, the family of particles that make up most ordinary matter. Baryons contain three quarks, fundamental particles that come in six different flavours, but many combinations have yet to be observed.

This latest find, by researchers on the LHCb experiment at CERN's Large Hadron Collider, is the first baryon confirmed to contain two heavier quarks known as charm quarks. The third constituent is an up quark. Unlike in other baryons, where the three quarks rotate around each other, the two charm quarks are thought to sit at the centre of the Xi_{cc}^{++}, with the lighter up quark orbiting them.

All that mass means Xi_{cc}^{++} weighs in at around 3621 megaelectronvolts, four times heavier than the proton, in line with theorists' expectations.

Studying the new particle could help physicists test quantum chromodynamics, the theory of the strong force, which holds quarks together in baryons.

TESLA

Electricity storage

Big battery

TESLA plans to build the largest-ever lithium ion battery in South Australia, it announced last week.

The 100-megawatt battery will act like an electricity back-up, storing excess energy generated by a wind farm when electricity demands are low, then feeding it back into the grid during peak hours.

South Australia has adopted renewable technologies faster than any other state in Australia,

but repeated blackouts since September have sparked concerns about their reliability.

In March, Tesla founder Elon Musk offered to fix the problem with a large-scale version of a Tesla car battery. He said he would get the system up and running within 100 days of the agreement being signed, or else do it for free.

The battery will be made up of thousands of Tesla lithium ion car batteries packed into hundreds of refrigerator-sized units spread across a field. Combined, they will be able to store enough electricity for 30,000 homes. They are expected to be ready in December.

CRISPR controversy

AS YOU were. In May, a study claimed that using the CRISPR gene-editing technique can cause thousands of potentially dangerous mutations, but this may be wrong.

As nearly 20 human trials of CRISPR get under way, the results of the study prompted its authors to urge regulators to reassess the technique's safety.

However, this call was based on evidence from just two CRISPR-treated mice. Now several new studies say the original experiment got it wrong.

The team behind the original study had assumed that the two treated mice plus a control were essentially genetically identical before CRISPR, but the way the colony of mice was maintained means this was unlikely, say the authors of one of the new studies (*bioRxiv*, doi.org/b9gz).

"We strongly encourage the authors to restate the title and conclusions of their original paper or provide properly controlled experiments that can support their claims," Luca Pinello of Harvard University and colleagues write. "Not doing so does a disservice to the field."

France bans diesel

THE French government has set out an ambitious goal for no more new petrol or diesel cars to be sold in the country by 2040.

The target, announced last week by environment minister Nicolas Hulot, is part of a wider effort to wean the world's sixth biggest economy off fossil fuels.

At a news conference unveiling a five-year government plan to encourage clean energy and meet France's commitments under the Paris climate accord, Hulot said French car-makers have projects that "can fulfil that promise".

The move came a day after Sweden's Volvo became the first major car manufacturer to pledge to stop making vehicles powered solely by the internal combustion engine.

France is unusually dependent on diesel fuel, blamed for pollution that often chokes its capital. The Paris mayor wants to ban diesel vehicles by 2020. Hulot's plan would cover the whole country and also target petrol cars, but it could face resistance from drivers and manufacturers.

Hulot also said France will stop producing power from coal – now 5 per cent of the total – by 2022, and will encourage green energy and technologies.

Large carnivores' range slashed

LIONS, tigers, and red and Ethiopian wolves have lost more than 90 per cent of their hunting grounds in the past 500 years, finds the first global study of the ranges of big terrestrial predators.

Chris Wolf and William Ripple at Oregon State University looked at large carnivores' range largely based on a variety of historic maps corresponding to around AD 1500, and found that these animals are now present in just a third of the land area they occupied back then.

Most of the 25 big beasts studied are now skulking on the margins of the areas they once occupied, making them more vulnerable to extinction, says Wolf. But there are exceptions.

The Eurasian lynx and Australia's dingo have lost only 12 per cent of their range. Striped, spotted and brown hyenas have conceded only 15, 24 and 27 per cent respectively, and the grey wolf 26 per cent.

In between, with losses of between 30 and 90 per cent, are various species of bears and big cats such as leopards, pumas and jaguars (*Royal Society Open Science*, DOI: 10.1098/rsos.170052).

There was a strong link between range contractions and human expansion. However, Wolf says reintroductions have a good chance of success in the future. "Many large carnivores are resilient, particularly when human attitudes and policies favour their conservation," he says.

DAVID PATTYN/NATUREPL.COM

Big cats have less space to hunt

60 SECONDS

Jupiter on the spot

NASA probe Juno just made a fly-by of Jupiter's Great Red Spot. The probe flew 9000 kilometres above the centuries-old storm with its sensors and camera on to find out more about the iconic feature.

West coast wildfires

From Canada to California, hundreds of wildfires are burning. The fire season was delayed in some places in the west due to a winter of heavy rains, but those also fed new growth that has since dried out and is fuelling the flames. More than 100,000 people have been forced to evacuate their homes.

Headache prediction

Could a model predict migraines? A study of 1613 headaches across 95 people found that a rise in the occurrence and intensity of stressful events in daily life can help predict when headaches are likely to occur (*Headache*, DOI: 10.1111/head.13137). The researchers behind the work hope to refine their model to predict migraine attacks.

Gig rights

Gig workers such as Uber or Deliveroo drivers should get better rights, concluded a UK government-commissioned review published on Tuesday. The Taylor review calls for the introduction of a new class of worker. These "dependent contractors" would have flexible work patterns, but would gain some employment benefits such as holiday leave and sick pay.

Smoking sinuses

Sinus pain? Quit smoking and wait a decade. Chronic rhinosinusitis causes problems breathing and sleeping. Smoking worsens it, but a study of people with the condition has found that quitters improve every year after they stop (DOI: 10.1177/0194599817717960). The study estimates that after 10 years, the reversible effects of smoking on CRS should have disappeared.

Hacking antidepressant doses

An online movement is helping people taper their meds to fight withdrawal

Clare Wilson

PEOPLE who want to stop taking antidepressants are hacking their dosing regimens to avoid withdrawal symptoms. A Dutch website that sells kits to help people taper their doses has now launched an English-language site, triggering safety concerns among UK regulators and doctors.

Around 1 in 10 people in the UK take antidepressants. Many find them helpful and even life-saving, but some struggle to stop taking them when they are ready. A study in New Zealand found that 55 per cent of people got withdrawal symptoms on stopping antidepressants.

"I felt like I had been run over by a bus," says James Moore, a mental health campaigner in the UK. He experienced dizziness, nausea and headaches when he stopped taking the antidepressant mirtazapine.

Others who stop taking antidepressants report side effects such as panic attacks or memory and concentration problems. Information leaflets that manufacturers provide alongside antidepressants warn of short-term withdrawal effects, and doctors usually advise people to reduce their dose slowly. But even if people do that, once they stop taking the lowest dose of tablet available, some still get problems.

People are often told to start taking their pills every other day, but with some drugs this can lead to levels in the body fluctuating. Instead, some people have been turning to online forums to swap tips about how to taper their medication – such as grinding up tablets and dissolving them in water, or breaking open capsules of beads and counting them out.

But the results of these DIY methods can be variable. "I was functioning one day, and the next I would be in bed," says Moore, who has tried cutting up his pills into smaller pieces.

"Some people who stop taking antidepressants report panic attacks or memory problems"

The Dutch website is part of a project by medical charity Cinderella Therapeutics and Maastricht University. Together, they have been creating personalised tapering kits with precisely weighed out tablets that gradually reduce in strength over several months. Since 2014, the project has distributed around 2000 kits for 24 different medications, the majority for antidepressants or anxiety drugs.

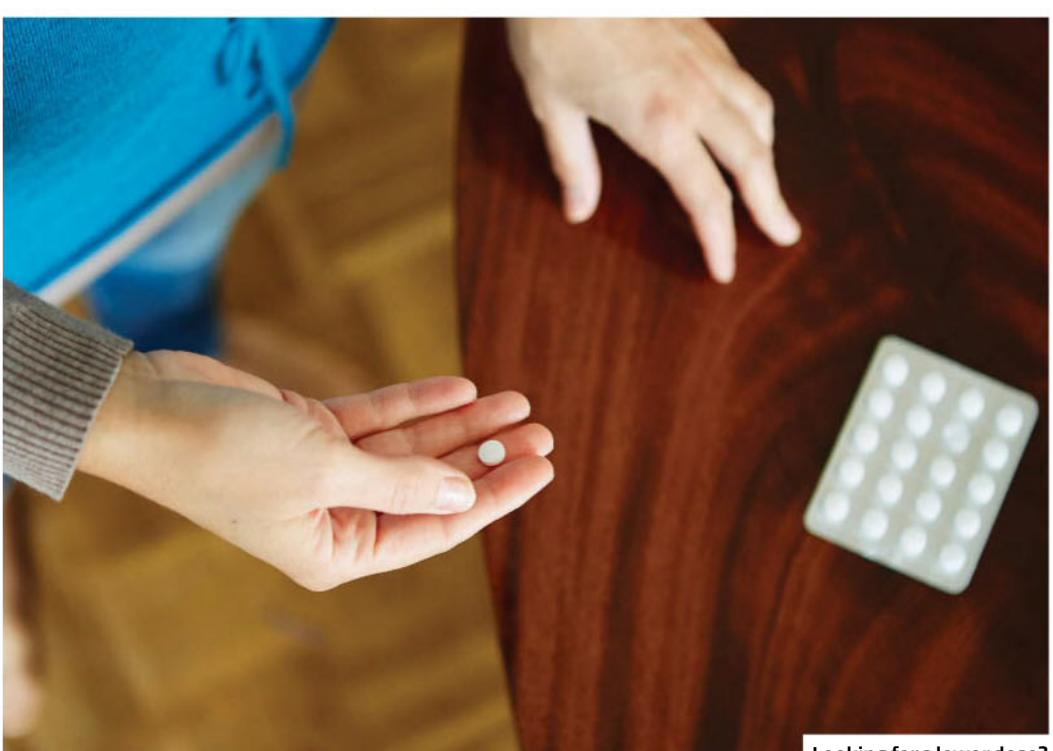
Most of these were for people in the Netherlands, where the project is legal, but a few kits have been sent to other countries, including the UK. The English-language site, launched this week, is likely to make it easier for people in other countries to use the service.

However, most medical bodies advise against buying medicines online. "Although prescription-only medicines can be imported for personal use, self-medication is potentially risky," says a spokesperson for the UK's Medicines & Healthcare Products Regulatory Agency (MHRA).

The Dutch site recommends people use the kits under medical supervision, and only sends kits to those with a doctor's prescription. The MHRA spokesperson says the agency will be contacting its regulatory partners in the Netherlands to make enquiries.

Sourcing pills online isn't the only other option. David Healy, a psychiatrist in Bangor in the UK, helps people with severe withdrawal symptoms by prescribing liquid formulations of their specific medicine, which can be measured out in small amounts. But these formulations aren't as widely stocked as their pill equivalents, and Healy says most GPs refuse to prescribe them because they are more expensive.

Tony Kendrick at the University of Southampton in the UK says another option for some people is to switch to using the antidepressant fluoxetine (Prozac), which is widely available in a liquid formulation. However, switching doesn't work for everyone. ■



KATHLEEN FINLAY/GETTY

Looking for a lower dose?

Ice melt blamed for Greenland's fake quake

EARTHQUAKES in Greenland are rare. At least, they're supposed to be.

So it was a surprise when a magnitude 4.1 "quake" struck Nuugaatsiaq, a tiny island off Greenland's west coast on 17 June. It triggered a tsunami that smashed homes, leaving at least four people dead. But what residents – and seismic equipment – initially labelled as a quake may be nothing of the sort.

"Everyone was fooled by the collapse of a mountain," says Martin Luethi, a glaciologist at the University of Zurich, who has been studying Greenland's glaciers since 1995. "The tsunami wasn't triggered by an earthquake."

Luethi thinks the culprit was a landslide at nearby Karrat fjord. As the falling mountain hit the ocean, it created enough seismic noise to dupe sensors and generate the waves that inundated Nuugaatsiaq. He blames melting ice for destabilising the rock below.

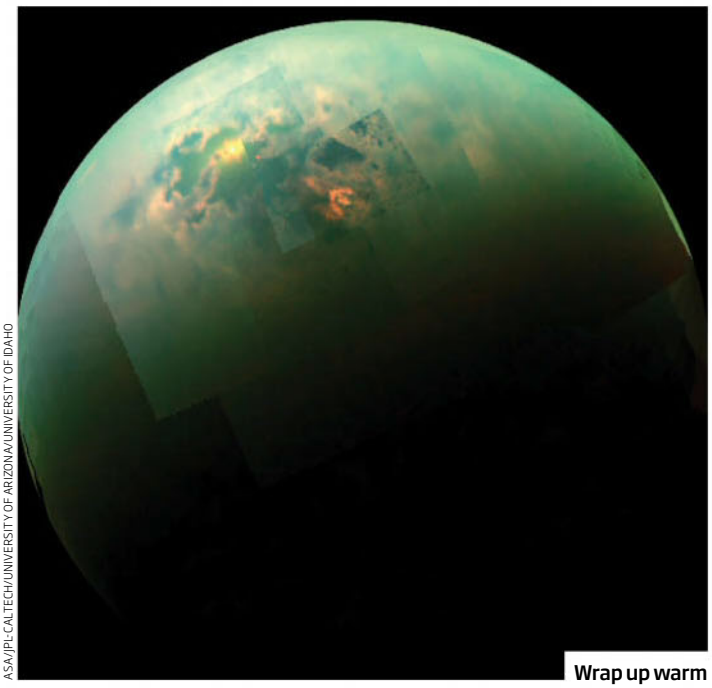
"Ice cannot hold a mountain together if the ice flows," says Luethi. "Melting and freezing cycles mean rocks are getting destroyed. There's so much unstable rock in Greenland and they have no earthquakes to shake it down."

That's why it is such a powder keg, Luethi says. This region is full of craggy fjords with shifting ice – and rocks. That means more so-called quakes – and accompanying tsunamis – seem imminent.

"All of these fjords are very steep," says Martin Truffer of the University of Alaska Fairbanks. "If you have loose materials cemented together with melting ice, there's potential for more of these tsunamis."

Truffer, a physicist who uses ground-based radar to measure the movement of glaciers, thinks this is linked to temperature rise. Now he believes the adjacent mountains are at risk and could soon erode and cause another tsunami.

Adam Popescu ■



NASA/JPL-CALTECH/UNIVERSITY OF ARIZONA/UNIVERSITY OF IDAHO

Wrap up warm

Titan's conditions could power US-sized colony

SATURN'S largest moon could suit human settlement – if we can keep the lights on. Thankfully, Titan may have several energy sources that fit the bill.

Titan is remarkably Earth-like: a thick atmosphere protects its surface from radiation and it is the only other place in the solar system with liquid on its surface.

"I think long-term, after Mars, Titan's probably the next most important place that people will have an extended presence," says Ralph Lorenz at Johns Hopkins University in Maryland.

Humans could live under the yellow haze of the moon's skies by using its resources to power their lives, according to Amanda Hendrix of the Planetary Science Institute and Yuk Yung at the California Institute of Technology (arxiv.org/abs/1707.00365).

Supplies from Earth could be used to make a nuclear power plant, fuelled by mining the moon – yet without studying its interior geology, the feasibility of this idea is mostly guesswork.

Titan is rich in easily accessible methane. While the lack of oxygen makes it inefficient to burn hydrocarbons, future Titanians could make energy by adding hydrogen to acetylene, which is theoretically abundant, though yet to be detected.

"It's possible it's being masked by the atmosphere," says Sarah Hörst, a planetary scientist at Johns Hopkins University.

"The strong flow of liquid hydrocarbons through a narrow sea channel could produce reliable power"

Dams or waterwheels could create power from hydrocarbons made liquid by Titan's frigid temperatures, but it would be a big engineering project to get them flowing downhill as the largest lakes and seas are lower than nearby terrain, Hendrix says.

A better option could be to put turbines in the seas. The largest sea, Kraken Mare, experiences up to a metre of tidal change each day from the pull of Saturn. The tides flow through a narrow channel nicknamed the Throat of Kraken.

"The Throat of Kraken is basically the Strait of Gibraltar," Lorenz says. "We're pretty sure there's a very strong flow of liquid back and forth every Titan day. If you want reliable power that you know is going to be accessible, that's where I would go."

Wind power is also tempting. Strong winds have been revealed in the upper atmosphere by cloud tracking and measurements made by the Huygens probe in 2005.

Hendrix says we could generate 10 times more power than we do from wind turbines on Earth by using wind machines in the upper atmosphere tethered to the surface, though this is beyond current technology.

The most unexpected idea is solar power. At almost 10 times as far from the sun as Earth, Titan receives just one hundredth the sunlight. "The brightest it ever is on Titan is like dusk on Earth," Hörst says. But solar panels are getting ever-more efficient and a civilisation on Titan would have the space to construct extensive, permanent energy infrastructure.

Hendrix and Yung estimate that supporting 300 million people – roughly the US population – would require a solar farm covering 10 per cent of Titan, or the area of the entire US. To make the same amount of power on Earth would take less than 10 per cent of the area of Kansas.

Despite Titan's energy resources, life there would be tough. The moon is cold and has an unbreathable atmosphere of nitrogen, methane and hydrogen, so colonists would need to wrap up and carry their air with them.

Squeezed by 1.5 times Earth's atmospheric pressure, yet buoyant under one-seventh its gravity, people on Titan would feel more like divers in an ocean than astronauts on an airless rock in space. **Mika McKinnon** ■

Why people sleep at different times

Linda Geddes

NUMEROUS dangers stalk the bushlands of Tanzania while members of the Hadza people sleep, yet no one keeps watch.

There is no need because it seems that natural variation in sleep means there's rarely a moment when someone isn't alert enough to raise the alarm.

That's the conclusion of a study that sheds new light on why teenagers sleep late while grandparents are often up at the crack of dawn. Fifty years ago, psychologist Frederick Snyder proposed that animals who live in groups stay vigilant during sleep, by having some stay awake while others rest. However, no one had tested this sentinel hypothesis in humans until now.

One way of maintaining this constant vigilance might be by the evolution of different chronotypes – individual differences in when we tend to sleep. This changes as we age, with teenagers shifting towards later bedtimes, and older people towards earlier bedtimes.

Would such variability be enough to keep a community safe at night? To investigate, David Samson, then at the University of Toronto in Canada, and his colleagues turned to the Hadza, a group of hunter-gatherers in northern Tanzania.

