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WEEKLY August 19 - 25, 2017

THE ANYTHING FACTORY

Getting to work on the  
atomic assembly line

FIRST BLOOD

Should we save up  
babies' stem cells?

MAP ATTACK

Secret cyberweapon  
leads victims astray

SPECIAL REPORT

## RADICALIZATION

If you want to understand extremism, read this



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## DISCOVER THE ANSWERS SHAPING TOMORROW

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SABINE VIELMO/PLAINPICTURE

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Oscar Wong/Lamarr Golding  
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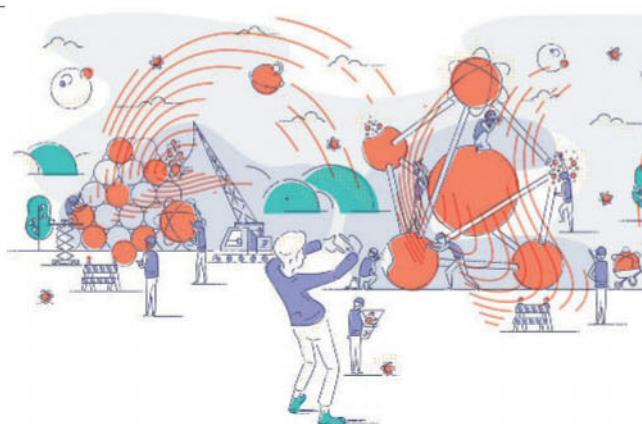
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EVELYN HOCKSTEIN/FOR THE WASHINGTON POST VIA GETTY

# Know thy enemy

To counter extremism we need first to understand it

NEW YORK. Paris. London. But it's not just Western capitals that are under threat from extremists: militants are on the march from the Middle East to Africa to Asia to Charlottesville, Virginia.

Terrorist violence horrifies and bewilders us—but that is its intention. In our disorientation, we reach for simple answers to the complex riddle of radicalisation: religious bigotry, brainwashing ideology or just plain evil natures. Such simple answers lead to simple responses: fiery rhetoric and fierce retaliation. And those can end up exacerbating the threat rather than defusing it.

It is crucial that we change this dynamic. Extremism, even when it seems completely senseless, is

not beyond comprehension. But armchair theorising won't cut it. We need to inject some rigour, creating evidence-based models of extremism's causes and effects. And that means getting data.

Researchers need to create and document case studies, conduct unconstrained interviews with the radicalised and learn directly from those who have worked out how to keep extremism at bay in their communities. Not many are qualified to do this kind of work. Not many of those so equipped are bold enough to go into the field (see page 30). And those who do can find themselves isolated.

Funding bodies may require a host country's government to sign off on field research. Such

permission may be hard to obtain, especially from hostile states or in conflict zones. Ethics boards and legal protections can make it hard for researchers to freely interview captured fighters. And on top of all this, academics may find their difficult work glibly co-opted or misrepresented by those with preexisting agendas. It is important to remember that studying extremism does not imply excusing it or appeasing it.

The public debate over tackling extremism, dominated by tough sloganeering, can make it hard for nuanced views to be heard. But the nuances that researchers can tease out might prove our most powerful weapon. It's time we gave them proper support. ■

# A small win for chemists

"HE MIXES this and that, and he shakes it, and he fiddles around": Richard Feynman's description of a chemist in his famous 1959 talk entitled "Plenty of room at the bottom" must have put many noses out of joint. To add to the insult, it's physicists who come to the rescue: "A chemist comes to us and says, 'Look, I want a molecule that has the atoms arranged thus and so; make me that molecule.'"

Chemists don't get enough credit. When DuPont adopted the slogan "Better Things For Better Living... Through Chemistry" in the 1930s, they couldn't have been more accurate. Chemists' careful advances in materials, medicine and food production have helped massively boost lifespans even as our numbers have grown.

The next big (or rather, tiny) thing is the manipulation of

individual atoms, just as Feynman foresaw, paving the way for new wonder materials (see page 38).

Physicists developed atomic assembly lines to make these entities; those who use them call themselves nanotechnologists or materials scientists. But it's chemists who know best how to get atoms to do what we want. With these new tools at their disposal, it's time they shook off Feynman's silly stereotype for good and claimed this exciting new field for chemistry. ■

## Bad vibes in Cuba

US DIPLOMATS in Cuba have been "exposed to an advanced device that operated outside the range of audible sound". That was the conclusion of a months-long US investigation into what caused some diplomats to experience hearing loss so severe they had to return early.

Last week, Rex Tillerson, the US secretary of state, elaborated that they had been the victims of "health attacks". The Cuban government has said it wasn't responsible for any possible attack on the diplomats, and that it has launched an "exhaustive, high-priority, urgent investigation".

Was it a state weapon? Was it a weapon at all? Part of the difficulty in finding information is that the history of acoustic weapons development is shrouded in rumour and conspiracy,

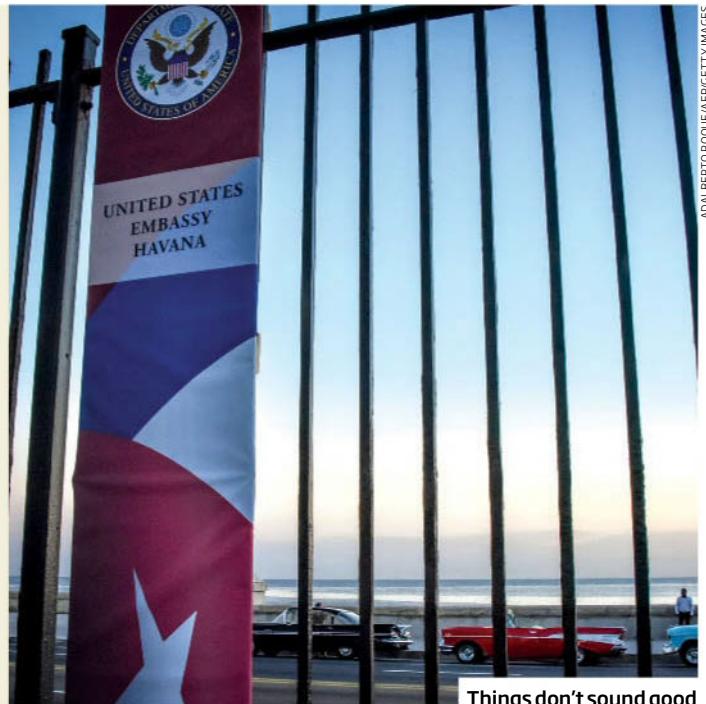
says Steve Goodman, the author of *Sonic Warfare*.

Nonetheless, "there are two ways that hearing loss could be effected without people knowing", says Toby Heys at Manchester Metropolitan University in the UK.

The first is with sound waves at a frequency too low for humans to hear. But to make these loud enough to do damage, you would need a large array of subwoofers - not so covert.

The other option is to use ultrasound: frequencies above the range of human hearing. There are already commercial speakers that can do this. "These can be directed into an ear quite precisely, but you need a clear path to the target," says Heys.

Until more details are uncovered, it's hard to separate signal from noise.



Things don't sound good

## Cancer treatment

PEOPLE with cancer who choose alternative medicine instead of conventional treatment are more than twice as likely to die from the disease.

So says an analysis of records in the US National Cancer Database by Skyler Johnson and his colleagues at Yale School of Medicine. They identified 281 people with breast, prostate, lung and colorectal cancer who had opted for unproven treatments, shunning chemotherapy, radiotherapy and surgery.

**"They could be herbs, homeopathy, diets or stones that people believe have healing powers"**

Their health outcomes were then compared with 560 other people matched in terms of age, race and disease, but who had conventional treatment. The team found that those who took alternative medicine were two-and-a-half times more likely to die within five years of diagnosis.

Among those with breast

cancer, people taking alternative remedies were 5.7 times more likely to die within five years. While 41 per cent of those receiving conventional treatment for lung cancer survived for at least five years, only 20 per cent of those who opted out did. And only 33 per cent of people using alternative medicine for colorectal cancer survived the next five years, compared with 79 per cent of those on conventional treatments (*Journal of the National Cancer Institute*, doi.org/cbsg).

Johnson doesn't know what alternative treatments people tried, but has seen many of his patients opt for a wide range of therapies. "They could be herbs, botanicals, homeopathy, special diets or energy crystals, which are basically just stones that people believe have healing powers."