The Hadza sleep in grass huts, each containing one or two adults and often several children. They live in camps of around 30 adults, although several other camps may be close by.

Samson recruited 33 adults from two nearby groups of 22 huts and asked them to wear motion-sensors on their wrists to monitor sleep, for 20 days. "It turned out that it was extremely rare for there to be synchronous sleep," says Samson, now at Duke University in Durham, North Carolina. Indeed, at least one person was either awake, or sleeping lightly and could easily be roused, for 99.8 per cent of the sleep periods sampled, and on average eight of the adults were awake at any given time. Further analysis revealed that this variation in sleep timing could be almost entirely accounted for by the mixture of ages in the group (*Proceedings of the Royal Society B*, DOI: 10.1098/rspb.2017.0967).

MATTHIEU PALEY/NATIONAL GEOGRAPHIC CREATIVE

Sentinel: no time for sleep

Humans live longer than many other mammals. One theory is that there's an evolutionary advantage to living beyond reproductive age because grandparents can help look after the children in a group – the grandmother hypothesis.

This study suggests there may be another advantage: "We're calling it the 'poorly sleeping grandparent' hypothesis," says Samson. "Having a mixed-age demographic increases the sentinel-like behaviour within a group."

The findings could also reassure those suffering from delayed sleep phase disorder, where people don't fall asleep until 4 am or 5 am, or age-related insomnia. "This normalises the experience of those individuals, and sometimes that can be all it takes to get a better night's sleep," Samson says. ■

Quantum bank cheques may be forgery proof

IT'S old meets new. Quantum computers could create cheques that are nearly impossible to forge.

Quantum computers store data using qubits which, unlike ones and zeros in classical computing, can exist in two states at once. It's impossible to observe a qubit in this superposition – it collapses into either a one or zero as soon as you measure it. Now Prasanta Panigrahi at the Indian Institute of Science, Education and Research in Kolkata has shown that, by harnessing this quality, it is possible to make a quantum cheque that can't be spied on, and so can't be copied.

Say Alice wants to pay Bob using a quantum cheque. The bank verifies her identity and issues her two qubits linked to the remaining qubits within their central computer – a quality called quantum entanglement. Measuring the state of any qubit in an entangled system reveals the state of all qubits in that system. The bank can use this to verify that its coffers were the origin of a quantum cheque.

Alice encodes one of her qubits with an amount of money and gives it to Bob. The bank confirms that it's a qubit from its own system, and has been encoded by Alice, and cashes the cheque (arxiv.org/abs/1707.00182).

The system has weak points, says Subhayan Roy Moulick, a researcher at the University of Oxford who first proposed the experiment. If someone stole the passcode that Alice uses to encode her qubit, they could tamper with it. But as long as the passcode is memorised or locked away, the risk is extremely low, says Moulick.

"The contents of a quantum cheque can't be spied on, and therefore can't be copied"

Transporting qubits is tricky, too. Current quantum computers need huge cooling systems. It is possible to store qubits at room temperature with diamonds, but Moulick says that a quantum cheque is more likely to be a laptop-sized box than something you can slip into your pocket.

This isn't scalable just yet. In this scenario, the bank gives away two qubits every time it issues a cheque. Even if it only issued one cheque a day, it would need hundreds of qubits, and quantum computers of that size are still decades away. Matt Reynolds ■

Now we can store video in living DNA

LIFE is an open book and we're writing in it. A team at Harvard University has used the CRISPR genome-editing tool to encode video into live bacteria – demonstrating for the first time that we can turn microbes into librarians that can pass records on to their descendants – and perhaps to ours.

DNA can store a lot of data: 1 gram of single-stranded DNA could encode 100 billion DVDs. So far, this has been done using synthetic DNA. You can store big files like images and text, but until now there's been no way to record something as complex as changes to an image over time, like a movie.

However, Seth Shipman at Harvard and his colleagues realised they could use CRISPR to insert information into living bacteria, allowing them to become active record-keepers.

The team encoded five frames of video showing a galloping horse into DNA, and injected it into thousands of *E. coli* bacteria. Then the living cells took over. When they detected copies of the first fragment of DNA encoding the video, the bacteria's CRISPR mechanism cut and pasted the sequence into their own genomes. They added subsequent fragments, too, in the proper order. To read the data back again, the team sequenced the DNA of more than 600,000 cells, to negate any individual variability (*Nature*, DOI: 10.1038/nature23017).

This technical demonstration proves it's possible to create a detailed history of events in the order they happened, says Shipman.

"This is a really neat paper," says Yaniv Erlich at Columbia University in New York. Inserting information into living cells opens up many possibilities, he says. For a start, it lets you amend the stored information later. And because the data is written into the bacterial genome, it gets passed down between generations.

Storing data in certain kinds of bacteria could even let us store information to survive a nuclear apocalypse. Douglas Heaven ■

WILLIAM LEAMAN / ALAMY STOCK PHOTO

Got a sense of swing

Some birds sing with rhythm like jazz masters

IT DON'T mean a thing if it ain't got that swing, goes the Duke Ellington song. By that logic, some bird songs really do mean something. At least a few bird species can swing in the same way that human musicians do, *New Scientist* can reveal.

This claim has been made on the basis of a mathematical analysis of the songs of the thrush nightingale. Not all the musicians *New Scientist* spoke to agreed what the thrush nightingale is doing can be called swing – but several said they have heard other birds that definitely do swing.

In the narrowest sense, swing means delaying the offbeat, so pairs of notes are played long-short rather than being of equal duration. This kind of swing is typical of jazz and related styles of music.

Swing is also used in a wider sense to describe a certain feel. "It's this quality of unevenness that is so hard to quantify," says musician David Rothenburg of the New Jersey Institute of Technology. "You have to feel it."

Or as jazz pianist Fats Waller is said to have put it: "If you gotta ask, you'll never know."

According to an analysis by Tina Roeske of the Max Planck Institute for Empirical Aesthetics in Germany and colleagues, the song of the thrush nightingale (*Luscinia luscinia*) has subtle deviations in note timing that make it more "expressive". In other words, they can swing in the wider sense (*bioRxiv*, DOI: 10.1101/157594).

"The most swinging bird is the veery thrush – its song is like a Miles Davis trumpet solo"

Rothenburg also thinks this quality of the thrush nightingale song qualifies as swing. But composer Hollis Taylor of Macquarie University in Australia is not entirely convinced. "It's a terrific study and a fascinating one, but not particularly helped by 'swing' being employed in the title," she says.

However, while Taylor is not convinced thrush nightingales swing, she says the Australian pied butcherbirds, whose songs she studies, play with rhythm in this way. "Some birds sing phrases that seem to momentarily swing," she says. "If I had a jazz band, I'd let them sit in."

The most swinging birdsong of all is that of the veery thrush of North America, says Rothenburg. "It's like a Miles Davis trumpet solo."

Whatever you call it, there's the question of why some birds vary rhythms in this way.

It might be to make their songs more interesting, but it could also be that they lose rhythmic control when they get excited or when their muscles tire, says composer Emily Doolittle, who has worked with biologists to study birdsong.

What everyone agrees on is that we've barely begun to scratch the surface when it comes to studying animal music.

"Whether or not we consider some animal songs to be 'music', I think it's beyond a doubt that some have enough in common with human music that we can understand them better by combining musical and scientific methods of analysis," says Doolittle. **Michael Le Page** ■

MARKA/SUPERSTOCK

Fair shares? Only in an ideal world

Toddlers expect bullies to get more

Aylin Woodward

EVEN babies seem to expect bullies to get more in life. For the first time, there's evidence that infants expect socially dominant people to be treated differently.

From as early as 6 months, babies begin to judge other people's characters, and by the age of 10 months, infants anticipate that bigger things will master smaller ones. Now an experiment has found that toddlers expect dominant people to have the lion's share of resources.

Previous studies discovered that, in the absence of any social differences, infants expect objects to be equally shared out between people. Toddlers who watched videos of Lego pieces being shared between two people were surprised by variations from a fair procedure. The findings were similar in other studies involving sharing crackers or milk.

Now a team has discovered that 17-month-old toddlers use social cues to adjust their expectations of what a person should have. "They are tuned to what they observe – who is more powerful or competent – and use that to make further predictions," says team member Hyo Gweon at Stanford University in California.

The team studied 80 infants across a variety of experiments in which they watched videos of human-like puppets. In one set of videos, the puppets happily sat on a purple chair and a brown stool,

"This might help explain why we like the idea of equal sharing, but struggle to change the status quo"

without conflict. In the second set, the puppets fought over who got to sit in the purple chair, and the pushier puppet won.

Lego pieces were then given to the puppets. When the puppets behaved themselves, the toddlers seemed to anticipate they would be handed an equal number of pieces. If one puppet was given more, the infants showed surprise by looking at the screen for an average of 6 extra seconds.

But when the puppets had been fighting, the toddlers were instead surprised when the pushier, dominant puppet wasn't given more Lego. They seem to have expected it to get more than its fair share, watching this scenario for an average of 8 seconds less than the more surprising scenario in which the Lego was shared equally (*Cognition*, doi.org/b9dw).

"The fact that dominance and resource notions are aligned and established so early may have consequences for larger societal issues," says team member Jessica Sommerville of the University of Washington in Seattle. "This might help to explain why people endorse egalitarian resource distributions, yet we struggle to change the status quo in which some folks wind up with more resources even if they are undeserving of them."

All of the infants tested were from the US. Laura Van Berkel at the University of Cologne, Germany, wonders if toddlers from more egalitarian countries would behave in the same way. ■

Invisibility cloak boosts solar panel efficiency

A CLOAK made of a polymer has been used to hide the metallic strips in solar panels, making the devices more efficient at using the sun's energy.

Invisibility cloaks are made of materials that bend the path of light around them and so hide things under them from view. Martin Schumann at Karlsruhe Institute of Technology in Germany and his colleagues have created a prototype solar panel with a cloak over the metallic contact fingers that extract the generated current.

Although crucial, these metal strips reduce the light a panel absorbs, lowering efficiency by about 10 per cent. Schumann and his colleagues designed a single solar cell with an added polymer coating. They then etched grooves into the coating, so it guides incoming light around the contact fingers and towards the solar cell (*Advanced Optical Materials*, doi.org/b9fd).

The team placed enough contact fingers on the cell to cover 6 per cent of the surface area. When they added the invisibility cloak, the efficiency rose by 9 per cent rather than the expected 6 per cent. This is because light that would otherwise have been reflected is trapped within the cloak and later absorbed by the panel.

Gerhard Peharz, an engineer at Joanneum Research in Austria, says the work is exciting, but he foresees problems. Dust will gather in the grooves in the cloaking material and block sunlight, he says. And, over time, UV light will degrade the polymer, decreasing its effectiveness.

"It needs to be shown that there is a polymeric material that you can pattern in order to achieve this effect and is reliable for 20 years outdoors in the desert of Arizona," Peharz says.

To get round these problems, Schumann wants to enclose the whole solar module in a glass case, sealing it off from the environment and protecting the cloak. But he doesn't yet know how that would affect efficiency. Shannon Hall ■

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AI poetry is so bad it could be human

Matt Reynolds

CAN a machine incapable of feeling emotion write poetry that stirs the soul? A neural network trained on thousands of lines of poetry has tried its hand at penning its own rhymes. Its best efforts even fool readers into thinking they're reading the output of a human mind.

The poetic bot is fully tunable, says Jack Hopkins, who developed the system while at the University of Cambridge. It can be programmed to write in a particular rhythm or on specific themes.

Set the theme to "desolation", for example, and the angst-ridden AI comes up with the following:

The frozen waters that are
dead are now
black as the rain to freeze a
boundless sky,
and frozen ode of our terrors with
the grisly lady shall be free to cry

The AI can be endlessly tweaked to produce different flavours of poetry. It could write about Brexit in the style of a Greek epic, or rewrite snippets of *Romeo and Juliet* while mimicking Eminem, Hopkins says.

But flesh-and-blood poet Rishi Dastidar suspects that the AI is all surface and no subtext. Real poems explore ideas that might not be immediately apparent in the text, he says. But an AI doesn't deal in ideas, it just puts one word after another.

Although it might be short on original thought, the AI poet did have plenty of examples to draw inspiration from. It was trained on over 7 million words of 20th-century English poetry.

"It could write about Brexit in the style of a Greek epic, or write snippets of Romeo and Juliet à la Eminem"

However, unlike most human poets, the neural network doesn't think in words; rather, to approximate poetic idiosyncrasies like archaic spelling and whimsical punctuation, it learned to write its stanzas one letter at a time. But rather than let the network freestyle, Hopkins added another element that encouraged it to write in particular styles or on certain themes.

DAVID HORNBACK/MILLENNIUM IMAGES, UK

But is it better than monkeys?

Tell the neural network to write about fire, for example, and it will keep checking to make sure some of the words in the line it is writing concern fire.

Hopkins employed a similar mechanism to persuade the AI poet to write lines that rhymed or followed a particular rhythm. For example, Hopkins could make the AI write verse in iambic pentameter – the poetic rhythm that is common in Shakespeare's plays and sonnets.

This puts the AI poet decidedly behind the times, says Dastidar. "The art form and the craft stopped thinking about these things 70 years ago," he says. Modern poets deliberately choose when to follow or depart from formal constraints.

You can't be truly creative, says Dastidar, if your template is only what has already been written.

Lack of creativity aside, the neural network still managed to fool some people. Hopkins asked 70 people to guess who'd written a fragment of poetry – a computer or a living, breathing poet. The most human poem, it turned out, was actually written by an AI. ■

Invasive plants scale warming peaks quickest

AS THE climate warms up, invasive weeds are outpacing native Alpine plants to the tops of mountains, threatening them with extinction.

To avoid warming temperatures, plants can migrate to cooler habitats higher up mountains, but new research is showing that invasive species are beating them to it. "We find that invasive species are responding to climate change far more quickly than the native ones," says Matteo Dainese of the University of Würzburg in Germany. He and his colleagues looked at the distributions of 1300 plant species over 20 years – from 1989 to 2009 – on an area around Mount Baldo in north-east Italy. From 130,000 observations, they found that on average, the non-native species were increasing their elevation range at twice the speed of the native species such as *Potentilla brauneana* (pictured).

FILIPPO PROSSER

It's a race to the top

The team found that the invasive species spread their seeds more widely and their passage up the mountain was helped by roads with verges that provided convenient conduits toward the summit (*Nature Climate Change*, doi.org/b9gv).

"A key finding of our study is that the combined effect of both global warming and human disturbance has accelerated species range expansion in an unprecedented way," says co-author Lorenzo Marini, of the University of Padua in Italy. "Limiting growth of tourism, skiing developments and roads could be central to reducing these impacts."

Andy Coghlan ■

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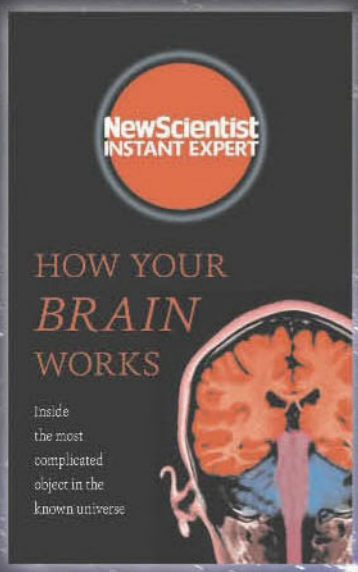

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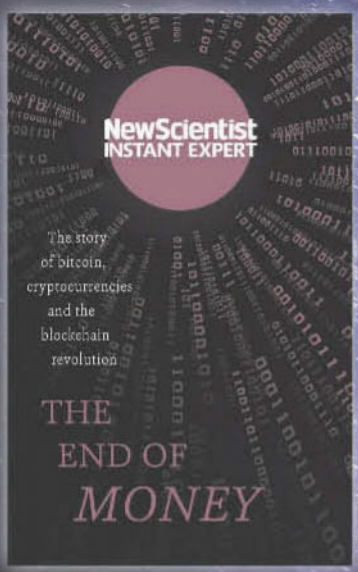

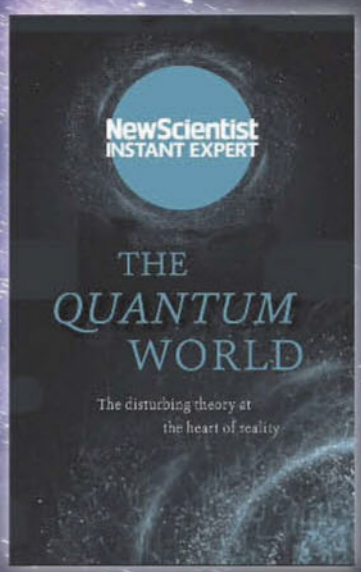

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Milk tooth reveals oldest Denisovan

Colin Barras

THREE becomes four. The sparse fossil record of the Denisovans – ancient humans who lived in what is now Siberia – has gained one more specimen: a tiny, worn tooth belonging to a child.

The Denisovans are perhaps the most mysterious of all ancient hominins. They were discovered in 2010 when geneticists were sequencing DNA from ancient bones, assuming they belonged to Neanderthals. The DNA from a 50,000-year-old finger-bone fragment turned out to be so different from Neanderthal gene sequences that the researchers concluded it must represent a separate group.

Later genetic studies suggested that these distinct hominins split from the Neanderthals between 470,000 and 190,000 years ago. They were named the Denisovans after the Denisova cave in Siberia (pictured right), where the finger-bone fragment was found. Later, Denisovan DNA turned up in two teeth recovered from the cave.

Now, Viviane Slon at the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany, and her colleagues have added a worn milk tooth lost by a girl aged 10 to 12 years old. Unearthed in the Denisova cave in 1984, it came from a geological layer formed between 227,000 and 128,000 years ago, making it potentially the oldest of the four specimens.

DNA analysis supports that idea: the tooth lacks some genetic features seen in the other three specimens, consistent with those features being later mutations. Judging by the accepted rate of mutation, the girl probably lived 20,000 to 40,000 years earlier than any of the three previously known Denisovans (*Science Advances*, doi.org/b9gg).

Despite these differences, the DNA in the tooth is remarkably similar to that from the three younger fossils. This fits with the idea that the Denisovan population was always small and had a low genetic diversity.

But Slon says it's still difficult to confirm this, since so little DNA could be recovered from the tooth – only about 1.5 per cent of the nuclear genome. "To really investigate the genetic diversity of this group across space and time, we would need to reconstruct full genomes from additional individuals," she says, which will mean we need more fossils.

There is a good chance that the Denisovans were reasonably widespread across Asia: chunks of their DNA are present in some people in East Asia and Oceania today, suggesting the Denisovans interbred with modern humans who arrived later on. But, for the moment, the details are sparse. "We really know nothing so far about the Denisovan range," says Chris Stringer at the Natural History Museum in London.

Stringer suspects that the population that occupied the Denisova cave might have been unusual. The cave has also yielded some fossil material containing Neanderthal DNA – but like the Denisovan DNA, it shows signs of having come from a small, potentially inbred population.

"This does suggest that these populations of Neanderthals and Denisovans were present in small numbers at the very edges of their species' ranges," says Stringer: most Neanderthals lived much further west of the Denisova cave, most Denisovans probably much further east. ■

RIA NOVOSTI/SCIENCE PHOTO LIBRARY

Home to two ancient hominins

Corporate diversity under AI microscope

BOARDROOM bias is tricky to assess. Many firms don't publish diversity reports, hampering efforts to tackle institutional biases. Now artificially intelligent algorithms have been used to dig into the data, confirming that there is a lack of diversity at the top of the world's corporate ladder.

Researchers from biotech firm Insilico Medicine in Maryland compiled pictures of top executives taken from the websites of nearly 500 of the largest companies in the world. The final dataset comprised over 7200 photographs from companies spanning 38 countries.

The team trained image recognition algorithms to automatically detect the age, race and sex of the board members, and compared the results with the population profile of each firm's country to highlight disparities.

Overall, the team found that only 21.2 per cent of the corporate executives in the study were female. And in every single company, the percentage of female board members was lower than the percentage of women capable of work in that country. Twenty-two companies had no women on their boards, with the majority of those firms being in Asia.

Nearly 80 per cent of the executives were white, with 3.6 per cent black and 16.7 per cent Asian.

"These huge companies lead industries and influence our everyday lives. Using machine learning makes it possible to examine their diversity in a way that couldn't be done before," says Polina Mamoshina at Insilico Medicine. The firm says it will publish the research on arXiv.

"Machine learning allows us to examine the diversity of these influential firms in a way we couldn't before"

"This paper confirms that we live in a biased world," says Sandra Wachter at the Oxford Internet Institute, UK. However, acknowledging the problems this causes is only a crucial first step. "Having a public discourse about these issues is vital," she says. "It is important to find out where the biases stem from and tackle the roots." Timothy Revell ■

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Coordinated leaning helps sunflowers get more light

SUNFLOWERS growing densely in a field adopt a zigzag pattern, with neighbours leaning in opposite directions to grab as much light as possible. The strategy – which other plants might be using, too, without anyone noticing – may give us a way to boost crop yields.

The alternating leaning isn't easy to discern, because leaves mask the pattern. But when Antonio Hall, a crop eco-physiologist at the University of Buenos Aires, Argentina, visited an unusually dense field of sunflowers at the end of the growing season, after the leaves had fallen, he noticed it.

Follow-up experiments by Hall's team revealed that the pattern starts early in growth, when one "pioneer" plant leans about 10 degrees from the vertical to escape a neighbour's shade. This causes the plants on either side of the pioneer to lean in the opposite direction to escape the pioneer's shade, and the alternation cascades outwards. "Each pioneer plant creates a wave," says Hall.

Yields of sunflower seeds were between 25 and 50 per cent higher in the leaning plants than in plants wired to remain upright, suggesting that the tilt allows them to make better use of available light. Hall's team also compared several sunflower varieties and found they differed in their leaning habit, suggesting that the trait has a genetic basis and could be harnessed for crops in the future (*PNAS*, DOI: 10.1073/pnas.1618990114).

Heavy head knocks double dementia risk

SERIOUS head injuries nearly double a person's risk of developing dementia. That's the message of a study of the long-term health of over 40,000 people who had head injuries between 1986 and 2014.

Half of them had moderate-to-severe head injuries, which caused lesions in the brain and required a hospital stay of three days or more. The other half had milder injuries with no lesions, and were able to go home within a day.

After accounting for education and socio-economic status, the group with moderate-to-severe injuries had a 90 per cent higher risk of developing non-Alzheimer's dementia than the group with milder injuries, found Rahul Raj at the University of Helsinki, Finland, and his colleagues.

In all, 696 of the 19,936 people with moderate-to-severe head injuries went on to develop dementia, while only 326 of the 20,703 people with milder injuries did. The risk of dementia was highest in those who sustained severe, traumatic head injuries between the ages of 41 and 50 (*PLoS Medicine*, doi.org/b9dh).

Previous studies have found that blows to the head can raise a person's likelihood of dementia, as can highly physical sports.

Tiny laser vanishes in a little water

ONE minute it's a laser, the next it has dissolved away. A new postage stamp-sized device could be injected into the body to help with medical imaging. After use, its non-toxic materials would be absorbed by the body.

Traditional lasers amplify light using mirrors on either side of a special material, releasing laser light through one of the mirrors. The new device, created by Yang-Fang Chen at the National Taiwan University in Taipei and his colleagues, bounces light between closely packed zinc oxide and titanium dioxide nanoparticles instead.

The nanoparticles collide to produce scatterings of light, like sun streaming through clouds, doing away with the need for bulky mirrors.

The particles are packed into a tiny polymer compartment that dissolves in water after 40 minutes (*ACS Nano*, doi.org/b9ds).

Frogs have hidden, ancient kneecaps

FROGS' legs have sprung a big surprise. Contrary to the textbooks, they have primitive kneecaps.

We failed to spot them earlier because they aren't clearly visible on frogs' bones, says Virginia Abdala at Argentina's Institute of Neotropical Biodiversity.

Her team found evidence of kneecaps in tissue slices from eight frogs, representing several species. Reconstructing the evolutionary history of the kneecap, they found that it could be ancestral to all land animals.

The team argue that kneecaps may have begun to evolve 400 million years ago, when the first four-legged animals reached land (*The Anatomical Record*, doi.org/b9dm).

Wire robot twists into any shape

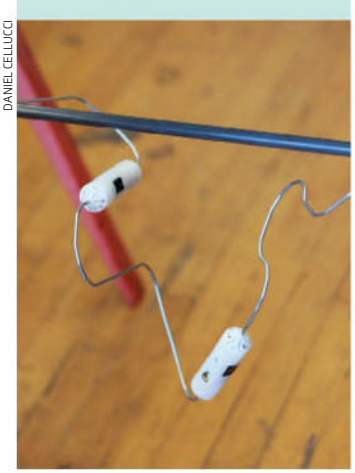
FROM wire to finished product: a new robot-builder delivers in less than 13 minutes. It works by bending wire with motors already attached into different shapes. Once the robot's task is complete, simply flatten it and feed back into the system to be recycled into a new type of robot.

"The idea is that you analyse the current situation, then make a robot on the fly that can deal with it," says Sebastian Risi at the IT University of Copenhagen, a member of the team that came up with the system. If you need a robot that can fit through a small space or around an odd-shaped corner, you input those constraints into the software and it will deliver something suitable (*IEEE Robotics and Automation Letters*, doi.org/b9gw).

"You then end up with a robot that can crawl under that awkward piece of rubble or over collapsed walls in a burning building," he says. "They are cheap and easy to make, and afterwards you can easily recycle them or make a new one."

The idea could be useful for space missions, Risi thinks, as they can't accommodate 15 different robots to do different things, so being able to create and recycle them quickly would be handy.

Risi and his colleagues now want to augment the robots with sensors, like cameras or microphones.



DANIEL CELLUCCI

Bacteria implicated in nasty flare-ups of eczema

MICROBES that live on our skin may play a role in eczema. Certain strains of *Staphylococcus aureus* bacteria are linked to skin irritation in children with the disorder, it turns out.

Eczema affects up to 20 per cent of children, causing bouts of dry and itchy skin. To learn more, Heidi Kong at the National Institutes of Health in Bethesda, Maryland, and her colleagues sampled bacteria from the skin of 11 children with eczema, as well as seven children who don't have it.

The researchers took samples while the skin was healthy, and during and after eczema flare-ups. They then used DNA sequencing to identify the bacteria present.

S. aureus is common on skin and is especially prevalent in people with eczema. What the team found was that particular strains of this species dominated the samples during severe flare-ups. When children had mild or no symptoms, the mix of bacteria was more diverse.

The team then let bacteria from the children colonise the skin of mice. *S. aureus* strains from those children with more severe eczema caused substantial inflammation, whereas other *S. aureus* strains provoked smaller reactions (*Science Translational Medicine*, DOI: 10.1126/scitranslmed.aal4651).

Understanding the precise role microbes play could lead to new treatments. "We are interested in figuring out what these bacterial strains are doing on our patients," says Kong. "If these are harmful, then finding a way to change what strains are on eczema patients may be helpful."

Drones that can dive like pelicans

FLYING submarines are about to make a splash. The US Navy has developed a version of the underwater drones known as gliders – but souped up so the vehicle can fly.

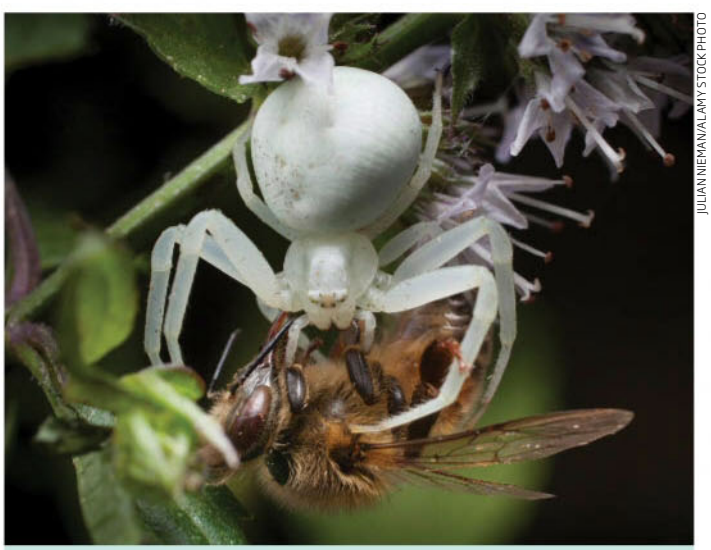
Gliders are so-called because they vary their buoyancy to slip through the water for great distances on little power.

But they can't get to a destination fast. So the Flying Sea Glider, which weighs around 30 kilograms, will attempt to fly for more than 150 kilometres and, at its destination, dive into the waves and convert into a submarine.

A small test version has already flown successfully, with the full-sized drone scheduled to make its debut flight next year.

The dive is the trick. The navy team opted for a pelican-style plunge as it was less likely to damage the drone. When it enters the water, sections of its body fill with water until it becomes dense enough to glide at depths of up to 200 metres.

At the end of its mission, a boat will recover it, as with existing gliders. The idea is that groups of the drones could be rapidly sent to find a crashed aircraft, for example, or track an oil spill.



JULIAN NIEMAN/ALAMY STOCK PHOTO

Spiders use UV trickery to hunt bees

SOME spiders are ambush hunters, but they neither use webs nor rely purely on the element of surprise. They reflect ultraviolet light, making the flowers where they live more appealing to the bees they prey on.

Felipe Gawryszewski at the Federal University of Goiás in Brazil and his team collected and studied individuals from 68 species of crab spider found in Australia, Europe and Malaysia. They discovered that multiple species had evolved a flower-based hunting strategy.

What's more, flower-dwelling crab spiders reflected more UV light than non-flower-dwellers (*Evolution*, doi.org/b9dx). This appears to be effective, because we already know bees are more likely to visit flowers with UV-reflecting spiders perched on them.

It is not clear why bees are lured in, but one possibility is that they mistake the spiders for "floral guides" – natural bright spots on flowers that guide pollinators to land on them.

It is also possible that bees prefer certain colour patterns and that spiders are tapping into this, says Gawryszewski.

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Lullaby and goodnight

Paediatricians say sharing a bed with your baby is dangerous, but anthropologists say it's natural. Who's right, asks **Alice Klein**

FOR decades, new parents have been warned against sharing a bed with their babies. While snuggling up with your newborn may seem like the most natural thing in the world, prevailing medical advice says this increases the risk of sudden infant death syndrome (SIDS), sometimes called cot death. Instead, doctors say your little ones should sleep in a separate crib in your bedroom.

On the other side of the argument are anthropologists and proponents of "attachment parenting", who believe that infant-parent separation is unnatural and at odds with our evolutionary history. They favour not just room-sharing but bed-sharing – putting them in direct conflict with paediatric advice.

This debate was recently reignited by a study suggesting that room-sharing for up to nine months reduces a baby's sleep, which in theory could have future health consequences. So what's a sleep-deprived parent to do?

Our ancestors slept in direct contact with their young in order to protect them, just as other primates do today, says Helen Ball at Durham University, UK. "Babies respond to close contact – their breathing, blood oxygen and heart rate are on a more even keel."

In Asia and Africa, most babies still share their parents' beds (see map, below). But in the West, bed-sharing fell during the industrial revolution as increased wealth let people afford separate rooms and value was placed on teaching early independence.

Then, in the 1990s, the perception of bed-sharing went from unfashionable to dangerous, after research suggested that SIDS was more common in babies who slept in their parents' bed. In 2005, the American Academy of Pediatrics (AAP) released guidelines advising against bed-sharing, which were also adopted in the UK and Australia.

The AAP acknowledged that the association between SIDS and bed-sharing wasn't clear-cut, but the link became gospel nonetheless. Billboards went up in the US depicting babies in adult beds with butchers' knives lying next to them, warning: "Your baby sleeping with you can be just as dangerous."

"Ninety-nine per cent of paediatricians would tell you never to bed-share," says Ian Paul at Pennsylvania State University.

"Ninety-nine per cent of paediatricians would tell you never to share your bed with your baby"

"We're not sleeping on cave floors anymore, we're on 21st-century mattresses with pillows and blankets that can suffocate babies."

But more recently, evidence has emerged that bed-sharing can be done safely. A 2014 study of 400 SIDS cases in the UK found that sleeping with a baby is only associated with SIDS if it is on a sofa, or the parents smoke or consume more than two units of alcohol before bed.

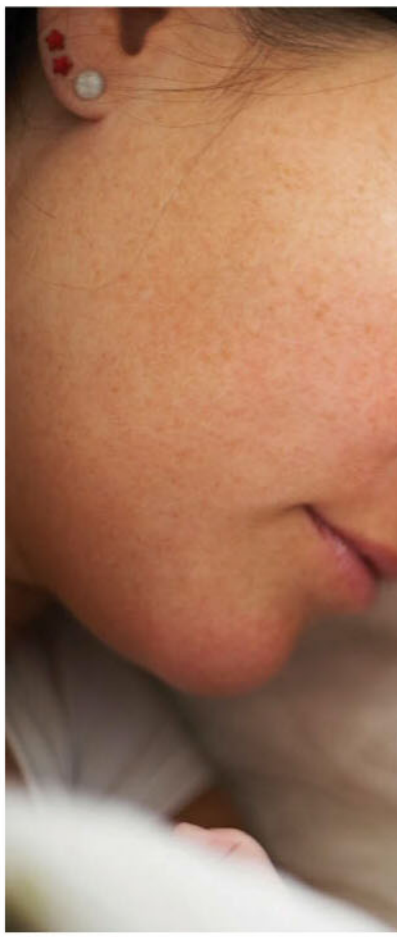
Parents without these risk factors can prepare safe sleeping spaces for their baby, says Ball. "Use a firm mattress, keep pillows and blankets away," she says. Lab observations show mothers instinctively curl around their babies, she says, but if you are afraid of rolling onto your baby, place them in a bedside crib attached to the bed to form a continuous but protected surface.

In Japan, where bed-sharing rates are high but SIDS rates are low, protective measures are part of the culture, says Fern Hauck at the University of Virginia. Japanese mothers generally sleep on firm futons, place babies on their backs, and don't smoke much, she says.

Hong Kong also has high bed-sharing rates and low SIDS rates, although the SIDS definitions in Japan and Hong Kong are slightly different to those in Western nations. Other countries where bed-sharing is common don't routinely collect data on SIDS.

Because we still don't really know what causes SIDS, it's difficult to know how bed-sharing and SIDS might be linked. But the latest research points to a role for biological factors unrelated to sleep location. For example, a study published last year found that babies who died of SIDS had faulty signalling from a brain chemical called orexin, which made it harder for them to wake up. Other research suggests the condition is caused by brainstem abnormalities that make it harder for babies to regulate breathing.

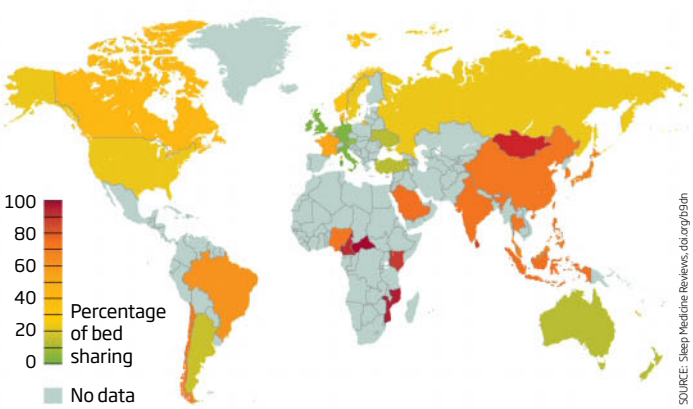
However, Hauck, who co-authored the AAP's most recent SIDS guidelines, says she is still not convinced about the safety of



SANDRA SECKINGER/WESTEND61/PLAINPICTURE

Sleeping soundly

The percentage of parents who share a bed with their babies is higher in African and Asian countries than in the West, where it fell out of favour during the 19th century



SOURCE: Sleep Medicine Reviews, doi.org/b9dh

Sleep well

bed-sharing, as her team's review of all the evidence suggested there is still a small risk of SIDS even if factors like parents being non-smokers are considered. "We're taking a cautious approach and continuing to recommend that infants sleep on a separate surface," she says.

Even if bed-sharing can be done safely, parents must still ask themselves whether it is worth it. Proponents say that the security children derive from sleeping with their parents helps make them more caring and empathetic, though little research has been done to support this. Others say it simply disrupts everyone's sleep.

One clear advantage is that bed-sharing makes breastfeeding easier, says Ball, which is linked to a lower risk of SIDS, infections, allergic disease and obesity. She led a trial in a postnatal ward, in which babies were randomly assigned to sleep in their mother's bed, a crib attached to her bed, or a standalone cot adjacent to her bed. It turned out that babies sharing a bed or in bedside crib breastfed twice as often as those in standalone cots.