Those who opted for alternative treatments tended to be wealthier and better educated. In the US, medical insurance doesn't cover unproven treatments, so only richer people can afford the most expensive alternative treatments, says Johnson.

## Satellite buddies

A SATELLITE on a leash could help us study odd, bright patterns on the moon's surface. By tethering together two CubeSats, NASA researchers hope to put one in an orbit close enough to the surface to investigate the mysterious swirls that show up in more than 100 places across the moon and the magnetic fields associated with them.

It has been difficult to get a close look at the swirls because an orbiter near the surface would

have to be travelling extremely fast to avoid being sucked down by the moon's gravity.

Small satellites such as CubeSats can't carry enough fuel to move fast, so a new mission concept proposes using two tied together: one in an easier-to-maintain orbit at 190 kilometres above the surface and another less than 10 kilometres up. During their year in orbit, the upper satellite would oppose the gravitational pull of the moon and keep the lower one from ending as a smear on the surface.

## Antarctic volcanoes unmasked

ALMOST 100 volcanoes have been found beneath the West Antarctic ice. No one knows whether they are active, but if they are, it could spell more trouble for ice sheets already in retreat because of global warming.

Robert Bingham at the University of Edinburgh, UK, and his colleagues made the discovery using ground-penetrating radar scans that show the profile of the rock under the ice.

They detected 138 volcanoes in West Antarctica, including 47 known

ones that protrude above the ice, leaving 91 newly discovered (*Geological Society*, doi.org/cbtd). They now want to use instruments to see how active the volcanoes are.

But Eric Rignot at NASA's Jet Propulsion Laboratory in Pasadena, California, thinks the impact of any volcanism will be minor compared with that of warmer ocean water. "This ocean heat largely surpasses what could ever be produced by a few active volcanoes," he says.

## 60 SECONDS

### Nuclear war off

NORTH Korean leader Kim Jong-un has shelved plans to fire a missile at the US territory of Guam, the state media has said.

Last week, an annual US military drill followed by North

**"Nothing suggests Kim Jong-un is insane. Nuking US territory would invite massive retaliation"**

Korean bluster escalated further than it has done in past years, thanks to a newly credible nuclear threat from North Korea. It ended in Kim promising to send missiles to Guam by mid-August.

Experts were not surprised when Kim backed down. "Nothing suggests Kim Jong-un is insane," says James Acton of the Carnegie Endowment for International Peace in Washington DC. "Nuking US territory would invite massive retaliation" aimed at regime change – which Kim doesn't want.

To prevent future escalation, the US must stop insisting Kim abandon his nukes before starting serious talks, says Jeffrey Lewis of the Middlebury Institute of International Studies at Monterey, California. North Korea must be dealt with as a nuclear power, and brought within the web of mutual deterrence that constrained the last Asian dictatorship to succeed in going nuclear: 1960s China.

NASA



Outlook, stormy

### Hurricane warning

BATTEN down the hatches. The US Atlantic coastline may be facing its worst hurricane season since 2010.

Forecasters at the National Oceanic and Atmospheric Administration (NOAA) predict 14 to 19 named storms – those with sustained wind speeds of at least 63 kilometres per hour – between 1 June and 30 November, compared with an average of 12. Six named storms have already

**"We urge people in hurricane-prone areas to be prepared with an emergency plan and kit"**

struck the region.

NOAA also predicts that two to five major hurricanes – with sustained winds of at least 179 kilometres per hour – will brew this year, compared with an average of three. So far none have formed.

"Our update to the initial outlook in May increases the likelihood of an above-normal season to 60 per cent from 45 per cent," says Susan Buchanan at NOAA's National Weather Service.

NOAA upgraded its alert because changing weather conditions since May make hurricanes more likely. One factor is abnormally warm waters in the tropical Atlantic Ocean,

which increase hurricane and cyclone intensity. There are also abnormally weak vertical shear winds; strong shear winds stop hurricanes forming.

"We urge people who live in hurricane-prone areas, especially those with a history of flooding from heavy rain and storm surge, to be prepared with an emergency plan and kit," says Buchanan.

### Opioid emergency

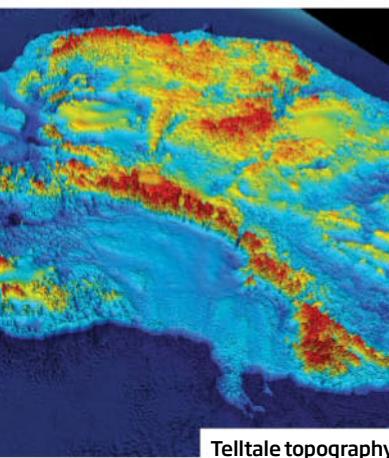
PRESIDENT Trump last week announced plans to declare the US opioid crisis a national emergency. Tens of thousands of people die from opioid overdoses each year.

"The opioid crisis is an emergency and I am saying, officially, right now, it is an emergency. It's a national emergency," Trump told reporters. "We're going to spend a lot of time, a lot of effort and a lot of money on the opioid crisis. It is a serious problem the likes of which we have never had."

A subsequent White House statement said the president had instructed his administration to "use all appropriate emergency and other authorities to respond to the crisis".

It is not yet clear how much funding will be made available for tackling the epidemic, nor how it will be used.

BAS



Telltale topography

### Cassini's final five

NASA's Cassini spacecraft has started the first of its final five orbits around Saturn before it crashes into the planet on 15 September. On 14 August, the spacecraft dipped lower into the atmosphere than ever before, forcing the thrusters to fire to maintain stability and allowing researchers to figure out the density of the top of Saturn's haze.

### Cardiac weight risk

You can't be "fat but fit". An analysis of more than half a million people in Europe found that even when overweight people have healthy blood pressure, cholesterol and blood sugar levels, they are still 26 per cent more likely to develop coronary heart disease (*European Heart Journal*, doi.org/cbs9).

### Game on

Artificial intelligence beat professional video gamers at the *Dota 2* championships in Seattle last Friday. Elon Musk's OpenAI developed the bot, and although it can only at present play a restricted version of *Dota 2*, the game is still considerably more complex than others AI has mastered.

### Care home demand

The average woman now requires three years of substantial care in old age and the average man 2.4 years, according to an analysis of 15,000 adults in England. The study predicts that by 2025, the nation will need an extra 71,000 care home places (*The Lancet*, DOI: 10.1016/S0140-6736(17)31575-1).

### Dino mystery

A strange dinosaur may be the "missing link" between two great dinosaur groups. *Chilesaurus* resembles a *Velociraptor*-like meat eater, but a new analysis suggests it is an Ornithischian, the group that includes *Stegosaurus* and *Triceratops* (*Biology Letters*, DOI: 10.1098/rsbl.2017.0220). It may reveal how the two groups diverged.

# Hints of a new cyberweapon

GPS spoofing may have thrown vessels off course in the Black Sea

**David Hambling**

REPORTS of satellite navigation problems in the Black Sea suggest that Russia may be testing a new system for knocking GPS off course. This could be the first hint of an electronic weapon that could be used by anyone, from nation states to petty criminals.

On 22 June, the US Maritime Administration filed a seemingly bland incident report. The master of a ship off the Russian port of Novorossiysk had discovered his GPS put him in the wrong spot – 32 kilometres along the coast, at Gelendzhik airport.

After checking the navigation equipment was working properly, the shipmaster contacted other nearby ships. At least 20 were affected.

While the incident hasn't been confirmed, navigation experts think this is the first documented use of GPS misdirection – a

spoofing attack that has long been warned of but never been seen in the wild.

Until now, the biggest concern around GPS has been that it can be jammed by masking the signal sent from a GPS satellite with noise. Although this can cause chaos, it is also easy to detect: GPS receivers on ships sound an alarm when they lose the signal.

But spoofing a satellite's signal with a false signal sent from a ground station simply confuses a receiver. "Jamming just causes the

**"It shouldn't be difficult for someone to divert a driverless vehicle or hijack an autonomous ship"**

receiver to die, spoofing causes the receiver to lie," says consultant David Last, former president of the UK's Royal Institute of Navigation. Last says the Black Sea incident suggests a device capable

of causing widespread disruption, for example, if used in the ongoing dispute with Ukraine.

Todd Humphreys at the University of Texas at Austin has been warning of the danger of GPS spoofing for many years. In 2013, he showed how a superyacht with state-of-the-art navigation could be lured off-course by GPS spoofing. "The receiver's behaviour in the Black Sea incident was much like during the controlled attacks my team conducted," he says.