However, little research has been done on the long-term impacts of bed-sharing. One study that followed 205 Californian children for 18 years found that bed-sharing as infants had no effect on self-acceptance, relationships with others, attitudes to sex, the use of drugs and alcohol, or criminal tendencies when they grew up. But teasing out the effect of sleep location among other factors on development is practically impossible, says Ball.

"There's no one-size-fits-all guidance, and people shouldn't reduce it to: 'you should do this or do that'"

The long-term effects of room-sharing are also unknown. A survey of 230 mothers in the US found that 9-month-old babies slept 40 minutes less on average per night if they shared their parents' room (*Pediatrics*, doi.org/b9bp). Poor sleep early in life could lead to cognitive and behavioural problems, says Paul, who carried out the study.

Whether this could have lasting effects is still conjecture. It is also unclear whether sounder sleep is desirable, since babies who wake up less are thought to be more at risk of SIDS, says Hauck.

Babies can usually be moved safely to their own room when they are about 6 months old, says Ball, when the risk of SIDS drops off sharply and infants start to develop object permanence – the understanding that objects still exist even when they can no longer be seen. "Then babies understand that even though they can't see their mum, she hasn't disappeared forever," she says.

The AAP recently shifted from recommending at least one year of room-sharing to at least six months. "We accepted concerns that sleeping in the same room for a year can be difficult," says Hauck. The UK's NHS also recommends six months.

Parental choice

Educating parents is better than simply telling them what to do, says Ball. "There's no one-size-fits-all guidance, and it bothers me when people try to reduce it down to: 'you should do this or do that'."

Rigid guidelines can also backfire. For example, parents who have been warned never to bed-share may end up falling into an exhausted sleep with their baby on a sofa, which is more dangerous than a carefully prepared bed, says Ball.

This idea is starting to catch on. Since 2016, the AAP guidelines have included advice on how to bed-share more safely, in case parents choose to do it or it happens accidentally. And in 2014, the UK's National Institute for Health and Care Excellence recommended discussing bed-sharing risks with parents, instead of banning it outright. In Australia, the National Health and Medical Research Council is also updating its guidelines.

The debate remains polarised, but the evidence suggests your baby can sleep wherever works best for you, as long as it is done sensibly. If you want to bed-share, there are ways to reduce the SIDS risk. If you want to move your baby into their own room after six months, you are unlikely to stunt their emotional growth. The important thing is to have informed choice – and hopefully, a good night's sleep. ■

Reboot and reform

Broader oversight of big tech's healthcare ambitions must follow the flawed DeepMind-NHS deal, says **Hal Hodson**

SO THE deal struck over patient data between the Royal Free Foundation NHS Trust and AI pioneer DeepMind "failed to comply with" the law. That's the long-awaited verdict of the regulator charged with upholding UK data protection rules.

The Information Commissioner's Office (ICO) said the trust, part of the UK's national health service, erred in four ways. It did not examine the privacy implications of the agreement closely enough. It failed to tell patients about the deal or offer an opt-out before handing over their records. Plus sharing 1.6 million identifiable records was in excess of that needed to test an app.

This vindicates *New Scientist*'s story in April 2016, which revealed the true extent of the data transfer and questioned its validity.

However, there are bigger questions beyond the ICO's remit.

Its ruling can't be the final line drawn under a flawed agreement, but must herald the start of a much wider discussion about how big tech firms use health data.

How should such deals take the value of NHS datasets into account? How do we ensure patients' needs are served by the open standards DeepMind and others are working on, and allow new players into the market? How much control do US parent corporations have over UK-based subsidiaries (DeepMind is owned by Google's parent company)?

It may seem premature to talk of monopolies and competition when DeepMind's NHS foray is barely a year old, but digital firms can dominate fast. DeepMind is not just building an app for the NHS, it is building infrastructure. If rivals have to interface with that infrastructure, they may find it hard to compete. Hopefully,

Flight of fancy?

If EPO doping in sport is just a placebo effect, would that stop its abuse, asks **Chris Cooper**

THE Tour de France, the greatest cycling race in the world, was dominated by US rider Lance Armstrong from 1999 to 2005. Then, in 2012, he got a lifetime ban for doping, for using among other things the blood-oxygen-boosting agent erythropoietin (EPO).

In a memorable scene in *The Program*, a film based on his fall from grace, he is portrayed being injected with EPO accompanied by the line: "This is science; no longer confined to Earth – now we have learned to fly."

That science may be crashing back to earth. Using amateur riders injecting either EPO or saline, a Dutch study says that in terms of road race performance, EPO is no better than a placebo.

So the blood doping emperor had no clothes? Maybe. For ethical reasons, the study couldn't use elite competitors, and blood oxygen content may not have been limiting performance in the amateurs. Participants were also asked to train as usual, so this didn't test any effect of EPO on how hard you can train.

The study also doesn't address use of a closely related doping technique: transfusions of blood

"EPO's relatively cheap price has led to a big rise in use at the non-elite level, in club athletes"

to boost red cell counts, shown to improve race performance.

Yet, this is still impressive work. Will it have an impact in the anti-doping world? Possibly not. The World Anti-Doping Agency will not remove EPO from its banned list as long as there is the slightest chance it boosts performance. One study, however careful, would not be enough to sway opinion.

What about use by unethical coaches? Coaching is as much art as science. Harnessing the placebo effect is a key part of it, and injections are great placebos. If improvements are seen in an athlete's performance, coaches will dismiss contradictory papers

Interopen, a new health data standards body, will address some of these concerns.

While it may or may not be a good idea for DeepMind to build, run and control core NHS infrastructure, it would certainly be bad for it to do so with no public debate whatsoever.

Turning that debate into robust regulation will require something beyond the ICO. Ofcom and Ofgem oversee communication and energy networks in the UK. We may now need Ofdim, the Office of Digital Markets.

The agglomeration of power and influence online is already taking a toll. The rest of the media industry is suffering, as the bulk of online advertising flows through either Facebook or Google. They also hold disproportionate power when it comes to informing and influencing the public.

We cannot afford to wait and see if analogous harms arise from digital healthcare platforms. It is a sorry state of affairs when a few big companies effectively control information dissemination in the rich world. Control of healthcare delivery would be worse. ■

Hal Hodson is a technology writer based in London. He broke the story of concerns over DeepMind's NHS deal

as irrelevant to that athlete. Personalised coaching is as hot a topic as personalised medicine.

But a real difference could be made where EPO use is increasing fastest. Its relatively cheap price has led to a big rise in use at the non-elite level, in club athletes who know they will never be drug tested. Knowledge of the real risk of blood clotting from EPO use and its small, or non-existent, benefits may deter these occasional users. Let's hope so. ■

Chris Cooper heads sports and exercise science at the University of Essex, UK. His books include *Run, Swim, Throw, Cheat* (OUP), about doping science

INSIGHT North Korea

STR/AFP/GETTY IMAGES

Kim Jong-un: mission accomplished

Can we stop the North Korean nuclear threat?

Debora MacKenzie

THIS week, North Korea gave what it described as a Fourth of July "gift" to the US: the test of an intercontinental ballistic missile (ICBM) it claimed could "strike the US mainland… with large heavy nuclear warheads".

Such a missile, notes Joe Cirincione of nuclear think tank the Ploughshares Fund, could hit Alaska, and based on North Korea's rate of progress, he fears it will be able to strike Los Angeles, New York or Washington DC in a few years.

But hit them with what? North Korea has nuclear weapons, but no one knows if it can make a nuclear device small enough to fly on a missile, as it claims.

The country says this week's launch successfully tested part of that capability, however. ICBMs leave the atmosphere before returning, so their payloads must be protected from the heat of re-entry. North Korea said its test missile carried a carbon heat shield, keeping the nose cool enough that on-board electronics meant to detonate a nuclear device still worked.

Russia and China responded to the launch by calling for talks aimed at preventing further nuclear development in exchange for halting US and South Korean military exercises that threaten Kim Jong-un's regime. Other allies also back talks, says Cirincione. Without them, he fears escalation into catastrophic war.

So it is worrying that the US and South Korea responded to the test with a drill of their own missiles that "showcased precision targeting of the enemy's leadership", according to a South Korean statement.

ICBMs are a game-changer because they extend North Korea's reach, turning it into a global threat. An ICBM must be able to travel 5500 kilometres or more. Anchorage, Alaska, is 5500 km from North Korea; Washington DC is over 10,000 km.

"ICBMs are a game-changer because they extend North Korea's reach, turning it into a global threat"

North Korea's rocket flew near vertical so it would descend close enough for mission control to track the missile's radio signals. That meant it came down only 970 km away from its launch site. Both South Korea and the US initially downplayed the test as "a land-based, intermediate-range ballistic missile".

But David Wright of the Union of Concerned Scientists in Washington DC says that its 37-minute flight time means a more horizontal trajectory would have carried it 6700 km – well into ICBM range. The US later admitted the missile was indeed an ICBM.

So all the evidence suggests Kim Jong-un is drawing ever closer to achieving his nuclear dreams. What can be done to stop him?

"There are three options," says Cirincione. "Negotiate a freeze with North Korea; take military action to destroy test sites; increase sanctions and pressure. Trump has refused the first. The second is possible but carries a high risk of catastrophic war. The third is ineffective but most likely."

But that third option means an uneasy short-term future, leaving the door open for the nuclear threat to grow. "The best we can hope for now is to sustainably deter, contain, constrain and reform the regime over the long term," says Adam Mount of the Center for American Progress in Washington DC.

And worse scenarios are not impossible. Amid sanctions, military posturing and "blustery tweets", Cirincione fears, "North Korea or the US could push too far, provoking a military response that could quickly escalate out of control." ■

The trap that glows

BENEATH this starry sky is a spectacular work of nature with a sinister twist.

The glittery rock is an abandoned termite mound taken over by firefly larvae. They dig tiny U-shaped burrows in the mound's surface, from where they glow bright green at night using bioluminescent chemicals in their heads. By wiggling this light around, the larvae lure flying prey such as butterflies, winged termites and ants to their deaths. In the foreground, a curious anteater sniffs around for prey of its own.

The image, shot in the Emas National Park in Brazil, earned Brazilian nature photographer Marcio Cabral a prize in the annual BigPicture Natural World Photography Competition. Cabral's photo can be viewed alongside 47 other prizewinning images at the California Academy of Sciences in San Francisco from 28 July. A selection of these shots is also online at biographic.com.

The sight of entire fields of glowing termite mounds has astonished witnesses. One likened the scene to "miniature cities or countless illuminated Christmas trees".

This firefly's species name, *Pyrearinus termitilluminans*, means "green fire that illuminates the termite nest". Adult females lay eggs at the base of an abandoned mound, and the hatched larvae climb up to burrow into it. Eventually, the larvae seal the burrows to pupate, finally emerging as adults. Andy Coghlan

Photographer
Marcio Cabral
fotoexplorer.com

Holy moley!

Astronomers taking a first peek at our galaxy's black heart might be in for a big surprise, says **Stuart Clark**

FASCINATING, bamboozling, vaguely terrifying: black holes are the love-to-hate monsters of the universe. These insatiable cosmic cannibals are concrete predictions of Einstein's general theory of relativity, the best theory of gravity we have. Even so, theorists long debated whether they could exist – until astronomers saw the first signs of them. Now we see black hole paw prints all over: in huge stars collapsing in on themselves, in distant collisions of massive objects that set the universe quivering, and in the dark hearts of galaxies including our own.

This year, we should have the clincher: the first direct image of the supermassive black hole at the Milky Way's centre. But as we gear up for that shadowy mugshot, some physicists are entertaining a maverick thought: what if it isn't there?

The new word is that our obsession with black holes might have blinded us to the existence of something even stranger – a basic phenomenon of particle physics whose significance we have failed to grasp. After all, there's good reason to want whatever is at our galaxy's heart not to be a black hole. For a start, black holes make a nonsense of quantum mechanics, the best theory of everything-besides-gravity that we have.

It is a speculative idea as yet, to be sure, but there are sound reasons to contemplate it. "We scientists tend to be completely arrogant about what we think we know," says theorist Luciano Rezzolla of the Frankfurt Institute for Advanced Studies in Germany. "I don't want to find myself in 10 years' time saying I was just another arrogant, overconfident scientist."

For all their complications, the basic notion of a black hole is remarkably simple. In general relativity, the magisterial theory Einstein introduced in 1915, massive objects bend space and time around them, creating the force we call gravity. An object with sufficiently large mass, densely enough packed, bends space and time so much and creates a gravitational field so strong that nothing, not even light, can escape once it crosses the "event horizon". The black hole is a celestial lobster pot, with the difference that it never gets emptied and just keeps on accumulating lobsters, no trace of which is ever seen again.

> "There's still a prize for anyone who can say what a black hole is"

The fact is, no one knows how black holes work on the inside. Relativity suggests that anything that falls in will be crushed by the black hole's gravity into a "singularity" of zero volume and infinite density, but the prize is still out there for anyone who can say what that truly means. Meanwhile, theorists' most refined calculations show that black holes must either destroy information – a complete no-no in quantum theory – or surround themselves in a seething mass of energy called a firewall, which breaks a tenet of general relativity. Black holes represent the point where the very large, the domain of general relativity, meets the very small, the domain of quantum theory – and the results are not pretty.

Such problems were already becoming apparent in the 1960s, but that didn't stop astronomers imagining ways for nature to produce black holes. When a massive star's fuel was spent, for example, it might collapse under its own gravity into a stellar-mass black hole. Such an object would by its nature be pitch black and impossible to distinguish from a pitch-black cosmos, but could make its presence known in other ways. Sure enough, in 1964, a huge outpouring of X-rays was discovered in the constellation Cygnus. Labelled Cyg X-1, it looked exactly like models of the radiation emitted by superheated gas plunging down towards a black hole. By the 1970s, astronomers felt confident enough to proclaim that Cyg X-1 was almost certainly a stellar-mass black hole eating matter in its surroundings.

That wasn't the half of it. In the early universe, when giant nebulae were collapsing to form galaxies, the gas at their centres would eventually become dense enough to form monstrous "supermassive" black holes, each weighing as much as millions or even billions of suns. The invisible object at the centre of the Milky Way, known as Sagittarius A* or Sgr A*, is thought to be one. It was identified in the 1970s as a particularly strong source of radio signals. Subsequent studies, particularly of the way its gravity pulls nearby stars around, ›

NATALIE NICKLIN

THE RIGHT KIND OF BOSON

Boson stars (see main story) depend on there being bosons to make them. In 1955, US physicist John Wheeler wondered whether stars might be made out of photons of light, rather than matter. He called these objects gravitational electromagnetic entities, or geons. But it soon turned out that geons made of "spin-one" bosons such as photons would be unstable and evaporate away.

In the 1960s, theorist David Kaup of the University of Maryland showed that spin-zero bosons could form stable stars. At the time, though, no spin-zero bosons existed. That changed on 4 July 2012, with the discovery of the Higgs boson. To those who had never lost faith in boson stars, it came as a huge fillip. "We knew that there is at least one such boson in nature, so it was a motivation to go further in that direction," says Frédéric Vincent of the Paris Observatory in France.

There is still a big hurdle to clear. The way bosons all clump together means that the smaller their mass, the bigger the star that they form. Very massive stars mean very light particles. The Higgs, at 125 gigaelectronvolts, or about 250,000 times the mass of the electron, was simply too heavy.

A possible alternative is an axion. This hypothetical particle has been proposed since the 1970s and is a candidate for dark matter, the mysterious glue that astronomers believe holds galaxies together. That idea, in turn, opens up the possibility that boson stars might account for at least some of the dark matter.

Although searches for axions have yet to bear fruit, the discovery of a boson star could help things along: by telling us the axion's likely mass, it could tell us where to focus in experiments to make the particles on Earth.

have convinced us that it is indeed a black hole with four million times the sun's mass.

Further convincing, but still circumstantial, evidence for black holes came last year with the announcement of the first detection of gravitational waves. These ripples in space-time emanate from very massive objects that are accelerating – two bodies spiralling inwards to smash into each other, for example. The signal observed by the LIGO collaboration in September 2015 was exactly that predicted for the collision and merger of two stellar-mass black holes. LIGO has since seen two more signals, each compatible with the mergers of stellar-mass black holes.

Case closed? Not so fast, says Rezzolla. "Although the presence of a binary black hole system is an obvious and simple explanation, it's not the only explanation," he says. In particular, the signals might not come from black holes, but from an entirely different theoretical invention: boson stars.

Let's back up a bit. The fundamental particles that make up most matter – you, me, those supposed black holes – all belong to a class known as fermions. Their signature characteristic is that they obey the Pauli exclusion principle, which says that particles cannot occupy the same quantum energy state as one another. The Pauli principle explains the appearance of the material world: it determines how electrons arrange themselves in different energy states around an atomic nucleus, and thus the properties of the various chemical elements.

> "Boson stars would hang there like doughnut-shaped cosmic couch potatoes"

Bosons are a different kettle of fish. The Higgs boson, discovered to great fanfare in 2012, is perhaps the most notorious example. It provides matter particles with their mass; other bosons carry the forces that allow matter particles to interact. Bosons aren't exotic. In fact, we see them all the time, quite literally: photons of light are bosons.

The thing about bosons is that they can cram together with virtually no limits. Rather than forming some kind of uncontrollable subatomic mosh pit, they become what is in effect a collective particle, a state of matter known as a Bose-Einstein condensate.

We know how to make Bose-Einstein condensates in the lab. We also now know that, given the right bosons, there's nothing to stop

NASA/JPL-CALTECH/ESA/CXC/STSCI

Radio telescopes such as ALMA in Chile (below) will team up to picture the bright X-ray source at the Milky Way's heart (right)

them forming something on a bigger scale – perhaps much bigger. Some physicists even think they can form stars, although not as we know them. "When we say star, we are basically just saying a collection of stuff that holds together," says theorist Steve Liebling of Long Island University in New York.

When normal matter forms a star, gravitational pressure heats it so it ignites into nuclear fusion, pouring out light. In contrast, boson stars would just hang there like cosmic couch potatoes. Doughnut-shaped couch potatoes: simulations suggest that if boson stars rotate as conventional stars do, centrifugal forces would give the bosonic matter that form.

These celestial doughnuts would be transparent. Emitting no light of their own, they would be invisible, and the primary thing that would give them away would be their intense gravity. Sound familiar? "Boson stars could mimic black holes," says Liebling. "And it is possible that we are getting tricked."

The idea of boson stars isn't new, but astrophysicists pooh-poohed it because no one could think what sort of boson might be used to make one – the particles such as photons that transmit the fundamental forces don't cut the mustard. Then came the discovery of the Higgs boson. It revived interest in novel bosons – not least because they could be a boon for particle physics,

too (see "The right sort of boson", left). That in turn has spurred physicists to ask how we might seek evidence of boson stars.