Humphreys thinks this is Russia experimenting with a new form of electronic warfare. There have been previous hints that they have the capability. Over the past year, GPS-reliant phone apps in central Moscow have been misbehaving. The problem became apparent when people were playing *Pokemon Go*: when hunting pokemon anywhere around the Kremlin, they found

the app thought they were at Vnukovo airport, 32 kilometres away. This is probably for defensive reasons; many guided missiles rely on GPS navigation, and spoofing would prevent them hitting their targets.

**Easy to build**

Now, some worry that spoofing is getting easier. It once required considerable technical expertise; Humphreys built his first spoofer from scratch in 2008. But now he says he can download software from the internet onto commercial hardware. Both Last and Humphreys say that any reasonably competent hacker could build a GPS spoofer.

If the ability to misdirect GPS signals becomes more accessible, others may spot an opportunity. There have been no authenticated reports of spoofing by criminals, but it shouldn't be difficult for someone to use it to divert a driverless vehicle or drone, or to hijack an autonomous ship.

But Humphreys believes that spoofing by a state operator is the more serious threat.

The spectre of electronic warfare has led to calls for more research into countermeasures. Research on receivers that could authenticate a GPS signal has been under way for over a decade. "Guarding against spoofing is not easy," says Last.

There is one other option: ditch GPS and return to Loran, the second world war era system of radio navigation beacons. It requires a large, complex antenna and spoofing can be detected and located relatively easily. It was switched off in 2011, but advocates have long rallied around a modern update, eLoran – a low-cost fallback for GPS that might now turn out to be priceless. ■



SABINE VIELMO/PLANPICTURE

Where am I?

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# Fish just can't resist the smell of plastic

HUNDREDS of marine species are known to eat plastic – including those that regularly end up on our dinner plates. But why? It now seems that ocean-borne plastic has a smell that marine animals find appealing.

Matthew Savoca, now at the NOAA Southwest Fisheries Science Center in San Diego, California, exposed schools of anchovies to seawater with an odour of plastic. To make this, the team left plastic beads in the ocean for three weeks, then stirred the beads into seawater samples before filtering them out – leaving just the associated odour chemicals.

In the ocean, plastic quickly becomes covered with a layer of algae that release smelly sulphur compounds. Foraging fish such as anchovies, which feed on algae-munching marine crustaceans called krill, are thought to use these compounds to help them locate prey.

When analysing videos of the anchovies, the researchers noticed that the fish reacted to the plastic-scented solutions as if they were their crustacean prey. The decision to use solutions with a plastic smell rather than actual pieces of plastic meant the fish weren't responding to visual cues but simply to the odours. The fish did not respond to clean plastic (*Proceedings of the Royal Society B*, DOI: 10.1098/rspb.2017.1000).

This could be an issue for animals higher up the food chain, like us. "There's no doubt that we eat microplastics when we eat seafood," says Chelsea Rochman at the University of Toronto. What we don't know, she says, is how much of the chemicals leaching out of the plastic then enter our systems – and whether it matters if they do.

A report by the UN Food and Agriculture Organization released last week highlights how little we know about plastic consumption by animals and the possible impact on human health. **Josh Gabbatiss**



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# Drug protects your gut bacteria from antibiotics

ANTIBIOTICS can save your life, but they can also mess up your microbiome. A formulation of activated charcoal could help, protecting your body from the downsides of antibiotics.

Stomach pains and diarrhoea are familiar side effects for many people who take antibiotics. But by messing with the balance of microorganisms in the body, antibiotics may also cause longer-term changes, potentially leading to obesity and allergies. And by killing too many of the good bacteria in your gut, they can make way for harmful and even drug-resistant bacteria, such as *C. difficile*, which is responsible for around 30,000 deaths a year in the US.

Jean de Gunzberg and his colleagues at Da Volterra, a

biotech company based in Paris, think they have found a solution. Activated charcoal – a super-absorbent material – is routinely used to soak up drugs in the guts of people who have overdosed, and the team have evidence that a modified version could do this for antibiotics.

To stop charcoal from simply soaking up an entire dose of oral antibiotics, the team covered tiny pieces of activated charcoal with a special coating. This breaks down by the time the charcoal reaches the large intestine, allowing it to mop up any antibiotics that make it this far and protect the rich ecosystem of beneficial bacteria that live there.

The team tested its slow-release activated charcoal, named DAV132, in a clinical trial of 44 healthy

volunteers. A five-day course of the common antibiotic moxifloxacin was given to 28 people, half of whom also took DAV132 twice a day throughout the treatment, and for two extra days at the end. A further eight volunteers took DAV132 on its own, while eight people took nothing at all.

De Gunzberg's team found that DAV132 didn't affect how much

**"A formulation of activated charcoal protected 90 per cent of bacteria species affected by antibiotics"**

of the antibiotic made it into a person's bloodstream, suggesting that it wouldn't stop the drug from treating a bad infection. However, the faeces of those who took DAV132 with moxifloxacin had only around 1 per cent of the level of antibiotic found in the faeces of those who took the antibiotic on its own. This indicates that the charcoal mopped up moxifloxacin in the large intestine (*bioRxiv*, doi.org/cbsj).

Around 250 species of bacteria fell in number in the guts of those who took the antibiotic alone.

"Close to 90 per cent of those species were protected by our product," says de Gunzberg. At this stage, the team didn't look at whether this reduced the incidence of side effects from antibiotics, such as diarrhoea.

"The results are promising," says Willem van Schaik at the University of Birmingham, UK. "It's a really exciting approach to protect the microbiome from antibiotics."

The team want to see if the product can stop resistant bacteria from developing. The plan is to start testing the charcoal in people taking antibiotics to treat infections next year.

In the meantime, people shouldn't give themselves regular activated charcoal, as this could simply stop their antibiotics from working. **Jessica Hamzelou**

# Ancient warriors ate dogs in rituals

**Joshua Rapp Learn**

THE remains of roasted, chopped and defleshed dog skulls in the Eurasian steppe are providing evidence of a bizarre rite of passage for young boys from 4000 years ago – one that might have echoes in the foundation myth of ancient Rome.

"The nature of this ritual was that they killed and then consumed very large numbers of dogs and some wolves," says David Anthony at Hartwick College in New York.

Anthony and his Hartwick colleague Dorcas Brown analysed the bones of at least 64 dogs and wolves. The remains came from a Bronze Age site roughly 3700 to 3900 years old, at the ancient village of Krasnosamarskoe in present-day Russia.

The researchers found that the dogs' bodies appear to have been expertly chopped. The skulls alone were cut into about a dozen pieces after being roasted. Cut marks on some of the skull fragments show that the flesh may have been stripped from them after roasting, which

Anthony says points to them having been eaten.

DNA analysis shows most of the dogs were male, which Anthony says suggests a men's initiation rite. The killings may not have occurred every year,

but the fact that the remains were stratified in the soil indicates the same process was done several times.

The dogs were killed mostly during the winter, based on chemical analysis of their teeth, while cattle and sheep bones discovered with them come from animals killed throughout the year. This hints that the dog killing was not just for meat, but for some sort of ritual purpose (*Journal of Anthropological*

*Archaeology*, DOI: 10.1016/j.jaa.2017.07.004).

In 2015, Anthony and Brown contributed to a study of ancient DNA that suggested Bronze Age humans moved westwards from the Eurasian steppe about 4500 years ago, leaving a significant genetic imprint on European populations. The archaeological evidence indicates the steppe communities may have had a cultural impact on Europeans too.

For instance, prehistoric myths in some European Celtic cultures involve a rite of passage for young males being initiated into war bands, before going out to raid nearby settlements. A similar practice is also mentioned in early Greek texts. Many of these rituals involved boys symbolically transforming themselves into dogs or wolves, possibly after sacrificing these animals, says Anthony.

He also points out that the institution of youthful war bands based on wolves was around long after this Eurasian steppe culture disappeared. They even pop up in the founding myth of Rome, in which young boys Romulus and Remus are brought up by a wolf – Romulus eventually rounds up a band of itinerant boys and creates the city that bears his name. "The myths of the founding of Rome are full of references to youthful war bands," he says. ■



Set ancient stomachs growling?

## Galaxies with tentacles feed black holes

JELLYFISH galaxies are dead ringers for their aquatic namesakes, with blob-like bodies and star-studded tentacles that can be tens of thousands of light years long.

Now it seems these galaxies host highly active supermassive black holes, which may be fed by the same process that gives the galaxies their distinctive tentacles. The black holes are at the centres

of the galaxies and tend to devour stars and other matter, says Bianca Poggianti at the Italian National Institute for Astrophysics.

Out of a sample of seven jellyfish galaxies, Poggianti and her team found that six contained huge black holes eating up hot gas from within each galaxy (*Nature*, DOI: 10.1038/nature23462). This suggests there is something about jellyfish galaxies that makes them the ideal feeding ground for supermassive black holes, she says.

But Alastair Edge at Durham University, UK, isn't convinced there are active black holes in the galaxies

examined. "It's an interesting conclusion, but an ambiguous one," he says, warning that what looks like an active black hole may actually be the traces of a collision between two gas clouds.

Studying jellyfish galaxies could improve our understanding of how galaxies age and why their rate of star formation drops over time, says James Aird at the University of Cambridge.

The tentacles are formed by a

**"Something about jellyfish galaxies makes them the ideal feeding ground for supermassive black holes"**

process called ram pressure. As a galaxy moves through a dense galaxy cluster, the cluster's hot gas blows away the cooler gas in the galaxy. Long chains of stars later form from this cool gas trailing behind.

If enough gas is drawn away from the galaxy's body into its starry tentacles, its rate of star formation will slow down, Aird says.

Ram pressure also churns the gas, pushing some of it out of a stable orbit and into the black hole. This may explain why jellyfish galaxies seem more likely than other types of galaxies to have active black holes at their centres. Matt Reynolds ■

## Young runners remember better when old

CAN exercise during childhood protect you against memory loss many decades later? Exercise early in life seems to have lifelong benefits for the brain, in rats at least.

"This is an animal study, but it indicates that physical activity at a young age is very important - not just for development, but for the whole lifelong trajectory of cognitive development during ageing," says Martin Wojtowicz of the University of Toronto, Canada. "In humans, it may compensate for and delay the appearance of Alzheimer's symptoms, possibly to the point of preventing them."

Wojtowicz's team split 80 young male rats into two equal groups, and placed running wheels in the cages of one group for a period of six weeks. Around four months after - when the rats had reached middle age - the team taught all the rats to associate an electric shock with being in a specific box. When placed in the box, they froze with fear.

Two weeks later, the team tested the rats in three scenarios: exactly the same box in the same room, the same box with the room arranged and lit differently, and a completely different box in a different room.

The rats without access to a running wheel when they were young then froze the same proportion of times in each of these situations, suggesting they couldn't remember which one was hazardous. But those that had been able to run in their youth froze 40 to 50 per cent less in both altered box settings (*eNeuro*, doi.org/cbtj).

"The results suggest the amount of physical activity when we're young, at least for rodents, has implications for brain and cognitive health - in the form of better memories - when we're older," says Arthur Kramer of Northeastern University in Boston, who has found that, in humans, exercise stimulates the growth of new brain cells. Andy Coghlan ■



Is it crunch time? Check pulse

## Gamers' vital signs help their fans stay hooked

NEVER let 'em see you sweat. It might appear to be sound advice, but maybe not for people who stream their gaming online. They seem to do better with audiences if they broadcast details like their heart rate and sweat levels.

Lots of us now spend a big chunk of our time watching others play games. Roughly 10 million people tune in every day to watch the more than 2 million people who stream their games on platforms like the Amazon-owned Twitch. Many of these live-streamers hope to make it to professional e-sports contests, where the big names can take home millions of dollars.

But winning and keeping an audience is hard. There are lots of games to watch, and Twitch spectators are a fickle bunch. Some watch certain gamers consistently, others tune in for only half an hour every day, says Raquel Robinson at the University of California, Santa Cruz.

To keep viewers hooked, gamers

dip into an evolving bag of tricks, for example, sharing performance statistics, playing music and displaying live chat comments in a frame that surrounds the view of the game itself. Robinson has given them a new trick: a peek into the state of their own minds and bodies.

**"The signals are interesting to watch. Everyone likes the voyeurism of seeing someone else's insides"**

Robinson and her colleagues created a prototype tool called All the Feels. The software pulls physiological data from a Fitbit-like wristband and displays the readings in a bar graph next to the gaming window.

It also uses face recognition software to turn the player's emotional state into one more feature of the game. When it determines that their joy, surprise, anger, disgust, sadness or fear has hit a certain threshold,

the corresponding emoji flashes up on screen.

"Everyone likes the voyeurism of seeing someone's insides," says Regan Mandryk at the University of Saskatchewan, Canada.

The viewers Robinson's team tested the tool on certainly did. The team observed them as they viewed a single gamer, first during a 1-hour session without the biometric data in the video stream, and then 1 hour with.

In a survey, 70 per cent said they felt more connected when they could view the player's physiological state. The team also found that this more than doubled chat participation and the number of viewers who stayed the whole hour. The work was presented at the Foundation of Digital Games conference in Massachusetts on Wednesday (DOI: 10.1145/3102103).

Though this was only a small pilot study, Robinson says the biometric add-on has elicited interest even in people who never watch video gaming. "I can see it being a frontier for getting into the head of a professional athlete too," says Mandryk.

By Lin Woodward ■

# Toxic waters turn sea snakes black

Aylin Woodward

POLLUTION from mining activities may be encouraging some sea snakes to evolve black skins – the first evidence of “industrial melanism” in a marine species.

Industrial melanism has been seen in invertebrate species, most famously the peppered moth. During Britain’s Industrial Revolution, the frequency of dark-coloured versions of this moth skyrocketed. Schoolchildren are often taught that such insects blended in with the soot-covered bark of trees in industrial areas, so their odds of surviving and breeding rose – although this might be an oversimplification.

In vertebrates, industrial melanism is vanishingly rare, says Rick Shine at the University of Sydney, but the Indo-Pacific sea snakes he and his colleagues study may provide a good example.

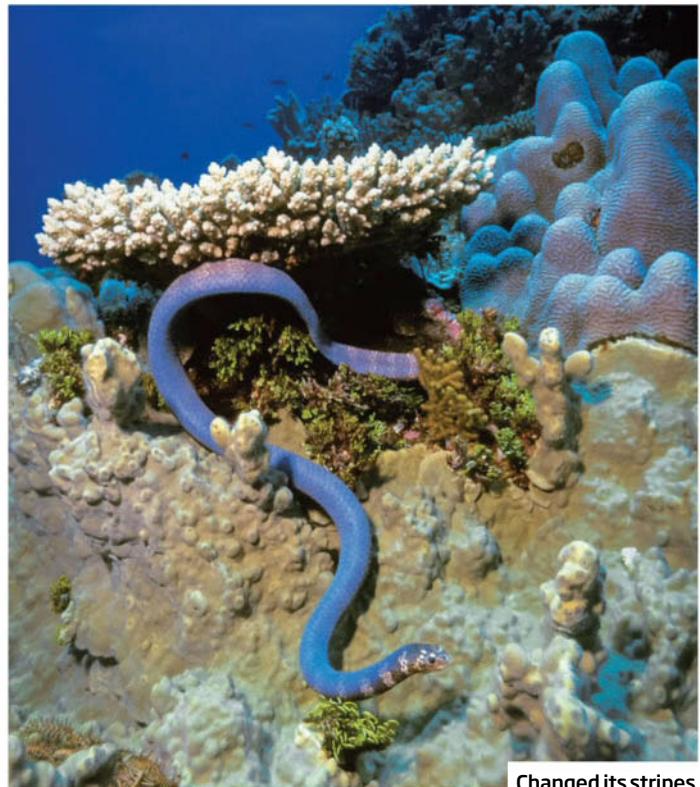
The turtle-headed sea snake (*Emydocephalus annulatus*) is largely found in certain tropical waters near Australia. Usually, the snakes look like black-and-white banded candy canes. But Shine and his colleagues found that

individuals living near polluted areas on the island of New Caledonia, a French overseas territory north-east of Brisbane, are entirely black.

The group already knew that pollutants such as arsenic or lead can bind to melanin, a dark pigment in the skin, and they wondered whether this might explain the black snakes. To find out, they collected and analysed the skins naturally shed – or “sloughed” – by the snakes.

Studying 17 turtle-headed sea snake sloughs, the group found that the concentrations of 13 trace elements – particularly cobalt, manganese, lead, zinc and nickel – were higher in snakes near urban areas, and higher in darker skin. Shine says similar concentrations of those trace elements have been reported to cause severe health problems in many domesticated species, from cattle to poultry.