LIGO is one obvious way, although the current detector can't tell whether gravitational waves come from two black holes merging, or from two boson stars. The place to look for the difference is not in the pre-merger phase, the inward spiralling that gives out the waves observed so far. Rather, it is in the aftermath, when the two objects have coalesced and are still quivering from the shock, like a rung bell. "As with bells, each object will have its own frequency and tone," says Rezzolla. "Black holes of a given mass will have their own tone, boson stars will have another." Unfortunately LIGO is not yet able to hear this "ringdown" signal with sufficient precision, and upgrades that will let it do so are probably at least five years away.

The Event Horizon Telescope – an international project to look directly into the maw of a black hole – might deliver clarity sooner. Radio telescopes across the globe have been wired up with the aim not just of detecting emissions from Sgr A* as superheated gas spirals across its event horizon, but of mapping them out. Do that with enough precision, and the shape of the black hole itself should show up as... well, a black hole in the middle of the image.

This is a tall order, the equivalent of sitting in London and taking a picture of a mustard seed in New York. For that reason, Heino Falcke of Radboud University in Nijmegen, the Netherlands, who is one of the driving forces of the Event Horizon Telescope, cautions against overexcitement – although he is enthusiastic about the data gathered so far. "It's not going to be a beautiful sharp image. It's likely to be an ugly peanut," he says.

Or perhaps an ugly doughnut. Opinions differ as to whether it will be easy to distinguish between images of a black hole and a boson star. Calculations by Frédéric Vincent of the Paris Observatory in France suggest that the gravity of a compact boson star will bend light around itself, creating an empty region that could be mistaken for the shadow of a black hole event horizon. "A boson star is really different to a black hole and yet still it produces features that look like a black hole," he says.

Rezzolla thinks this analysis is overly pessimistic. Like a black hole, a boson star will be sucking in matter from its surroundings, but the boson star's transparency means this matter will be visible at its centre. It is also likely to heat up and start emitting light or some other form of electromagnetic radiation. "This light might remove the presence of a shadow all together," says Rezzolla.

Vincent agrees that the behaviour of matter inside a boson star is an area that needs investigation. "It's a programme of research that I am trying to develop. We are developing the codes to do this from scratch," he says.

Falcke is not expecting any surprises when the first image from the Event Horizon Telescope finally comes together. "I am afraid it is nothing other than a boring black hole," he says. That choice of words indicates just how deep-seated the belief in black holes now is. Even those working on boson stars admit they are a long shot. "I am open to arguments but still they are pretty exotic," says Liebling.

Then again, the reward for killing off black holes is potentially immense. Embodying the conflict between general relativity and quantum theory as they do, they are a massive roadblock to progress on an overarching theory of nature. Put like that, it seems this is a puzzle where keeping our options open would be wise. "It is best to stay open minded," says Rezzolla. "Then let the experience tell you what you really have there." ■

ESO/B. TAFRESHI (TWANIGHT.ORG)

Stuart Clark is a consultant for *New Scientist* and the author of *The Unknown Universe* (Head of Zeus)

It's a no-brainer

Some of the simplest life forms are able to learn. How do they do it, wonders Erica Tennenhouse

SNAILS, jellyfish and starfish have taught us that you don't need a brain to learn. These seemingly simple creatures are capable learners, despite being completely brainless. Perhaps this is no great surprise. After all, it's not as if they lack nerve cells. Strictly speaking, it's neurons that enable learning – theirs are simply spread out, rather than being packed into centralised bundles.

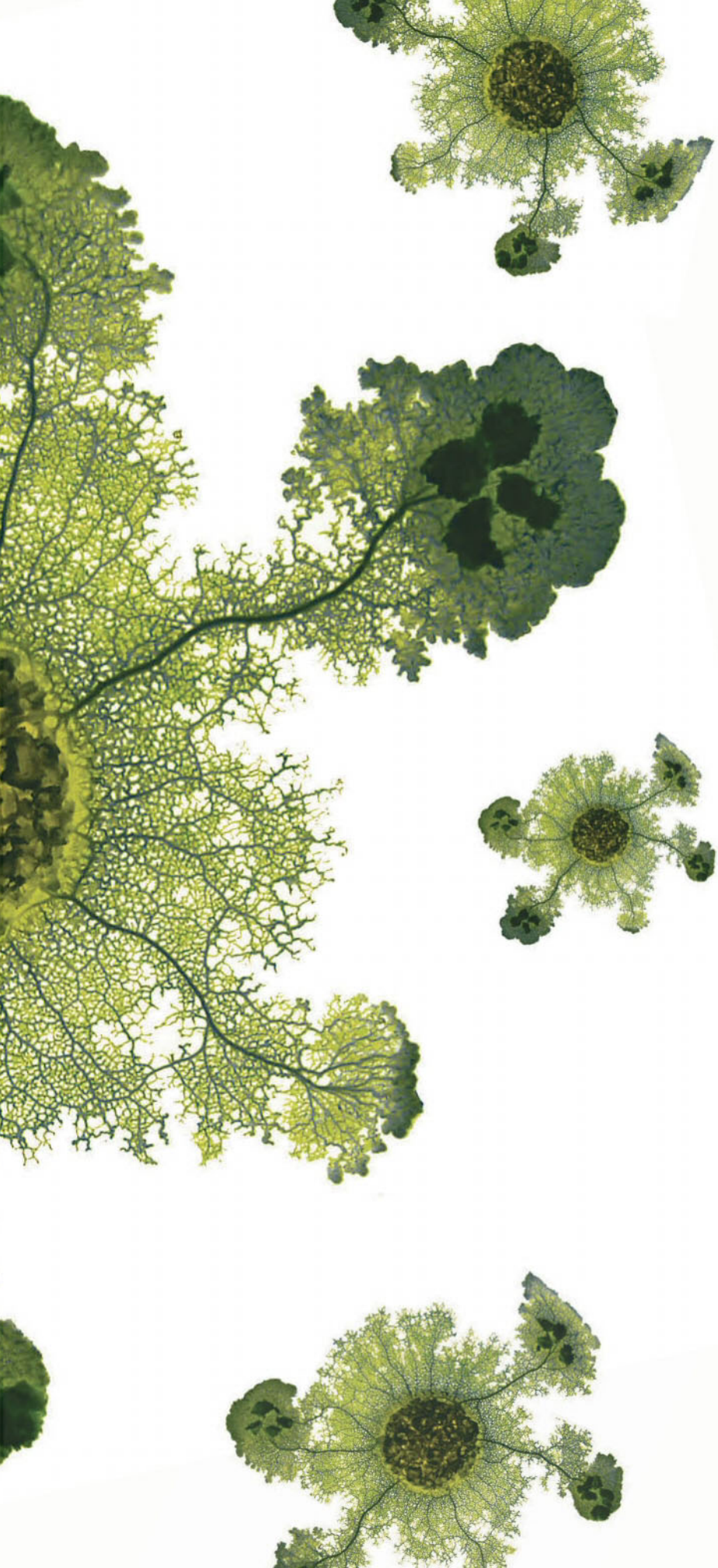
But what if you take away the neurons?

Most life forms on Earth lack neurons, and yet they frequently manage to behave in complex ways. Previously, we have chalked this up to innate responses refined over generations, but it is beginning to look as if some of these humble non-neural organisms can actually learn. While that's left some scientists scratching their heads, others are busy investigating how this ability could offer new approaches to fighting diseases and designing intelligent machines.

Take a slime mould. It certainly doesn't look smart. This unusual creature, which is not a plant, animal or fungus, often resembles a glob of lemon curd that has fallen on the floor. Really, this manifestation is just one stage in the slime mould's life, formed when many single cells, each with their own distinct DNA, mingle and fuse. The resulting yellow blob can grow to a few square metres, and is just one enormous cell containing thousands of nuclei.

In nature, a slime mould relies on chemical receptors on its surface to sense substances in its path as it creeps along the forest floor. If it gets a whiff of something attractive, like food, it will rapidly pulsate, pushing itself closer to the source. Toxins elicit the opposite response, causing the slime mould to slow down its rhythmic throbbing and retract from potential harm.

They may be sluggish, with maximum speeds of around 4 centimetres an hour, but the fact that slime moulds are mobile has



DR AUDREY DUSSUTOUR

allowed researchers to get creative with their experiments. Last year, Audrey Dussutour grew some in giant Petri dishes in her lab at the University of Toulouse, France. Then she prepared a feast of blended oats and placed it strategically out of reach, save for a bridge that the slime moulds could crawl across. Their path was clear. That is, until Dussutour polluted the bridge with bitter compounds such as caffeine. Although the concentration was not high enough to harm the slime moulds, it was sufficient to stop them in their tracks for several hours. Eventually though,

> "Slime moulds aren't just capable of learning, they can teach each other too"

the lure of a meal induced them to push past.

As time went by, the slime moulds began to cross the bridge more quickly. After a few days, the caffeine was no longer a deterrent: the slime moulds had learned to ignore it. "Learned" is the key word here. More specifically, they had habituated – a simple form of learning where the response to an irrelevant cue weakens over time. "I was surprised because they don't have neurons and everybody was saying that ability relies on a neural system," says Dussutour.

If neurons weren't enabling the slime moulds to learn, what was? Dussutour admits she doesn't know. But one idea she hopes to test is that their experience modified their genes. In a cell's nucleus are swarms of molecules that can stick to DNA and switch genes on or off. They don't rewrite the genetic code, but they do temporarily alter how it's read. This process – known as epigenetic regulation – satisfies one of the most basic requirements for memory and learning, according to neuroscientist David Glanzman at the University of California, Los Angeles. "All you need is to have some information in the cell changed." His research suggests this might be how slime moulds learn.

Neuroscience tells us that the memories created when an animal learns something get stored in the synapses between neighbouring neurons. So when Glanzman took sea slugs and broke apart the synapses that had formed during training, he was not surprised to find that the memories vanished. ›

However, when he gave the neurons involved a jolt of electricity, the synapses regrew and the memories returned. Glanzman believes that remnants of the memories had been stored in the neurons' DNA, in the form of epigenetic changes. There is no reason why similar changes couldn't occur in other cell types, he says. "You don't really need a nervous system to learn."

And with slime moulds, it's not only about learning. Dussutour has discovered that they can teach too. In a second experiment, she allowed slime moulds habituated to salt to fuse with others that had never encountered the deterrent. These hybrids scurried across a salt-laced bridge without hesitation. After three hours, she tore the companions apart and the once-naive slime mould continued to ignore the salt when crossing the bridge, as though the habituated mould had somehow transferred its learning.

"One might speculate that what is getting exchanged during the fusion is epigenetic information," says Glanzman. Eva Jablonka, an epigeneticist at the University of Tel Aviv, can see how a single cell such as a slime mould could learn through such modifications to its DNA. But a brainless multicellular organism is another matter. "It's not just that there are more cells, but they also have to behave in a coordinated manner," she says. "When you don't have a nervous system that can integrate and coordinate, how is that happening?"

JEFF ROTMAN/GETTY

That makes the research coming out of Monica Gagliano's lab at the University of Western Australia tough to explain.

A few years back, Gagliano's team repeatedly dropped potted mimosa plants 15 centimetres to a soft landing pad on the floor. When mimosa plants are disturbed, they curl up their leaves as though hiding in fear. But after surviving about five drops unscathed, they stopped withdrawing their leaves. They had learned that they could safely ignore the fall. Even after being left undisturbed for a month, a reprise of the dropping experiment failed to elicit the slightest response. They had remembered their lesson.

Encouraged by the plants' ability to habituate, Gagliano wanted to see if they could do more. Could they learn to associate a reward with a neutral cue, as Pavlov's dogs had learned to link food with the sound of a bell?

A plant will naturally grow towards light. So to train her pea plant seedlings, Gagliano put them in the dark and then shone a light (the reward) towards them from one direction and blew a fan from the opposite direction. She also switched it up for some seedlings by blasting the light and the air from the same side. Once their training was done, she removed the light and hit all the plants with a fan. Those that were accustomed to light and wind originating from the same side grew towards the fan, while those that had experienced the light and wind from different directions grew away from it. The plants seemed to be seeking their reward. They had learned to associate wind with light.

Other scientists have greeted the tantalising results with a healthy dose of scepticism. A leading critic is plant physiologist Lincoln Taiz, now retired from the University of California Santa Cruz. He thinks Gagliano's initial evidence for habituation was tenuous and she should have shored it up before building on it. He also points out that in associative learning experiments with

Big brains optional: sea slugs (above) and box jellyfish can do clever things with few neurons

Who needs brains?

Organisms with tiny brains, or no brain at all, are capable of amazing feats

SLIME MOULD: 0 NEURONS
When their food is scattered in a pattern matching the layout of the cities around Tokyo, slime moulds spread themselves into a network that closely resembles Japan's highly efficient rail system.

PEA PLANT: 0 NEURONS
When allowed to grow their roots into either a pot with a steady food supply or one with a boom-or-bust supply, pea plants prefer the former if food is plentiful, but gamble on the latter if they are starved, accepting the higher risk for a higher potential reward.

BOX JELLYFISH: ~13,000 NEURONS
Box jellyfish use four of their 24 eyes to peer up through the water's surface at tree canopies, which they use to help them navigate mangrove swamps.

FRESHWATER SNAIL: ~20,000 NEURONS
Using a circuit of just two neurons freshwater snails decide whether or not to eat. The controller neuron signals the presence of food, and the motivator neuron lets the brain know whether the snail is hungry.

FRUIT FLY: ~250,000 NEURONS
Fruit flies take longer to distinguish between very similar concentrations of odours than very different ones, suggesting that they deliberate rather than acting on impulse.

BUMBLEBEE: ~1,000,000 NEURONS
Bumblebees can learn to pull a string to get a sugary treat by observing another bee performing the task. They can also be trained to move a tiny ball to a target.

THE POWER OF ASSOCIATION

Pavlov's dogs learned to associate the sound of a bell with the imminent arrival of food. It's a simple form of learning, but it could lie behind seemingly complex animal behaviours.

Take chimps with a knack for cracking nuts with stone tools. This precision behaviour is considered one of the most sophisticated observed in wild animals, but it might be learned as a sequence of small associative steps in a process called backward chaining. First the chimp might steal a shelled nut from its mother, so it learns to associate nuts with a tasty reward. Then, when it strikes a nutshell with a stone, that act becomes associated with the reward. Handling stones then becomes rewarding, and so on until the chimp is a proficient tool user. Establishing the sequence requires very little in the way of reasoning, but once the chaining is complete it adds up to an advanced skill.

This idea could have far-reaching implications for simple organisms. Even some plants seem capable of learning through association (see main story). So, in principle, they are equipped to acquire more complex behaviours via backward chaining. And all without even a single neuron.

animals you would expect around 90 per cent of subjects to respond, whereas just over 60 per cent of the pea plants did. However, the brunt of Taiz's argument is rooted in language. According to neurobiology, "both learning and memory are mental processes carried out by the mind, which is centred in the brain," he says. "By this definition, plants are incapable of learning and memory."

Not everyone subscribes to such a strict definition. For his part, Glanzman is open to the idea of plants learning by association, but wonders about the mechanism. He notes that

> "Plants can learn to associate a reward with a cue, like Pavlov's dogs"

animals link events together using molecules found in nerve cells called NMDA receptors, which help strengthen connections between neurons that are repeatedly stimulated at the same time. A similar "associative molecule" would need to be operating in plants, he says.

Gagliano is equally mystified. "There must be some system that allows this memory to be recorded and literally etched into the organism, and those triggers then get recalled and those are memories," she says.

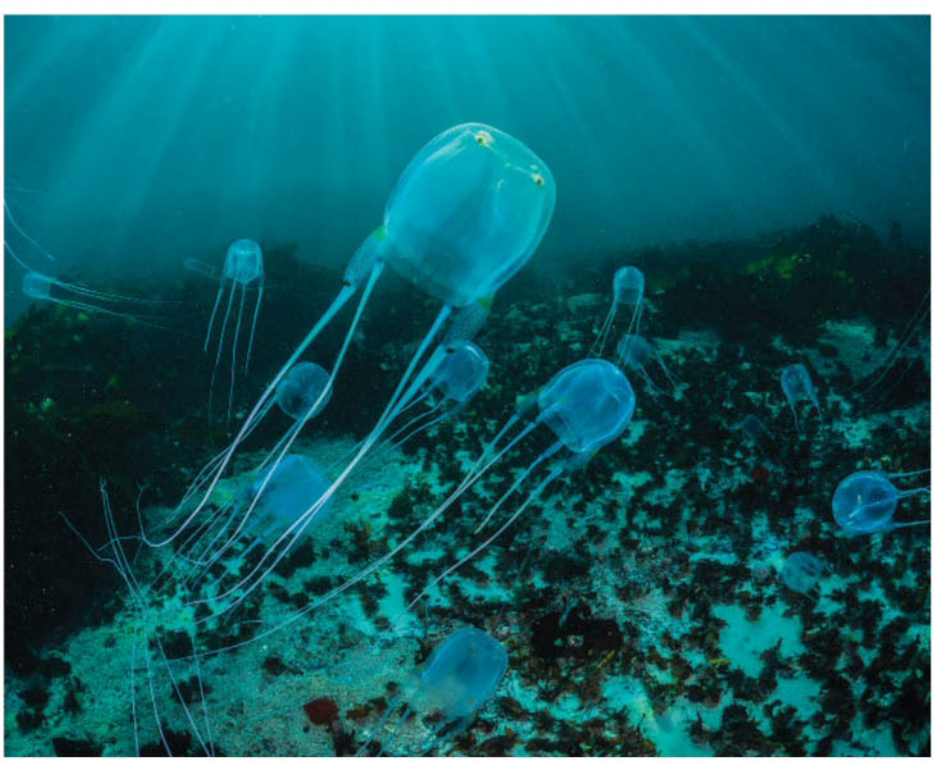
The mechanism may be elusive, but simply realising that brainless organisms are capable of learning could have some practical payoffs. "There are lots of unicellular organisms that are very harmful for humans, like those that cause malaria," says Dussutour. "They belong to the same group as slime moulds, and we never thought about these organisms as being able to learn." She suggests that knowing whether and how pathogens learn could help guide new strategies for combating them.

Considering epigenetic learning could also help computer scientists improve artificial neural networks, which model biological learning. Current neural network models are based on the Hebbian theory of learning – the idea that a synapse becomes stronger when the neurons on either side fire in synchrony. In other words, neurons that fire together wire together. Jablonka believes that incorporating epigenetic memory into those models would enrich them.