What is more, Shine’s group found that the black sea snakes shed their skins twice as often as their lighter counterparts. This suggests the snakes are, indeed, adapting to deal with the polluted water – both by developing skin with a better capacity to bind



Changed its stripes

potentially harmful trace elements, and by shedding that skin more often to reduce their trace element load (*Current Biology*, doi.org/cbrc).

The shallow waters, particularly near the New Caledonian city of Nouméa, are highly polluted by intensive mining activity and industrialisation.

“Our urban, turtle-head sites are literally right beside the city

of Nouméa,” says Shine. The city also has a large nickel factory.

The study does seem to suggest the sea snakes are evolving in response to industrial pollutants, says Susana Clusella-Trullas at Stellenbosch University in South Africa. But she wants to know whether black sea snakes have higher survival rates and more offspring than their paler peers in these polluted environments. ■

## Polite robots learn to keep out of our way

FOR robots to coexist amicably with us, they need to learn about personal space. A software upgrade could help droids navigate crowded places like malls without jostling people around them.

Harmish Khambaita and Rachid Alami at the University of Toulouse in France wanted to programme a robot to mimic human manners like

stepping around one another, yielding to groups and respecting personal space. “The robot has to reason what the human would like to do and react,” says Khambaita.

This may seem akin to what driverless cars do, but humans are tougher to predict than traffic. “We know where the roads are going and what the crossing points are,” he says. “Indoors, the paths are not predefined. Anybody can move anywhere.”

In order to apply its etiquette lessons, the bot first needed a navigation upgrade. Robots normally

get around using a two-step process, with the robot trying to predict where other objects will be, then planning how to move. If something moves unexpectedly between the steps, the software can freeze up.

To fix this, the team wrote new software combining the steps, so the robot constantly adjusts its planned path (arxiv.org/abs/1708.01267). Two laser scanners let their robot detect

**“The robot mimics our manners – it has to reason what a human would like to do, and react”**

objects such as furniture, and a motion capture system tracked human positions using markers stitched into helmets that volunteers wore. Every tenth of a second the robot scanned for changes, then updated its predictions and trajectory, all while remaining fastidiously polite.

The team tested their robot in a 15-by-20-metre hallway with rooms on both sides. It was able to avoid bumping into people when someone was walking towards it, and when two people were passing on either side. It also yielded to a person emerging from a doorway. Aylin Woodward ■

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## FIELD NOTES Kamloops, British Columbia

# Facing Canada's wildfire disaster

Mika McKinnon

IT'S stiflingly hot and I'm trapped inside a dome of smoke. I know I'm in a river valley nestled within mountain ranges, but the visibility is cut so low that I can't see any of the peaks that dominate landscapes across British Columbia. It's the worst documented wildfire season since 1958.

"We have a very significant fire season unfolding," says Daniel Perrakis, a fire research scientist at the Canadian Forest Service. Over 591,000 hectares have burned so far.

I've left my coastal home in Vancouver and travelled to Kamloops to support evacuation efforts. Shifting winds have helped funnel smoke into the city, filling the air with fine material that makes breathing difficult. My eyes sting when I walk outside.

The story of how things got like this is a slow-speed disaster of climate change, a beetle invasion and the unintended consequences of well-meaning policy gone wrong.

British Columbia is a mountainous province in western Canada. It is more than half covered in forest, with lodgepole pine dominating every

ecosystem except the alpine tundra. Over the past century, the forest industry has transformed native woodland into denser, more homogenous stands of trees by suppressing fires and replanting the area with only the most economically valuable species for the timber industry.

An unintended recent consequence has been a province-wide outbreak of the native bark beetle that has devastated the region's forests, particularly between 2006 and 2008.

The dense, homogenous stands of lodgepole pine allowed the beetles to spread quickly, while a changing climate reduced the severity and duration of winters that historically kept the beetle population in check.

I've grown accustomed to seeing the once-green mountain slopes spotted with beetle-killed trees: first, the needles on one pine turn red as it dies, then more and more trees follow in speckled red waves. Later, the needles drop, leaving trees that look like grey, dry skeletons.

Now, over 11 per cent of the province is covered in a forest graveyard of dead trees.



Beetle-enhanced burn

CANADIAN PRESS/REX/SHUTTERSTOCK

The dying trees in the "red attack" phase are already known to pose a high fire risk. "We saw fire spread rates two to three times higher in these red-attacked stands," says Perrakis.

But starting in around 2011, forests became dominated with the grey tree skeletons – and we don't yet fully understand how this "grey attack" phase affects wildfires. Firefighting

efforts this year will provide invaluable experience for tackling future blazes in forests that have reached this stage.

During the drive home, I pass through a recently burned area. Helicopters with buckets of water cross the highway, dumping their load on fires I can smell but not see. Smoke thins over the 500-kilometre journey home, but never disappears. ■

## Smart cameras spot dirty hands in hospitals

IF YOU end up in a hospital in Europe, you have a 1 in 20 chance of acquiring an infection. Despite campaigns and gel dispensers, one of the leading causes is still poor hand hygiene.

In a recent pilot study, researchers may have found the solution. Using a combination of depth cameras and computer-vision algorithms, they tracked people around two hospital wards and automatically identified

when they used gel dispensers. The trial was so successful that the group is going to kit out three hospitals for a year, to see if the system can reduce the acquired infections.

"We're trying to shed light on the dark spaces of healthcare," says Alexandre Alahi at the Swiss Federal Institute of Technology in Lausanne.

During a busy Friday lunchtime, the team collected anonymised images from cameras overlooking corridors, patient rooms and alcohol-based gel dispensers, among other places. Of the 170 people the cameras recorded entering a patient's room, only 30 used the gel dispensers correctly.

The team then trained its algorithms to exclusively detect healthcare staff, track them and monitor their hand hygiene. Once trained up, the system could tell with 75 per cent accuracy whether people had used the dispensers ([arxiv.org/abs/1708.00163](https://arxiv.org/abs/1708.00163)). A human attempting comparable monitoring during the same period was only 63 per cent accurate.

This kind of surveillance could

**'Of 170 people recorded entering a patient's room, only 30 correctly used the gel dispenser'**

deliver important and counter-intuitive insights.

Philip Polgreen at the University of Iowa has used similar wearable technology to monitor hand hygiene, and made discoveries that would have escaped human observers. For example, some individuals turned out to be far more important than others for controlling the problem: "We found that if you can improve the behaviour of a few, very well-connected people, you end up having a much bigger effect than when trying to target the overall average. This can tell us how to stop outbreaks," says Polgreen.

Timothy Revell ■

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## AI artist paints reality by numbers

Matt Reynolds

TAKE a good look at the German street pictured above. The image could be a blurry dashcam photo, or the work of one of those apps that turns snaps into paintings.

But you won't find this street anywhere on Google Maps. An imaginative neural network created it by stitching together its memories of real streets it was trained on.

Nothing in the image actually exists, says Qifeng Chen at Stanford University, California, and Intel. Instead, his AI works from rough layouts that tell it what should be in each part of an image. The centre might be labelled "road", while other sections are labelled "trees" or "cars" – it's painting by numbers with an AI as artist.

Chen says the technique could eventually create game worlds that look truly real. "Using deep learning to render video games could be the future," he says. He has already used the algorithm to replace the game world

in *Grand Theft Auto V*.

Noah Snavely at Cornell University, New York, is impressed. Generating realistic-looking artificial scenes is tricky, he says – even the best existing approaches can't do it well. Chen's system creates the largest and most detailed examples of this kind he has seen.

Snavely says the technology could allow people to describe a world, and then have an AI build

**"Nothing in this image actually exists – it was generated by the memories of an AI"**

it in virtual reality. "You could conjure up a photorealistic scene just by describing it aloud," he says.

At the outset, Chen's system is fed a photo of a real street it hasn't seen before. Crucially, humans have labelled the image to indicate which bits are cars, people, roads and so on. The AI then uses this as a template to generate a completely new image.

The system was previously trained on 3000 images of German streets, so when it comes across a part of the photo labelled "car", it draws on its training to put a car there in its own creation ([arxiv.org/abs/1707.09405](https://arxiv.org/abs/1707.09405)). Intel researchers will present the work in October at the International Conference on Computer Vision in Venice, Italy.

The algorithm was also trained and tested on a smaller database of photos of domestic interiors, but the results were less realistic. Snavely says achieving its full potential will require a data set that captures the true diversity of the world.