There's also the provocative idea of memory transfer. If one slime mould can teach another by fusing with it, might something similar take place in animals? Experiments done by James McConnell at the University of Michigan over half a century ago suggest it might. He trained freshwater flatworms to fear light by repeatedly pairing it with electric shocks. Then he ground them up and fed them to untrained flatworms, which proceeded to twitch whenever a light flashed.

McConnell believed that the memories of the trained flatworms were encoded in small molecules that the naive flatworms then ingested. Unfortunately, his findings proved impossible to replicate. But the idea that small strands of RNA – one type of epigenetic molecule – could mobilise memories resonates with many scientists today, including Glanzman. "In principle, there should be no reason why you couldn't transfer some aspects of memory by transferring RNA from the brain of one animal to another," he says. The implications are mind-boggling.

Jablonka stops short of suggesting that memories could ever be transplanted, but she can imagine that it might be possible to transmit something like an increased sensitivity to a stimulus. "Once upon a time I would have told you I don't agree with this kind of thing at all… but I think the more we're learning, the more flexible we should be in our thinking," she says. "There are very curious things in this world." ■



THOMAS P. PESCHAK/NATIONAL GEOGRAPHIC CREATIVE

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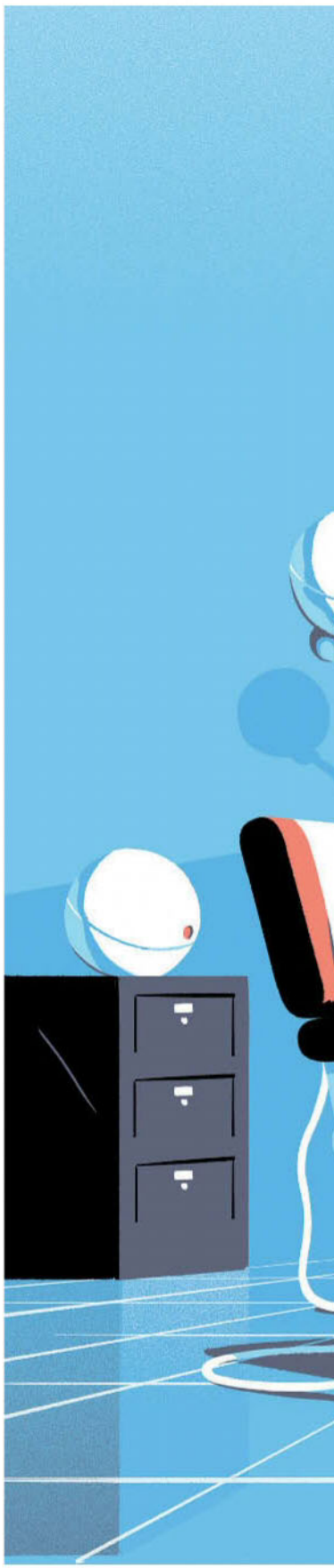
With a little help from AI friends

Artificial intelligence will soon be a standard part of your medical care – if it isn't already. Can you trust it, asks Kayt Sukel



THE doctor's eyes flit from your face to her notes. "How long would you say that's been going on?" You think back: a few weeks, maybe longer? She marks it down. "Is it worse at certain times of day?" Tough to say – it comes and goes. She asks more questions before prodding you, listening to your heart, shining a light in your eyes. Minutes later, you have a diagnosis and a prescription. Only later do you remember that fall you had last month – should you have mentioned it? Oops.

One in 10 medical diagnoses is wrong, according to the US Institute of Medicine. In primary care, one in 20 patients will get a wrong diagnosis. Such errors contribute to as many as 80,000 unnecessary deaths each year in the US alone.

These are worrying figures, driven by the complex nature of diagnosis, which can encompass incomplete information from patients, missed hand-offs between care providers, biases that cloud doctors' judgement, overworked staff, overbooked systems, and more. The process is riddled with opportunities for human error. This is why many want to use the constant and unflappable power of artificial intelligence to achieve more accurate diagnosis, prompt care and greater efficiency.

AI-driven diagnostic apps are already available. And it's not just Silicon Valley types swapping clinic visits for diagnosis via smartphone. The UK National Health Service (NHS) is trialling an AI-assisted app to see if it performs better than the existing telephone triage line. In the US and mainland Europe, health insurers and national healthcare providers are hopeful AI-based medical apps will improve care. But is the hype around medical AI all it's cracked up to be? Would you trust your care to a robot?

For decades, researchers have been honing artificial intelligence, including deep-learning algorithms, which are designed to learn without being fed rules or constraints (see "A glossary of AI speak", page 38). "These would take in hundreds or even thousands of symptoms and then would learn to diagnose various diseases," says Pedro Domingos, a computer scientist at the University of Washington and author of *The Master Algorithm: How the quest for the ultimate learning machine will remake our world*. "By training these systems with the data from a medical database of patient records for, say, diabetes or lung cancer, or any other condition, you can push a button and literally get something that will diagnose things more accurately than human doctors can."

Outperforming doctors

That's not just hype. When Sebastian Thrun and his team at Stanford University in California trained a deep-learning neural network using more than 100,000 images of skin problems, ranging from cancer to insect bites, then tested it on 14,000 new images, the system correctly diagnosed melanomas more often than seasoned dermatologists. Deep-learning networks have also outperformed doctors at diagnosing diabetic retinopathy, a complication of diabetes that damages ›

BRUNO MANGYOKU

blood vessels in the eye. Other AI tools can identify cancers from CAT scans or MRIs, or even predict from data about general health which people may have a heart attack.

But should we trust their successes? What are these systems seeing that highly trained doctors aren't? It's not a question that can always be answered. While some deep-learning tools are designed to spit out the rules they come up with, Thrun's, for instance, was a "black box": it's unknown what features it homed in on.

That makes some nervous, with reason. Consider the experience of Joshua Denny, a medical informatics specialist at Vanderbilt University in Tennessee. He recently developed a machine-learning tool to identify cases of colon cancer from patients' electronic health records, but soon learned that it was latching on to the wrong information. "It was performing excellently," he says. Unfortunately, it was picking up on the fact that all of the patients with confirmed cases had been sent to a particular clinic, not clues from their actual medical data. "There's always the risk that a black box model can learn features that you won't expect – and won't be stable over time," he says.

While acknowledging potential pitfalls, Thrun is circumspect about the nature of the black box approach. "If your doctor looks at your skin and says, 'I think this is a melanoma,' you aren't going to stop him and say, 'What are the rules you are using to determine this?'" he says. "No, you are going to have a biopsy and then, most likely, get treatment. We shouldn't distrust these rules just because we can't say exactly what they are."

Garbage in, garbage out

Still, Thrun concedes that deep-learning tools are only as good as the data they are trained on. Thanks to the rise of electronic medical records, we finally have big enough data sets to do this training, but there are major logistical hurdles to overcome. The wide range of healthcare IT systems can mean that their records vary just enough to skew any algorithm trying to process them. That means up to 90 per cent of the effort in designing these AI tools is spent simply cleaning up the data, Thrun says. Kyung Sung, a radiologist at the University of California, Los Angeles, agrees. It took his team more than five years to clean up a set of prostate cancer images for his AI, which aims to better identify aggressive tumours. "Unfortunately, the fact that we now have all these images available doesn't always mean that they will be useful," Sung says.

It's even possible that an emerging or evolving disease might skew the results, which is something developers have to look out for. For example, the creators of diagnostic app Ada trained it on vast troves of medical files, and it now refines its results with data from users. To avoid the AI picking up on the wrong things and warping the outcomes, human-supervised and unsupervised learning are both used to fine-tune the algorithms, says Claire Novorol, the company's chief medical officer. "We use multiple experienced doctors as well as other technical feedback loops," she says.

Humans keep the AI in check, but there will be times when they shouldn't. "If there are presentations not currently known by experts or in the literature, humans may not be the best ones to catch that," says Novorol. "Those trends will be patterned in the data and, ultimately, patient outcomes – and the algorithms can help us identify those patterns and use them in a predictive way."

Today, deep-learning diagnostic tools are not used in hospitals except in research studies, but many think they will be within five years. By then, they will be able to do far more than diagnosis, says Eric Horvitz, a medical AI researcher at Microsoft. "The hard part is managing diseases, figuring out

therapies over time and tracking progress," Horvitz says. New, more detailed algorithms should help doctors better understand how conditions progress. "Diabetes, arthritis, hypertension, asthma and other chronic diseases – these are the expensive, challenging cases. These are where most of the healthcare costs come in. Machine learning may offer us new opportunities to better manage them."

Horvitz is not alone in his optimism. Valentin Tablan, principal scientist at Ieso Digital Health, sees potential for AI to revolutionise mental healthcare. Ieso provides cognitive behavioural therapy online for NHS patients and has treated more than 10,000 people to date, keeping digital records of every exchange. The company wants to mine that immense data set to help understand what really works. "Machines are very good at helping find the elements that are very important and can really help patients get better," Tablan says.

> "We can create a tool for human therapists that makes them superhuman"

A GLOSSARY OF AI SPEAK

Artificial intelligence Applying computers to tasks that normally require human-level intelligence, like reasoning, decision-making, problem-solving and learning

Big data The huge data sets that can be analysed by computers and algorithms to reveal patterns, trends and associations

Machine learning The capacity of an algorithm to learn from new information and modify its processing as a result, without being explicitly programmed to do so

Neural network An algorithm used in deep learning that imitates the activity of layers of neurons in the brain, filtering data through tiers of virtual brain cells

Deep learning The "black box" of AI. Unsupervised neural networks that create their own processing constraints as they learn from vast troves of training data

COLIN CUTHBERT/GETTY

An AI could spot the significant picture much faster than a doctor

With some studies suggesting that patients may be more open with therapists when talking to them via a computer screen, is it time to consider removing the human altogether? Tablan scoffs at the idea. "AI doesn't have the capabilities to work at that kind of level yet. But by building models based on these data sets, we can create a tool for human therapists to use that makes them superhuman therapists."

That's a recurring theme: the rise of the superhuman doctor. By equipping medical professionals with enhanced abilities, AI is poised to change the very delivery of healthcare, says Isaac Kohane, head of biomedical informatics at Harvard Medical School. At present, doctors have to manage mounds of paperwork and digital form-filling while trying to stay on top of the emerging research to keep their knowledge current. If AI could ease some of this burden, that would free them to focus more time on patients, to take detailed histories, to listen.

Ultimately, it may even reshape what it means to train as a doctor. Denny says medical education will need to include data science and may shift away from rote learning to focus on problem-solving, critical thinking and how to best deal with the probabilistic outcomes that so many AI systems produce.

As medical AI matures, Thrun believes it will replace many roles in dermatology, radiology and pathology – those that mainly involve repetitively reviewing images. At the same time, there will be growth in other areas, such as specialised surgery.

It could also change what it means to be a family doctor, says Kohane. "They will be able to offer their patients specialty care, like imaging and dermatology procedures right in their office, with expert-level performance – and then refer the patient to a specialist if and only if a truly actionable finding comes up." That could mean a more holistic approach, and not having to split care between half a dozen doctors. "That would be a great thing both for the doctor and the patient."

There are a few significant obstacles to jump first. To start: how to provide the massive data sets that AI systems need, while protecting patient privacy. The advent of electronic medical records has also ushered in stringent regulations, such as the HITECH Act in the US and the Data Protection Act in the UK. Last year, *New Scientist* discovered that the NHS had shared patient data with Google DeepMind, a deal the UK Information Commissioner's Office just found "failed to comply with data protection law". The irony is, for medical AI to truly take off, even more rapid and wider sharing of data may be necessary. That might require new legislation. "Current laws don't really cover the kind of sharing scenarios we need to make these systems work," Denny says.

Who is in charge?

Domingos agrees that the legal framework will need to change, and stresses that any policies must require informed consent. But he also argues that sharing your health data should be seen as a civic duty, and that only those who opt in should reap any benefits. "If someone won't allow their data to be used, then they shouldn't have access to the better treatments that result," he says.

Even as the debate over privacy flares up, there's still the matter of liability. Malpractice laws are complex and vary from place to place, so it's unclear how they might need to change to accommodate AI. Kohane isn't worried, though. He points out that doctors already use machines to make a diagnosis – software that helps them identify tumours in MRI scans or abnormalities in echocardiograms, for example. "If a doctor is in the loop, the legal and ethical stuff is not going to be that challenging," he says; ultimately, it's the doctor's responsibility. If AI and doctor disagree, a supervising physician or committee could break the tie.

Standalone AI systems would require further consideration, however. "That is indeed terra incognita and something we'll have to figure out as we go along," Kohane says. Liability may ultimately switch from the physician to the manufacturer, as with self-driving cars. "Volvo has said they will assume liability for their self-driving cars. For the kind of AI machines you might find in your corner pharmacy, the company that made that machine is going to have to assume liability for its range of parameters," says Denny. As for what happens if that AI gets it wrong, "it's something we need to really think carefully about", he says. "To my knowledge, the malpractice industry hasn't yet thought about this kind of thing. But it's time that we do."

> "Sharing health data should be a civic duty. Only those who opt in should benefit"

Once these thorny issues have been worked through, the question is whether standalone AIs will ultimately replace doctors. Not likely, says Denny. By streamlining diagnosis, they will make it easier to access credible medical advice no matter where you live and will assist with a lot of routine care. "These systems will allow physicians to reduce their mental load, to pay more attention to each patient, to prioritise which patients need critical care right now – to be more efficient overall," says Denny. "It's going to be a win for everyone."

Doctors won't be cut out of the picture, because their empathic relationship with the patient is an essential part of care, says Vimla Patel, a cognitive psychologist and specialist in biomedical informatics at the New York Academy of Medicine. AI can augment clinicians' abilities, but can't do all the heavy lifting. "When things get complex, and medicine often is complex, you need human reasoning to make decisions," she says. "Computers, no matter how sophisticated, cannot replace that." ■

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Inside the minds of torturers

How do ordinary people end up committing atrocities? **Françoise Sironi** is one of the few people in the world who tries to treat the perpetrators of violence

WHEN Françoise Sironi was 6, her grandfathers met for the first time. One was Italian, the other from the French frontier region of Alsace. She remembers the conversation turning serious, then being mystified when the men fell weeping into each other's arms. They had discovered they fought in the same first-world-war battle – but on opposite sides. The incident sparked a lifelong interest in what drives ordinary people to extraordinary acts. She became a clinical psychologist and, in 1993, helped found the Primo Levi Centre in Paris to treat the victims of torture. She is now an expert witness for the International Criminal Court in The Hague, specialising in assessing those accused of crimes against humanity or genocide.

Why did you decide to help people who have committed atrocities?

I was at the Primo Levi Centre in 1995 when a French NGO called Santé Sud asked if we could help Russian veterans of the Soviet-Afghan war. These were young men who had come home psychologically damaged only to discover that no one cared about that war any more because the Soviet Union had ceased to exist.

Some of my colleagues refused to help them because they had committed atrocities. I saw them as time bombs that would go off if they weren't treated. They kept being drawn back to violence. Many had been recruited by the Russian mafia or as mercenaries.

Helping both torturers and their victims didn't strike you as incompatible?

Not at all. By then I had realised that to understand one, you have to understand the other. For example, a torturer inflicting sexual abuse might say, "You'll never be a man again." To treat the person those words were directed at, you need an insight into the torturer's intentions. But often the victim is too ashamed to repeat this. I was ineluctably drawn to become interested in torturers.

Do you believe in evil?

As a psychologist, you have a choice: either you think of the person opposite you as a monster or as a human being. If they are a monster, that's the end of the conversation. It's far more interesting to ask, what made them that way? In my view, people who commit evil acts have followed life paths that have led them to view those acts as reasonable.

Can you remember the first time you sat down with a torturer?

It was in the early days at Primo Levi. I treated many victims who had themselves tortured – police officers who had fought jihadists during the Algerian civil war of the 1990s, for example, before the jihadists caught and tortured them in turn. It was the same with veterans of the Yugoslav wars. Over the past 25 years, I have treated the survivors of torture, massacres and forced deportations, and there have always been perpetrators among them.

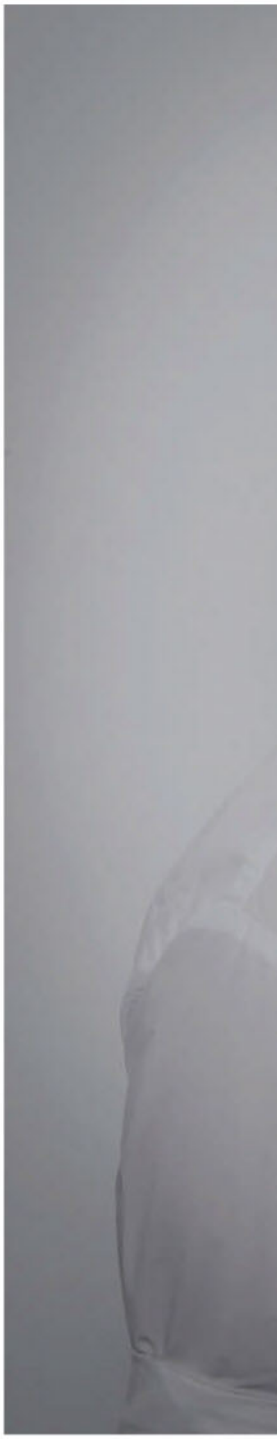
What kind of person becomes a perpetrator?

Many have grown up in a violent family, or experienced humiliation early in life. Then when they are recruited, their identity is often broken down in some way. This might involve a traumatic initiation process: children who are forced to become soldiers may be required to kill members of their family, for example. They can no longer return to their families or villages and they become dependent on the new group – their fellow child killers – and in particular, on the commander of that group.

This may help to explain one of the most troubling scenarios, which is medics who facilitate torture – advising interrogators when to turn the electricity off, for example, so that the victim's heart doesn't give out too soon. They no longer belong to a group whose identity is defined by doing no harm.

How does someone become a torturer?

There are schools. We know, for example, that French soldiers who fought in Vietnam in the



In Sironi's experience, the perpetrators of violence are often the victims too

Photographed for New Scientist by Serge Picard/Agence Vu

1950s learned techniques from their enemies that they later taught in camps in South America. Torture camps are well hidden, but there are plenty of them. Torture is thought to go on in half of all countries, and torturers have to learn somehow. The schools all have things in common: they are secret, they are set apart from the military, they portray themselves as elite. They inculcate a sense of duty, necessity, pride, of impunity.

There are cultures of torture. In the 1970s, the Syrian secret services used techniques honed by former Nazi interrogators whom they employed as consultants. Declassified manuals describe the techniques the CIA considered effective.

In 2008, you assessed Duch, the Khmer Rouge leader who tortured and killed thousands at the notorious S-21 prison. What did you conclude?
Duch is an example of what I call a man-system – someone who has relinquished their own identity and adopted that of the ideological system they grew up in. The same is true of Pascal Simbikangwa, who I also assessed and who is in prison for his role in the Rwandan genocide. They don't fit any known psychiatric category. Their behaviour can only be understood in the geopolitical or historical context in which it arose.

What are the main characteristics of such individuals?
A strong sense of group belonging and duty, and an ability to compartmentalise. Duch was capable of talking normally about his family one minute and discussing his "work" at S-21 the next. It wasn't easy for him to torture, he told us, yet he trained youngsters to do it.

"Child soldiers can be forced to kill family members. They can never go back"

When he expressed regret, it was on behalf of the Khmer Rouge, not himself. At one point I asked, "What happened to your conscience?" He replied he didn't understand the question.

Can you cure a torturer?
No, I don't think they can be cured, as such. But we can help them to dismantle the psychological mechanisms that pushed them to commit violence. You can lead them to understand why they participated in torture, how they became capable of it, and then to process their emotional response to that. Before this can happen, though, the person has to want to address this dark chapter of their past, and many – I would say most – do not.

What effect does it have on you to spend time with torturers and murderers like Duch?
I interviewed Duch 16 times. Strangely, my reaction was physical rather than emotional. It was hot in Phnom Penh, but every time I left his cell I felt cold. My colleagues and I – I was always accompanied by a Cambodian psychiatrist and an interpreter – would have our debrief huddled together for warmth.

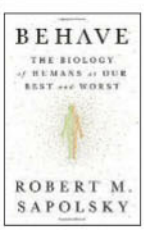
What is your goal in all this?
One goal, of course, is prevention – for the sake of the perpetrators as well as others, because as I said they suffer too. My role is to induce awareness in them, and if possible change. It's also to transmit what I learn to other professionals who deal with violence so that it may be of use in the treatment as well as the prevention of extreme behaviour. ■

By Laura Spinney.
How Do You Make a Torturer? by Françoise Sironi will be published by La Découverte in September

It's complicated

Forget simple explanations. The story of human behaviour needs the intellectual equivalent of cinematic zooming out, finds **Alun Anderson**

Behave: The biology of humans at our best and worst by Robert Sapolsky, Penguin Random House



FOR sheer ambition, it's hard to beat Robert Sapolsky's new book, *Behave*. Sapolky's goal is nothing less than a new way of seeing ourselves, free from separate "buckets of explanation" and walled-off sub-disciplines.

Biology alone isn't enough, he explains, to understand the roots of cooperation, empathy and altruism (our best side), and violence, aggression and competition (our worst). Sapolsky, a professor of biology and neurology at Stanford University, California, brings in psychology and culture too, for all are "utterly intertwined" in our behaviour. And everywhere the writing is informed by his vast, world-leading knowledge of baboon behaviour.

Unsurprisingly, the book comes to a huge 790 pages, requiring time, stamina and a liking for Sapolsky's chatty and exuberant style. It reflects its author, a "card-carrying liberal" with a great grey beard and a quirky personality, who tells us that violence "scares the crap out of me".

Sapolsky's avoids the buckets of explanation through a device akin to the film-maker's zooming out. His opening chapter looks inside your brain during the second before you do something, be it good or bad. Here you learn to be fluent in a new way of thinking, seeing behaviour as something modulated by interactions between amygdala, hippocampus, insula and, most important, the subregions of the frontal cortex, which try to plan and control.

Sapolsky adds more regions, the nucleus accumbens and the tegmentum, as he explains the relentless logic of the brain's inner dopamine-based reward system. It ensures that what was "an unexpected pleasure yesterday is what we feel entitled to today, and what won't be enough tomorrow".

We zoom out to ever-wider horizons: past the outer and inner sensations that affect you in the minutes before a decision, past the hormonal states that operate over hours to days, and on to the extraordinary plasticity of the brain, which allows change over days to months.

Pull back again, through childhood and adolescence, the influence of the genes you inherit, the centuries of culture which affect how you categorise the world, and out to our primate relatives, where we witness the evolutionary pressures shaping our ways of thinking and feeling. By then you are at the midpoint of the book, where Sapolsky encourages you with a "no one said this was easy", although by now the hard work is done.

"If 'we' screw up, it is down to special circumstances. If 'they' do, it's because that's how 'they' are"

Having mastered his lessons, you will find, as you chat with friends, a new sensibility to the inner question, "Why did I just say that?" This sensibility reaches through the tiny biases and physiological states that made one sentence pop out rather than another, through the inner tremblings of fear and anxiety, right back to an understanding of the primate roots of our obsession with rank and hierarchy. It takes in the status differences we detect in a blink of an eye, our ever-shifting groupings of "us" and "them", and why some two-thirds of our daily speech is gossip ("with the vast majority of it being negative", Sapolsky reminds us).

You can then breeze through the book's second half, in which you zoom in and out of levels of explanation, examining big questions about the best and worst of our behaviour. Hierarchy, obedience, morality, the hidden perils of empathy, free will, evil and criminality, war and peace are all here.

Sapolsky explores at length our inescapable and terrible tendency to create us/them dichotomies. The process is not only quite automatic but also easy to manipulate, altering our sense of who belongs to "us" and "them". We readily forgive "us"; if "we" screw up, it is because of special circumstances. If "they" do, it is because that is how "they" are.

Sapolsky's liberal bent is everywhere apparent. He is passionate about the terrible things that childhood deprivation

XINHUA NEWS AGENCY/REX/SHUTTERSTOCK

Human life: not so much linear as a network of possibilities

and inequality can do to people's brains and health. He is also disturbed that people living in unequal societies become less kind and more likely to displace their anger on to those lower down in the pecking order: "Giving ulcers can help you avoid getting them," he writes.

Sapolsky so dislikes the "caustic, scarring impact on minds and bodies" inflicted by the socio-economic status quo, which arrived with agriculture, that he values older, egalitarian hunger-gatherer groups. "Agriculture. I won't pull any punches – I think that its invention was one of the all-time human blunders, up there with, say, the New Coke debacle," he writes, not entirely joking.

He is passionate too about reforming the justice system: words like forgiveness, evil, soul, volition and blame "are incompatible with science and should be discarded", he argues. It angers him that it took so long for post-traumatic stress disorder to be recognised as a "real" condition for US military personnel, and scorns lawyers who use bogus ideas from genetics, like the "warrior gene", to excuse their clients' wayward behaviour.

By the book's close, Sapolsky attempts a summary of what he has said. It turns out to be: "It's complicated." This is a brave message in the age of Trump, but enigmatic too. I think Sapolsky means that "context", a word he uses often, is always critical.

You may view testosterone, for example, as the male hormone that boosts aggression. Wrong, says Sapolsky. Rising testosterone levels do prompt behaviours aimed at maintaining social status. But if that requires people to be nice, extra testosterone makes them more generous. "In our world riddled with male violence, the problem isn't that testosterone can increase levels of aggression. The problem is the frequency with which we reward aggression," he writes.

Context wins, again

Oxytocin you might see as the "love hormone". Wrong again. Oxytocin does elicit "trust, generosity, and cooperation", but only among "us". Bring in some of "them", and oxytocin amplifies pre-emptive aggression and "advocacy of sacrificing Them (but not Us) for the greater good".

And you might think that "a gene causes some biological event to happen". Not at all. Sapolsky urges you to repeat the mantra: "Don't ask what a gene does, ask what it does in a particular context." Take the *5-HTT* gene, which affects the removal of the neurotransmitter serotonin from synapses. One variant increases the risk of depression, but only in the context of childhood trauma.

Moving on to culture, context wins again. Zoom in, for example, on the common view that boys "naturally" reach the top levels of mathematics. It might seem true in US schools, but the more gender-equal the country, the better girls are at maths. In Iceland, "the most gender equal country on earth", girls are better at maths than boys.

From my reading of this book, Sapolsky sees life as "complicated" because there are always contexts, possibly ones we are unaware of, in which things could go some other way. Even he seems a little overwhelmed by it all. "Nothing seems to cause anything; instead everything just modulates something else," he muses. This seems far from an "essentialist" view of life as linear causation, and closer to seeing it as a network of possibilities, with an open future.

"If maintaining status requires people to be nice, extra testosterone makes them more generous"

Whether the thought of life as "complicated" appeals to or appals you may reflect something profound about human nature. Sapolsky explores research on how liberals and conservatives think. Liberals are more comfortable with "integrative complexity", whereas conservatives dislike ambiguity or novelty, and crave structure and hierarchy. If you are a liberal, you may be happy that this sprawling book has no one simple conclusion; if you are more conservative, its apparent incoherence may prove worrying.

Inevitably, Sapolsky does not try to say what constitutes "good" or "bad", although we do learn how these categories may differ across cultures and be shaped by ecological circumstances. But he does shift the perspective from which we might view our behaviour, and offers pithy insights to help us do it. Two I liked: "We are constantly being shaped by seemingly irrelevant stimuli, subliminal information, and internal forces we don't know a thing about", and "The road to hell is paved with rationalization".

And, most important, never let your frontal cortex get tired: it consumes huge amounts of energy and when stress and cognitive load tire it out, you start to screw up. ■

Alun Anderson is a consultant for *New Scientist*

A mouthful of history

Teeth help reveal our past, but it's a tricky business, finds **Adrian Barnett**

Evolution's Bite: A story of teeth, diet, and human origins by Peter S. Ungar, Princeton University Press

WE BRUSH them every day, flash a smile, chomp through our meals. Yet it's easy to forget the amazing role teeth play in the story of mammalian evolution.

Apart from being covered in one of nature's hardest substances so that it can take anything a million years of geology can throw at it, a tooth's 3D shape is a phenomenally subtle food processing surface. Unless its main job is to threaten rivals, then, depending on where it is in the mouth, a tooth's shape is one adapted to slice, shatter, chop, crush, pulp or simply retain whatever foodstuff has just slipped past the lips.

Matching form to function, interpreting diet and, from that, the likely social ecology of a species: this has been a cornerstone of palaeoecology since its 19th-century beginnings. Fine if you're dealing with sloths, bison or bears, but for socially sophisticated beasts, you hit the hurdle that behaviour doesn't fossilise – a key problem for that most behaviourally flexible lineage of mammals, the hominins.

In fact, as Peter Ungar shows in his new book *Evolution's Bite*, even judging a species' ecology by its teeth is not scientifically foolproof. Teeth tell you the physical properties of the most mechanically challenging thing a species ate on a regular basis, not day to day. So, while the food that fuelled and formed a species of human, and around which its social ecology and societal expectations were based, might have one size and consistency, the teeth will only reveal what that species needed to eat to get it through the worst of times.

Those that withstood these various mini-apocalypses are our ancestors, and their teeth show what was needed to survive. But dental morphology's subtle undulations can be a maze for the unwary. Luckily, as Ungar shows, palaeoanthropologists now have a well-stocked toolbox to probe the inner secrets of incisor, canine, premolar and molar.

In diet-based death, grasses and bushes mark their killers. Grass leaves, rich in silica crystals, etch a sketch of their passing on the tooth surfaces that crushed them. And different metabolic pathways operate in various leaves, so grass-eating grazers and bush-chewing browsers will have different carbon-13 and carbon-14 isotope ratios in their fossil teeth and any bones that might still be attached.

"Ungar was the first to apply NASA-style landscape mapping to 3D tooth topography"

Such "foodprints", as Ungar calls them, have overturned many established anthropological ideas. The early hominin *Paranthropus boisei*, for example, didn't crack nuts with its huge, penny-sized molars all the time, but used them to their mechanical maximum only in the hardest times.

However, change in food supply isn't only seasonal. One of Ungar's central themes is how diet and climate are intertwined, and so how the presence of mountain ranges, rain shadows and planetary precession cycles shaped us. The complexities of such interactions and how they were discovered is told with enthusiastic clarity.

With techniques ranging from mapping deep-sea mud strata to X-ray movies that visualise real-time chewing action, Ungar shows how cutting-edge studies of tooth shapes, wear patterns and palaeoclimatology combined to uncover ever more about human evolution. He relishes the use of new techniques to solve old and stubborn academic puzzles. Now head of anthropology at the University of Arkansas, he got his start there by being the first to apply NASA-style landscape mapping to the 3D topography of tooth surfaces, revolutionising a science that previously used laborious comparisons of the positions of dental peaks.

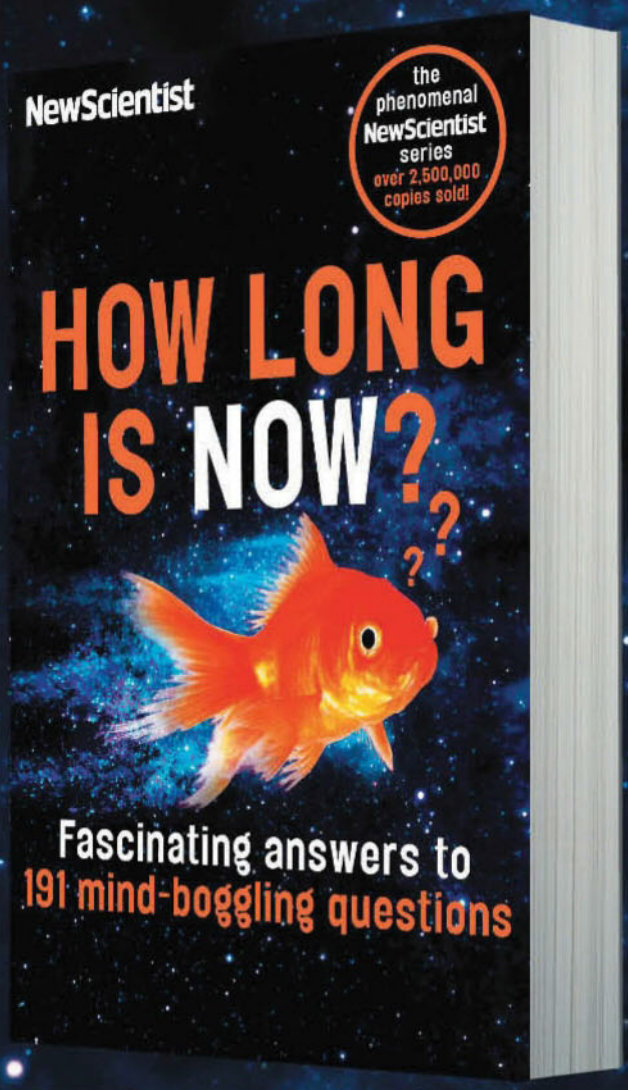
The revelation of not only how the science is done, but also what a huge difference a tangential idea such as Ungar's topographic analysis can make, is one of the great delights and strengths of the book. Our mouths are full of history. *Evolution's Bite* will change forever how you see your early morning smile. ■

'Foodprints' on fossil teeth show what early humans ate to survive

KENNETH GARRETT/NATIONAL GEOGRAPHIC CREATIVE

Adrian Barnett is a rainforest ecologist at Brazil's National Institute of Amazonian Research in Manaus

WHY ARE DOGS' NOSES WET?



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Questions regarding this position can be addressed to **alvarez@wjh.harvard.edu**. The committee will consider completed applications starting immediately on a rolling basis through October 1. Interviews will be conducted in late September and continue in October.

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$500,000 career awards empowering assistant professor-level investigators to answer persisting questions on the mechanisms and nature of human pathogens.
Pre-Proposals due 14 July 2017
Full Proposals due 15 November 2017

Career Awards at the Scientific Interface (CASI)
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Pre-Proposals due 06 September 2017
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Kelley Harris, Ph.D.
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Felix J.H. Hol, Ph.D.
Stanford University

Ashok Litwin-Kumar, Ph.D.
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Tatiana V. Mishanina, Ph.D.
University of Wisconsin

Octavio Mondragón-Palomino, Ph.D.
Caltech

Priya Moorjani, Ph.D.
Columbia University

Amy Elizabeth Shyer, Ph.D.
UC Berkeley

Amy M. Weeks, Ph.D.
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$500,000 awards for assistant professor-level investigators to answer persisting questions on the mechanisms and nature of human pathogens.

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EDITOR'S PICK

Sorry, but 'sorry' has more meanings than making an apology

From Howard Bobry, Nehalem, Oregon, US
Moya Sarner discusses the upsides of saying "sorry" – but seems to equate the phrase "I'm sorry" with an apology (17 June, p 38). It can also be an expression of regret. "I'm sorry, but you are being an idiot" is not my apology; it is an expression of my regret that the person is being an idiot. When people bump into each other and say "sorry", it's the concise way to say "I wish that hadn't happened". And don't we all say "I'm sorry…" when learning someone has lost a loved one? Surely we aren't saying that we are at fault.

From John Lucas, Toronto, Canada
Sorry, but when I almost bump into somebody, what am I supposed to do? Tell them to get out of the way or push them aside? Perhaps a ubiquitous "sorry" is a way to defuse the inevitable frictions when surrounded by crowds of strangers in our cities.

From Michael Harrington, Bonnet Bay, New South Wales, Australia
A regrettable omission from Sarner's piece is the use of "sorry" to convey empathy, as in "My mother died on Sunday" – "I'm sorry, you poor thing". I might also suggest that its use when recovering from unintended contact is not an apology but more a statement of empathy without assigning responsibility to either party.

From Valerie Yule, Mount Waverley, Victoria, Australia
As a child I was constantly punished for refusing to say I was sorry for something I did or didn't do. If I refused, I felt I had won; if I did say I was sorry, it meant I had lost and was being obedient. Then I married into a family that constantly apologised to each other. I was amazed. I copied them and said sorry constantly. I was surprised at how easy it made my life.

Social differences must affect all research in what it means to say sorry.

More ways we could tackle climate change

From Iain Climie, Whitchurch, Hampshire, UK
The simplest retort to climate change sceptics is that many actions that are vital if global warming is occurring make sense anyway (24 June, p 28). Restoring fish stocks, habitat conservation with careful exploitation, and alternatives to fossil fuels make sense regardless of the extent, nature and origin of climate change. Reducing waste may be the simplest approach of all.

The UK's Institute of Mechanical Engineers reported in 2013 that at least 30 per cent of global production fails to reach markets or shops; and it is wasteful to use human food for livestock feed or biofuels. Can dealing with these obvious concerns really be seen as anti-business or even

"What are they articulating to whom? Otherwise it's just a piece of wallpaper"

Jac Hughes suggests it's a stretch to call the images that artificially intelligent painters invent "art" (8 July, p 14)

irreligious, even though the inability of conventional free markets to cope sensibly with gluts still has to be addressed?