Chen says the system still has a long way to go before it can build photorealistic worlds. Right now, the images it produces have a blurry, dreamlike quality, as the neural network isn't able to fill in all the details. He is already working on a larger version that he hopes will be much more capable.

But when it comes to virtual reality applications, that dreamlike nature might not be such a bad thing, says Snavely. We are used to seeing super-slick worlds on film and in video games, but there's not quite that level of expectation when it comes to VR. "You don't need total photorealism," he says. ■

## CRISPR pigs could donate organs to us

TRANSPLANTS from animals are a step closer, after the birth of piglets that have had harmful viruses in their DNA inactivated using gene editing.

More than 1000 people in the UK die every year for lack of a donor organ. As pigs are similar to us in size and anatomy, there's hope we can use their organs to tackle this shortage – an idea known as xenotransplantation.

But pigs have viruses embedded in their DNA. When pig cells are grown in a dish with human cells, such porcine endogenous retroviruses (PERVs) cross into the human cells. Were they to do the same if pig organs were put into people, they might cause cancer.

Luhan Yang of Boston biotech firm eGenesis and colleagues previously used the gene-editing technique CRISPR to disable PERVs in pig cells grown in a dish. Now they have taken genetic material from such cells and, using a similar technique to the one used to clone Dolly the sheep, put it into pig eggs. They then implanted these into sows, which went on to give birth to clones that are the first PERV-free pigs. "This is a great step forward for xenotransplantation," says Joachim Denner of the Robert Koch Institute, Germany.

So far, 37 such piglets have been born and 15 are still alive (*Science*, doi.org/cbq8). It is too early to say if this group has a higher death rate than normal, because piglets often die from infections, says collaborator George Church of Harvard University.

The team plans to create pigs that have also been altered to make them more immunologically similar to people. In theory, this should mean transplanted organs are less prone to attack by a recipient's immune system.

But Robin Weiss of University College London, who discovered PERVs, says there are other viruses in the pig genome that might jump to people, so although the risk has been reduced, it has not been eliminated.

Clare Wilson ■



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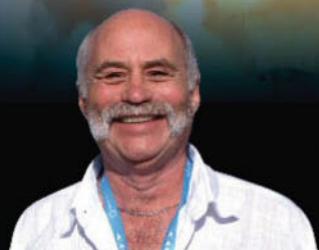
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## Primate brains have a distinct way of reacting to VIP faces

TWO newly identified brain areas in rhesus monkeys seem to help the animals recognise familiar faces.

We already knew that areas of the temporal and prefrontal cortex are involved in unfamiliar face perception in rhesus monkeys. Now, Sofia Landi and Winrich Freiwald at Rockefeller University in New York have identified additional regions that play a part in the perception of both unfamiliar and familiar faces.

The pair looked at whole-brain fMRI scans of four monkeys while the animals examined photos of familiar and unfamiliar monkeys. Both sets of photographs sparked

activity in two regions in the anterior temporal lobe.

Landi then probed the behaviour of those regions in more detail by presenting the monkeys with faces that were either personally or just visually familiar. It's like the difference between us seeing a picture of our best friend or that of a celebrity, she says.

She found that the two new areas activated almost 50 per cent more when the monkeys saw personally familiar faces as opposed to visually familiar and unfamiliar ones.

What's more, when Landi showed the monkeys blurred images of personally familiar faces that then slowly pulled into focus, brain activity in the two regions jumped at the moment the face became sharp enough to recognise – essentially documenting a neural "aha!" moment (*Science*, DOI: 10.1126/science.aan1139).

## Immunotherapy may halt diabetes

AN EXPERIMENTAL treatment for type 1 diabetes seems to stop it from getting worse. The therapy is designed to modulate the immune system, an approach normally used for autoimmune conditions like multiple sclerosis.

In type 1 diabetes, the immune system attacks cells in the pancreas that make insulin. But so far, no immunotherapy has been found to be safe for the condition.

Now a small trial suggests one method could be both safe and effective. It involves injecting short segments of an insulin precursor molecule into the blood, helping to train immune cells to stop attacking the insulin-producing pancreatic cells.

For six months, 21 people with type 1 diabetes received the injections every few weeks. A placebo group got

saline injections instead.

A year on, the placebo group had needed to raise their insulin doses by 50 per cent on average. But those who got the immunotherapy were stable, with no need to boost their insulin (*Science Translational Medicine*, doi.org/cbq3).

"We're looking at a drug that could be usable in five to 10 years, if everything goes well," says team member Mark Peakman at King's College London.

## Mars has millions of dust devils per day

THE Martian surface has 10 times more dust devils than we thought. These rotating columns form around low-pressure air pockets, flinging up dust that traps heat and helps control the planet's climate.

Brian Jackson at Boise State University in Idaho and his colleagues used data from barometers on landers there to calculate how many dust devils swirl across the planet. On any day, about one dust devil pops up per square kilometre of surface, at an average size of 13 metres across (arxiv.org/abs/1708.00484).

They usually last a few minutes before dissipating. If you were on the surface, you might be able to see dozens of dust devils at any one time, says Jackson. Understanding them will be important for exploring Mars, as the static electricity from grains rubbing against one another could disable electronics, he says.

## AI learns about the world from video

AN ARTIFICIAL intelligence has taught itself to recognise concepts just by watching snippets of video.

Usually, to learn, an AI relies on humans to provide labels. But the new system, developed by Relja Arandjelovic's team at Google DeepMind, simply matches up what it hears in audio with what it sees in related video. For example, from a photo of someone clapping and the sound of clapping, it was able to grasp the idea of clapping even though it had never learned the word.

After viewing 400,000 unlabelled videos, it also learned to recognise crowds, tap dancing and water (arxiv.org/abs/1705.08168). The team thinks this could lead to an AI that learns about the world by watching YouTube.

## Moon's magnetic field lasted aeons

THE moon's magnetic field may have lasted at least a billion years longer than we thought, according to tests of a moon rock that formed between 1 and 2.5 billion years ago.

Sonia Tikoo at Rutgers University in New Jersey and her colleagues heated the lunar sample to 780°C, close to the temperature at which it formed, to reveal preserved traces of its old magnetic field.

When hot magnetic rocks are exposed to a magnetic field, their electrons align with the field like tiny compasses. As the rocks cool, those orientations, and with them the magnetic field, are set in stone.

Tikoo measured the moon's field at around 5 microtesla, about 10 times weaker than Earth's magnetic field (*Science Advances*, doi.org/cbqj). Previous studies showed that 4 billion years ago the strength of the moon's field was about 100 microtesla.

Around 3 billion years ago, that magnetic field died off as the moon drifted further from Earth. Before that, it was close enough for Earth's gravity to pull and rotate its rocky exterior and jostle its molten centre. The motion of the liquid metals in the moon's core would have created a strong magnetic field.

Tikoo says that this later weaker field may have been sustained by the churning of the moon's liquid core as it cooled.



## Goldfish survive months without oxygen by brewing booze

GOLDFISH and their wild crucian carp relatives can survive for five months without breathing oxygen – and now we know how.

The fish carry a set of enzymes that, when oxygen levels drop, helps convert carbohydrates into alcohol that can be released through the gills.

For most animals, including humans, a lack of oxygen can be fatal in minutes. We can metabolise carbohydrates without oxygen, but the process generates toxic lactic acid that quickly builds up in our bodies.

The carp – and goldfish – have developed a workaround. When they metabolise carbohydrates anaerobically, the end product is alcohol, which is easier to remove.

"The adaptation is very rare among animals," says Michael Berenbrink at the University of Liverpool in the UK.

Berenbrink and Cathrine Fagernes at the University of Oslo, Norway, and their colleagues discovered that the fish carry an extra set of the enzymes that specifically helps generate alcohol when metabolism occurs in the

absence of oxygen (*Scientific Reports*, doi.org/cbqj). The enzymes act in essentially the same way as brewer's yeast.

The adaptation evolved 8 million years ago in the common ancestor of carp and goldfish, via a process known as whole-genome duplication. This is when an organism by chance ends up with an extra set of its genes, which can then be repurposed.

By making alcohol, crucian carp and goldfish can survive all winter in icy ponds when other fish would suffocate, says Fagernes.

## Mystery of missing tsunamis explained

WHY does one underwater landslide trigger a devastating tsunami, but another of similar size barely cause a ripple? The answer may lie in the way the sediments slide.