A few years ago, a colleague queried whether human activities could really be so significant. I mentioned the points above and he replied "But that's a win-win; I'm happy to support that."

From Stewart Reddaway, Ashwell, Hertfordshire, UK

Bob Holmes correctly says that reducing air travel can have a big effect on climate change. An equally big effect can be achieved if people who currently fly premium switch to economy. For long-haul flights, first class seats occupy about five times more space than economy, and business class seats about three times more. Configuring a plane to have more seats greatly reduces the carbon emissions per passenger.

From Louise Doswald-Beck, Geneva, Switzerland

Alice Klein mentions risks of geoengineering. There is another reason it is a really bad idea. Fossil fuel companies will use the possibility to say that climate change is no longer a problem; and governments are already dragging their feet. If they get any sense that geoengineering could "fix" the problem, they will use this as an excuse to not bother with further efforts to switch to renewable energy.

Self-reporting surveys of smell's effect

From Anne Steinemann, Melbourne, Australia

Clare Pain reports research on exposure to fragrances (10 June, p 34). She quotes Peder Wolkoff of the Danish National Research Centre for the Working Environment saying that my work "involves talking to people in short interviews". The surveys were conducted through a web-based questionnaire, without any researcher interference, to reduce or eliminate potential bias. Respondents reported what products they were exposed to, and what they experienced.

Knock, knocking on the atmosphere's door

From Robin Russell-Jones, Stoke Poges, Buckinghamshire, UK

Fred Pearce's article on Thomas Midgley, the inventor of both lead additives in petrol and CFCs, is a timely reminder that blind enthusiasm for technology can have terrible consequences (10 June, p 42). There are parallels with the situation facing us today.

Some of the long-term effects of lead are only now becoming evident, including the very strong correlation between the amount of lead added to petrol and violent crime rates in the US two decades later. What may the long-term effects of diesel emissions turn out to be?

In 1989, the UK government proposed a tax break in favour of diesel. As the then Chair of the Campaign for Lead Free Air I wrote to its chief scientific advisor, John Fairclough, warning of the carcinogenic impact of diesel emissions. Diesels were nevertheless encouraged through the 1990s. The ability of governments to remain in denial in the face of scientific certainty itself deserves serious study.

From Cedric Lynch, Potters Bar, Hertfordshire, UK

Fred Pearce says that engine knock prevents the use of higher-octane fuel. In fact, knock is caused by ›

part of the fuel-air charge in the engine cylinder exploding before the flame front spreading from the sparking plug reaches it. It may be caused by the use of fuel with too low an octane rating.

Tetraethyl lead does something else that made it very attractive to vehicle manufacturers: it forms deposits on hotspots that may be caused by pitting of a valve or seat. This makes the valves effectively self-healing and allows them to be formed directly in the cast-iron cylinder block or head of an engine, reducing the engine's cost.

A free vote on hunting was a sensible step

From Jim Barrington, Countryside Alliance, London, UK

You introduce an online comment piece by Stephen Harris by saying that a Conservative Party manifesto commitment was an "unscientific vow to resume fox-hunting" (1 July, p 24). What was being offered was a vote on the future of the Hunting Act – surely a sensible step, providing an opportunity to debate what effect this law has had on wildlife.

Quoting public opinion polls on the subject of hunting, especially when most people have little or no first-hand experience of the activity, and with some of the wording designed to achieve the desired results, can hardly be regarded as scientific. Harris's contention that the control of foxes is unnecessary is disputed by other scientists. He ignores the obvious change the Hunting Act has brought about, which is an increase in shooting (both good and bad) that has filled the vacuum in hunting's absence.

Why do broccoli pills need regulation?

From Giles Cattermole, Wallingford, Oxfordshire, UK

You report online that Anders Rosengren and his colleagues are applying to regulatory authorities for approval of sulphoraphane powder to reduce diabetes complications, allowing a dose equivalent to eating 5 kilograms of broccoli a day, which "could take as little as two years" (24 June, p 19). Why? Sulphoraphane tablets have been widely available in over-the-counter markets in the UK and elsewhere for years.

The editor writes:

■ Generally you can sell anything as a "food supplement" if it's not prohibited or poisonous. Claims of medical efficacy need more thorough backing.

Measuring metabolites is no help with health

From Gareth Byrne-Perkins, Broughton, Hampshire, UK

I agree that Anthony Warner's distaste for food trends, particularly #JERF, is completely founded – as is that for the deadly marketing that has encouraged us to consume the foods we do (17 June, p 24). But the focus on a randomised trial of only 20 people isn't a good foundation for a critique of sourdough, or anything else for that matter.

The study has no reference to the long-term benefits of not shovelling down tasteless white pap. A spot-check on metabolic markers completely misses the point. If we eat loads of sourdough we will get fat, as we will if we eat loads of white, mass-produced bread. We do know that sourdough tastes better and has an almost personalised ingredient make-up.

Can scanning brains help validate witnesses?

From Ed Prior, Poquoson, Virginia, US

Andy Coghlan's report of brain signals from monkeys being used to recreate photos of faces is potentially important for many reasons (10 June, p 14). One not mentioned is law enforcement.

Witnesses to a crime often have great trouble identifying suspects or helping police artists sketch a recognisable face. I hope this research will eventually be applicable to the human brain.

For the record

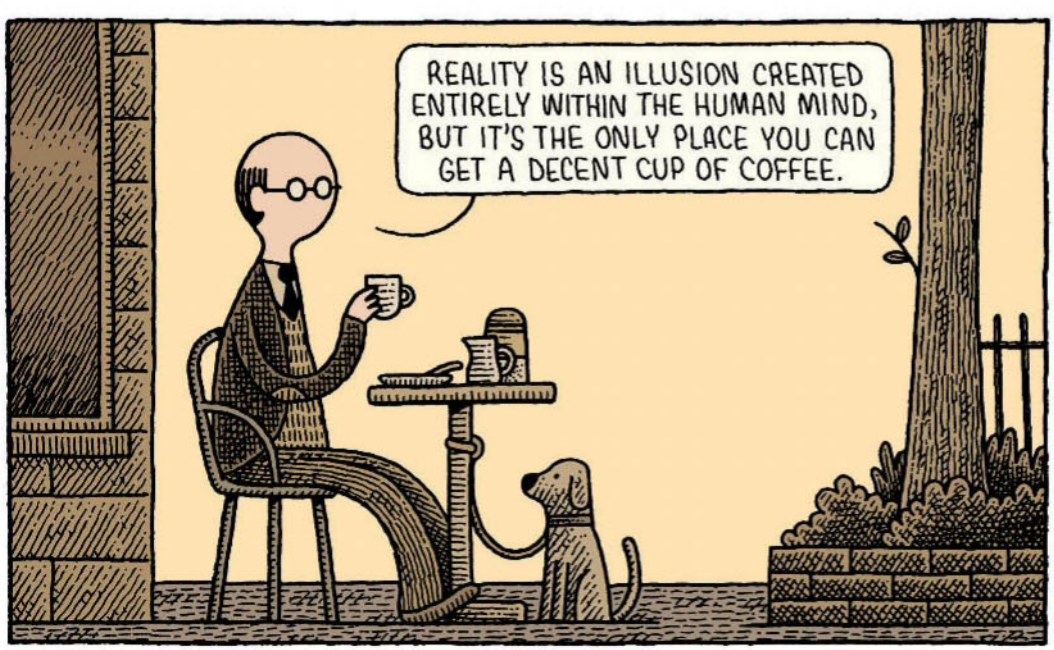
■ **Every last drop. The Bureau of Transportation Statistics reports jet fuel consumption by US scheduled airlines as 42 billion litres per year; and burning this or other hydrocarbons releases little methane (24 June, p 28).**

■ **Over there! Eoin Travers and colleagues found that subliminal cues made people slower at pressing the right button. Even when cues were wrong half the time, they could not help looking in the direction of an unconsciously perceived arrow, so taking longer to respond (1 July, p 8).**

■ **Hellfire! Other drones capable of firing anti-tank missiles are available, at rather higher prices than the Ukrainian proposal we mentioned (1 July, p 22).**

■ **Only the rocket that SpaceX launched on 23 June was pre-loved (1 July, p 7).**

TOM GAULD



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SIGNAL BOOST

Offering your projects a helping hand

At the end of the rainbow

VANISHING white matter disease… never heard of it? That's not really surprising as it only affects 1 in 40 million people. There are currently fewer than 200 children living with the condition worldwide. Nonetheless it is a devastating and life-limiting genetic condition. The mutation occurs in one of the five genes that are collectively known as eIF2B. These make proteins in the body without which we cannot exist.

Vanishing white matter disease (VWM) is characterised by progressive breakdown and loss of white matter in the brain. Deterioration continues with every fever, infection, head trauma and stress a child experiences. It is incurable and because of its rarity, very little research is currently being done to find a treatment. However, a team led by Orna Elroy-Stein at Tel Aviv University, Israel, has had promising results.

Her team has discovered that genetically-engineered mice, developed to aid research into leukodystrophy, could help researchers study the related condition of VWM. Drug matches at the molecular level have already been identified, the next step will be to test them on the mice.

"I feel that pursuing a VWM cure is my purpose in life. I don't dare stop and let these people down," says Elroy-Stein.

Without effective treatments there will unfortunately be more children like 4-year-old Bella from the UK (pictured above). Bella is losing her motor skills; she lost the ability to walk at two and a half. In the future she can expect to lose her arm movement, core strength, vision, speech and hearing.

Most people with VWM die within 10 years of diagnosis. With no current cure, parents are helpless. Bella's family set up The Rainbow Dream Charity to help fund Elroy-Stein's promising research. **Peter Morris, charity chairman**

Please visit **www.therainbowdreamcharity.com** for more information, to raise awareness and to donate to the research fund

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PAUL MCDEVITT

ALL great minds need lubrication, and where better to fuel idle curiosity than in the pub? Michael Zehse writes to tell us of his trip to The J. P. Joule in Manchester, UK, named after physicist James Prescott Joule, who spent the last years of his life nearby. He wonders: how many other hostelries bear the names of famous scientists?

Surely this name game has the makings of a great pub crawl. We can offer the John Snow in London, near the location of the cholera-spreading Soho water pump whose handle was removed at the epidemiologist's behest. The John Snow's taps continue to flow, and thankfully with no trace of the disease.

No doubt there are plenty more pubs named for great scientists. Tell us where to head next.

ONE more for the retronym store: Elizabeth Belben says "I am surprised that no one has mentioned 'alphabet', created from the first two letters of the Greek alphabet, alpha and beta."

Elizabeth agrees with Glenn Pure that "em" and "en" are handy words in Scrabble (24 June), and adds "in my family we not only allow names of letters in our own alphabet (including both 'zed' and 'zee', but also Greek letters such as 'mu' and 'nu'. However, after I played 'aleph' we agreed to be cautious about using the names of Hebrew letters until we could agree on how to spell them."

AND straying into the margins, Paul Allen writes to say that as well as being dashes, "en" and "em" were used to measure lengths across the page. "In the noisy environment of a printing works, it is very hard to discriminate between the sound of 'em' and 'en'," says Paul, "so printers invented alternative names for them." To make it easier to tell them apart, an en space was referred to as a "nut" and an em space as a "mutt".

"Before you ask," says Paul. "I should point out that printing before the days of phototypesetting required the use of lead-based type metal and that might have been the cause of such useless alternative names."

PAUL DORMER writes: "If Nina Baker is interested in eponyms named after women (10 June), she may be interested to know that in crosswords, a hidden message discovered in the completed grid is known as a Nina." This apparently stems, he says, from the American caricaturist Al Hirschfeld's habit of hiding his daughter's name in his drawings.

EARLIER Feedback claimed that the 7 in 7Up was derived from the atomic number of lithium, one of the ingredients (1 July). "When, long ago, I was at school the atomic number of lithium was 3," says Keith Parkin, "albeit with a common isotope having a mass number of 7."

PREVIOUSLY Jake Burger related the retronym Esso, stemming from the letters of Standard Oil (13 May). "Meanwhile, Kuwait Petroleum International has done quite the opposite," says Dan Salmons, "and trades as Q8. Perhaps we ought to call these petronyms."

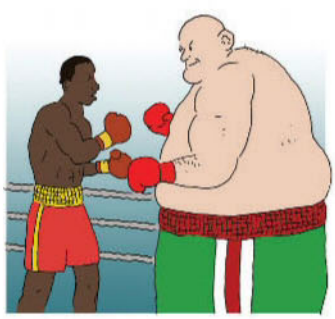
NOT so fast, says Anton Fletcher, who thinks some retrospective correction is in order. "A previous contributor suggested that the oil company Esso is derived from the first letters of Standard Oil spoken aloud. This is questionable, as the company's full name was Eastern States Standard Oil."

Anton concludes that the name Esso is simply an acronym. But Feedback has discovered that court cases were fought over exactly this issue, after regulators broke up Standard Oil into 34 companies, one of which tried to hold on to the brand heritage – or at least an echo of it, by marketing their fuel as Esso.

Readers will doubtless be pleased to learn that when the company using the Esso brand, Jersey Standard, was forced to give it up, they chose instead to use Enco – a German-style clipping of "Energy Company".

FEEDBACK reader Mick Martin previously found himself on a bus seemingly bound for the infinitely accommodating Hilbert Hotel (1 July). "This reminded me of a company in Ilford who might be capable of creating such a thing," writes Steve Ingamells, "Infinite Building Solutions Ltd".

AUSTRALIA is a fearsome place, overrun with an improbable number of creatures ready to kill you. So it follows that a fighting man in this continent needs to be just as fearsome to survive. Every morning, The Macquarie Dictionary – the authoritative text on Australian English – sends Pierre Du Cray its word of the day. Thus he discovers its definition of "welterweight" is: "A boxer weighing between 635 and 67 kg (in the amateur ranks) and 63503 and 66678 kg (in the professional ranks)." That ought to tip the balance in their favour.



REFLECTING on our colleague who was told he "could already have won" an imagination-sized chocolate hamper (20 May), Pete Goddard has a suggestion. "Many companies chose to disappoint the vast majority in this way, given the small likelihood of success," he says. "Surely it would be better to send a message saying that 'you may already have not won', and anticipate the unbounded joy when the hamper of whatever size arrives!"

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.

Doug Lawrence spies a local tool-hire company offering "various chemical free cleaning fluids". He suspects "they all must be very similar"

Stirring up trouble

My son was vigorously stirring a very hot cup of drinking chocolate as he thought that would cool it down. I said stirring the liquid was adding energy to it. Who is right? If him, what's the best speed to stir at to cool the hot chocolate? And if me, is it possible to heat it up by stirring very fast?

■ Stirring will help cool a hot drink because it speeds up the process of convection by bringing the hottest liquid at the bottom to the top, where it can be cooled by the air. But in truth, convection occurs pretty quickly anyway, and you're only slightly speeding it up.

Experiments show that, instead of the conventional method of stirring, the best way to cool a hot drink is, in fact, to repeatedly lift a spoon in and out of it. This is because the spoon heats up in the liquid and cools when removed, taking heat from the system more quickly.

It is understandable to think that rapid stirring would add energy to the drink, but to heat it up by a noticeable amount, your stirring would have to be so fast it would cause the drink to be pretty much everywhere else but inside the cup.

Overall, weighing up the marginal decrease in the time it takes the hot chocolate to cool if you vigorously stir it against the risk of a spillage, it's probably best to just let it cool by itself.

Corry Traynor
London, UK

■ When the hot chocolate is gliding around the edge of the cup, it can move in layers when the flow is slow – known as laminar flow – or turbulently when its movement is disorganised, such as when it is agitated by faster stirring.

The driving force for heat transfer is the difference in temperature between the drink and the air. The greater the difference, the higher the rate at which the heat will flow between them from hot to cold.

In a laminar flow, the layers of fluid have an insulating effect, reducing the heat transfer. In a

"The driving force for heat transfer is the difference in temperature between the hot chocolate and air"

turbulent flow, more fresh cold air will be in contact with the surface of the hot chocolate, resulting in faster heat transfer due to a larger average temperature difference between the drink and air. Away from the surface, convection and contact with colder liquid will cool down warmer parts.

You are fundamentally correct in stating that adding kinetic energy to the fluid will increase its temperature. Proof of this principle is that you can heat up soup by whizzing it in a powerful blender over an extended period.

However, the difference between the scale of heat loss to the air through convection and the amount of energy needed to be added to the hot chocolate to significantly raise its temperature is several orders of magnitude more than any vigorous stirring by hand could deliver.

So in theory, Son 1 Parent 1, but in practice, Son 1 Parent 0. Sorry parent.

Adriana Fernandes
Urrbrae, South Australia

■ The fastest method for cooling drinks is "saucering", where you pour part of the beverage into your saucer then back. This gives a larger surface area and agitates the liquid. In my test, saucering cooled the drink quickly. Some people even sip the cooler liquid out of the saucer, a practice that is hundreds of years old, but fell out of fashion around the second world war and is now considered impolite in some circles.

Ron Dippold
San Diego, California, US

■ Another time-honoured way of cooling a drink is to blow on it. That brings cool air, with a fairly low relative humidity, into contact with the liquid surface and increases cooling evaporation. Blowing and stirring together will work the fastest.

Eric Kvaalen
Les Essarts-le-Roi, France

■ In 2014, undergraduates at the University of Leicester, UK, calculated that stirring tea would speed up cooling. They would doubtless reach a similar conclusion with hot chocolate.

Stirring at a rate of 100 rotations per minute increased the surface area of the tea by 6 per cent, simply because the liquid in the resulting vortex is depressed at its centre and raised where it meets the side of the cup.

The undergraduates modelled the top of the liquid as a smooth hemispherical surface, but this probably underestimates the area across which convective cooling takes place. After all, the surface of a real liquid being stirred would be lumpy and constantly changing. Turning over the liquid would also increase the rate of cooling by evaporation.

In any case, I suspect that simply leaving a metal spoon standing in your favourite hot beverage will lead to faster cooling by providing an alternative thermal path.

Mike Follows
Sutton Coldfield,
West Midlands, UK

This week's questions

PLAYING FOR TIME

How is it possible for concert pianists to play faster than the eye can follow?

John Sharvill
Deal, Kent, UK

LEAD ASTRAY

How much lead was used in the manufacture of leaded petrol before it was banned, and where is that lead now?

Robin Moorshead
Southolt, Suffolk, UK

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Professor Dame Carol Robinson
2015 Laureate for United Kingdom
By Brigitte Lacombe

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