Finn Løvholt at the Norwegian Geotechnical Institute in Oslo and his colleagues produced computer models of two types of underwater landslides and compared their tsunami-generating potential.

The first model, a "retrogressive slide", starts at the bottom of a slope and releases its energy block by block, in a staggered series of smaller landslides.

The second model, a "debris slide", begins as a retrogressive slide but spreads much more quickly up the slope, leading to multiple sediment blocks failing in one go.

Løvholt and his colleagues found that only the second type has tsunami-generating potential. This might explain why the Storegga slide off the coast of Norway 8000 years ago generated a massive tsunami, but a slide in the region 4500 years ago did not (*Geophysical Research Letters*, doi.org/cbq9).



VANDERLI RIBEIRO PHOTOGRAPHY/GETTY

## Piglets learn how to walk super-fast

NEWBORN piglets may totter slowly at first, but within 8 hours they are trotting with confidence. New evidence suggests that this ability is not something they are born with, but must largely be learned.

Chris Van Ginneken of the University of Antwerp in Belgium and her colleagues analysed video of 14 piglets toddling on 10 occasions over the first four days of life.

They examined the piglets' speed and stride length, as well as how often they took steps and how long each foot spent touching the ground.

From birth, the piglets knew the

fundamentals of limb coordination: their feet hit the ground in the same order as in adult pigs. But other aspects of walking – such as stride length relative to body size and matching the movements of their left and right limbs – took a few hours to develop. It took 8 hours for the piglets to walk like adults (*Journal of Experimental Biology*, doi.org/cbqj).

The results suggest that the footfall pattern of piglets is "completely innate", the team writes, whereas the other elements of walking are not – although they develop very soon after birth.

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## Banking on the future

Is storing umbilical cord blood a good idea, asks **Jessica Hamzelou**

IT IS only half a cup of blood, but it could change your life. Blood taken from a newborn baby's umbilical cord is a rich source of uniquely potent stem cells. Parents are often encouraged to donate it to a public bank, so that it might be used to treat others with rare blood disorders.

However, there is no guarantee you will get to use your own blood later if you need it. This was not a problem when the disorders it treated were exceptionally rare. But this is changing.

Even now, researchers are busy investigating whether cord blood could be used to treat more common disorders including heart disease, diabetes and Alzheimer's. Hundreds of trials are under way, and some are

starting to show positive results.

Perhaps unsurprisingly, a growing number of people are choosing to bank their children's cord blood privately, even before the science is settled. Given that they might not need it for decades, should you hedge your bets and bank your baby's cord blood?

The official line – touted by organisations including the American Congress of Obstetricians and Gynecologists and the American Academy of Pediatrics – is that private banking should be discouraged, or at least not recommended, because it is

**"Researchers are busy investigating whether cord blood could treat common disorders like diabetes"**

a waste of time and money.

"Frankly, I encourage parents to put the money towards college education," says Jeffrey Ecker at Massachusetts General Hospital in Boston.

In the UK, you'll pay between £1000 and £2000 to bank the blood in the first place, followed by an annual storage fee of around £100. Costs are similar in the US, where banking cord blood for 20 years will set you back around \$4000. While it is free to donate, there is no guarantee you will get to use the blood later if you need it.

That doesn't matter much based on current uptake. Since banking took off in the 2000s, an estimated 750,000 units of cord blood have been donated publicly, but only

around 35,000 transplants have been performed. That's a take-up rate of less than 5 per cent. A whopping 4 million units are thought to be stored in private banks, though no figures are available on how many of these have been used.

With such a big public supply, private banking seems like an unnecessary expense. As rare disorders are, well, rare, there is only a vanishingly small chance that someone whose parents banked their cord blood will end up using it for such conditions.

However, according to a new wave of research, there could be a lot more to cord blood than just treating rare diseases.

That's largely down to its rich supply of stem cells, which have

the ability to become many other cell types in the body. A newborn's cord blood cells are particularly "naive", meaning they are thought better at morphing into new types than other stem cells.

That makes cord blood useful for treating rare blood cancers and bone marrow disorders. These diseases can wipe out a person's blood cells, as can treatment itself, but stem cells can replenish the body's blood cell supply.

### Reject me not

Adult bone marrow can be used as a source of stem cells, but cord blood cells seem to be more effective. Their naive state makes them more malleable and less likely to be rejected by the body's immune system. "The advantage is that umbilical cord blood doesn't have to be perfectly matched," says Karen Ballen at the University of Virginia.

These benefits have led to an explosion in research – if the cells can form beating heart tissue, could they cure some cardiovascular diseases? If they could become neurons, might they treat neurodegenerative disorders like Alzheimer's? The possibilities seem endless.

In 2013, David Allan and his colleagues at the Ottawa Hospital Research Institute in Ontario assessed the research into cord blood. The group hunted for the results of published studies in people. "There were lots of small reports, with no control groups," says Allan, meaning no one was given a placebo treatment for comparison. "If there's no control group, you don't know if the treatment is beneficial – it could be harmful."

When the team repeated their study this year, they found that research into cord blood had exploded. "We found 57 clinical trials that included over 800 patients," says Allan. Sixteen of these included a control group. Most of the trials were conducted in China and the US (*Biology*

of Blood and Marrow Transplantation, doi.org/cbhr).

And these are just the published results – hundreds more trials are looking at a range of diseases and disorders and are yet to report their findings.

The most commonly studied is cerebral palsy, a group of disorders caused by abnormal development or damage to the brain that can impair movement. To date, results have been published from four placebo-controlled trials, which included a total of 141 people. All four studies found that an infusion of cord blood seemed to be beneficial, lessening the symptoms of people with cerebral palsy.

Three trials investigated cord blood for treating type 1 diabetes, which tends to start early in life, and is caused by the immune system attacking the body's insulin-producing cells. So far, results are mixed, but Michael Haller at the University of Florida is hopeful.

That's because cord blood has unusually high levels of a type of immune cell that dampens down the activity of other immune cells. These regulatory T-cells are lacking in people with type 1 diabetes, says Haller, who is running his own clinical trial. "There's the potential to give them back," he says.

There are plenty of trials testing cord blood for disorders of the brain and spinal cord, too. Allan's team found published results from 25 clinical trials of neurological disorders, including traumatic brain injury, stroke, spinal cord injury and degenerative conditions like multiple sclerosis and motor neuron disease. These are showing positive results: cord blood reduces inflammation and boosts the growth of new neurons and blood vessels.

So it seems cord blood shows promise for future treatments, but Allan is keen to stress that they are still very much preliminary. "We can't say these

### I PAID £2000 TO BANK MY SON'S CORD BLOOD

The number of people banking their newborn baby's cord blood is on the rise, but what is the experience actually like?

Alan\* and his wife decided to privately store their son's cord blood when he was born in 2005. "We thought, if we are ever going to need this, we're really going to need it," says Alan. "We thought, let's just go for it."

The couple had heard about cord blood banking, and had seen leaflets from cord blood banks in their local hospital. "At the time, there was a lot of excitement surrounding stem cells," says Alan. "We'd thought we'd err on the side of the potential for the future."

That potential was worth the one-off fee of £2000 for Alan and his wife. "We had to think carefully about spending that money," says Alan. "It's expensive, we didn't know if we would end up using the cord blood."

Eleven years later, Alan did want

to try using the stored blood. The couple's son developed a heart condition called dilated cardiomyopathy, which leaves the heart unable to function properly.

"I had read about the possibility of treating his condition with stem cells," says Alan. "But a clinical trial of stem cells for his condition had been carried out a few years before, and found that it didn't work, so the hospital that was treating him had no interest in using his cord blood. He ended up having a heart transplant."

Alan doesn't know whether his son, or any other members of his family, will ever use the banked cord blood. "It seems that the conditions cord blood could be used for are limited and rare," he says. "We found ourselves in an extreme situation that we'd never imagined, and found out that we couldn't use it. If forced, I would probably say that we wouldn't go for it again."

\*Not his real name

are proven treatments," he says. "We need bigger studies and more long-term evidence."

And if some treatments do work, there are still questions over exactly how the cord blood should be obtained, stored and treated. Some groups inject the stored cord blood as it is, but others are working on ways to isolate the most potent stem cells from the

**"We can't say these are proven treatments, we need bigger studies and more long-term evidence"**

mix. It's also unclear if we can rely on cord blood stored longer than 20 years, as normal transfusion blood is not kept this long.

Perhaps one of the biggest questions is how much better a person's own cord blood is compared with a stranger's. Although donated cord blood is more likely to be accepted by the immune system than adult

stem cells, there is still a risk of rejection triggering potentially life-threatening graft-versus-host disease. That risk disappears if a person uses their own cells.

Your own cord blood isn't always a silver bullet, though. If a person has a genetic disorder, their cord blood cells will carry the same mutation, and so will be useless as a treatment. But they could still benefit from the cord blood of a family member, which is also less likely to be rejected by their immune system.

So should you consider privately banking your baby's blood in case they want to use it, sometime in the future? The treatment might not be possible today, but the field could look totally different in 20 years' time, says Allan. "I don't know the answer right now," he says. "It's like buying insurance, I guess." Parents will have to look at the potential – and their finances – for themselves. ■

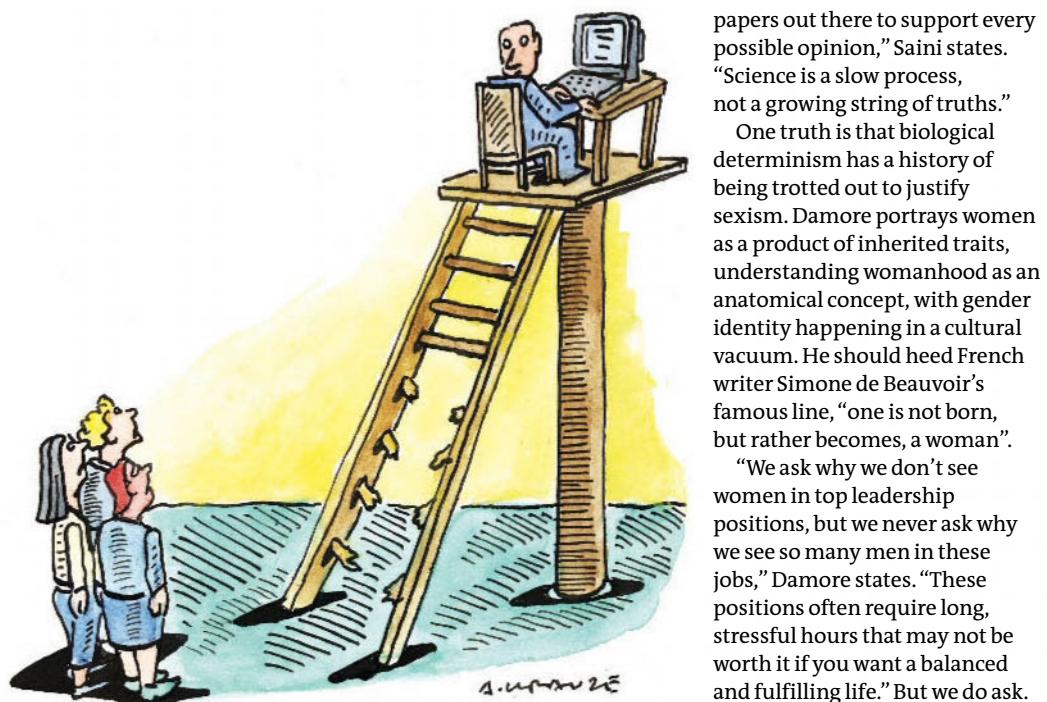
# No way up this ladder

Memo to all the bros: sexism, not biology, is what stops women advancing in the technology industry, says **Lara Williams**

**SEXISM** in the tech industry is a long-standing problem. The latest manifestation comes in the form of an internal memo written by one James Damore – an engineer at Google (since fired).

Titled *Google's Ideological Echo Chamber*, the “anti-diversity” essay comprises 10 pages of bad science and biological determinism. Damore outlines research that he says supports his view that women are intrinsically different to men, and broadly less likely (and capable) of working in the same careers and industries.

Some of the science he uses to prop up his argument, as Angela Saini wrote in *The Guardian*, is valid; but only insofar as there is a school of neuroscientific thought venturing theories of anatomical differences between men and women’s brains. Equally, there is a school of thought dismissing them. “There are published scientific



papers out there to support every possible opinion,” Saini states. “Science is a slow process, not a growing string of truths.”

One truth is that biological determinism has a history of being trotted out to justify sexism. Damore portrays women as a product of inherited traits, understanding womanhood as an anatomical concept, with gender identity happening in a cultural vacuum. He should heed French writer Simone de Beauvoir’s famous line, “one is not born, but rather becomes, a woman”.

“We ask why we don’t see women in top leadership positions, but we never ask why we see so many men in these jobs,” Damore states. “These positions often require long, stressful hours that may not be worth it if you want a balanced and fulfilling life.” But we do ask. Men do not have a biological

## Good without god?

Even in secular states, anti-atheist bias rules. Will it ever fade away, wonders **Bob Holmes**

ARE atheists as moral as religious believers? Surprisingly, even atheists seem to think not. This belief is almost certainly wrong, but it reflects a long-standing bias that morality stems from faith.

New evidence comes from a study that polled more than 3000 volunteers from 13 nations with a wide range of faiths to glean

views on atheists and believers. A trick was used to get people to reveal what they really think. Volunteers were told a story about a man who tortured animals as a child and grew up to become a serial killer. Half were asked whether it was more likely he was A) a teacher, or B) a teacher who did not believe in a god. For the

other half, option B was a teacher with religious belief.

The correct answer is always A. There are more teachers as a whole than teachers who are atheists or teachers who are believers. But the study found people chose option B when it matched their intuitive notion of how things should be.

In almost every country polled, more people made the error when B was the atheist teacher. This suggests they found an atheist

**“In almost every country people found an atheist serial killer more plausible than a religious one”**

mass murderer more plausible than a religious one. Remarkably, even those who did not believe in any god showed the same pattern.

But this is not borne out by the facts. In both the US and the UK, atheists are under-represented in the prison population and over-represented among civil rights and anti-war activists. The world’s most secular countries – notably in Scandinavia – are among the most peaceable and civic-minded. So why the bias against atheists?

One reason may be that the basis of religious morality is clear. Less so for atheism. Widespread atheism is also fairly new. Even today, most atheists were raised in

predisposition towards stressful hours any more than women. And a “balanced and fulfilling life” comes with different expectations if it is likely you are the half of a partnership that has to pick up most domestic and child-rearing duties. Structural differences that create inequality go way beyond genitals and genetics.

Damore outlines Google’s diversity strategies – mentoring and classes for marginalised candidates – as harmful, stating they increase tensions. They increase tensions only for those with a sense of entitlement, threatened by the usurping of a status quo they benefit from.

What he does not address is the prevalence of an aggressively masculine “bro-culture”, making those long office hours even less palatable for women. A 2016 survey found that 60 per cent of female staff in tech roles reported unwanted sexual advances and 87 per cent reported demeaning comments from male colleagues.

Damore will no doubt be happy to know that 69 per cent of Google’s staff is male – so the damaging culture of gender parity he seems to fear is still a long way off. Phew. ■

Lara Williams is a writer based in Manchester, UK

religious homes and bring that baggage to matters of morality. As societies become more secular, the hope is that this influence will recede within a few generations.

Finland, a secular country, was the only one of the 13 in which participants showed no anti-atheist bias. Those behind the study plan to examine whether Finland has a longer secular tradition, and hence had more time for the instinctive moral/religious link to dissipate. Let’s hope this helps end the idea that you can’t be good without god. ■

Bob Holmes is a consultant for New Scientist

## INSIGHT Natural birth reversal



Alive and well by any means

# Time to stop pushing natural over safe

Clare Wilson

FOR decades, women have been encouraged to give birth naturally – that means avoiding all medicines and interventions, including continuous monitoring of the baby’s heart rate and caesarean sections.

But now, several events suggest the pendulum is swinging back the other way. In May, the UK’s Royal College of Midwives (RCM) quietly cancelled a long-standing campaign to promote natural births. Separately, doctors are beginning their own more proactive approach to ensuring interventions happen as soon as they are needed. And campaigners have formed a new pressure group called “Maternity Outcomes Matter” to ensure all healthcare staff prioritise safety over the process of childbirth.

What’s behind this sudden backlash? Isn’t natural birth a good thing?

While it is sensible to avoid medical interference where possible, take this approach too far and childbirth becomes more dangerous, leading to brain-damaged

babies and avoidable deaths.

Some of these occurred when women were denied caesarean sections even after begging for them.

The natural childbirth movement within the UK health service is mainly driven by midwives, who oversee the care of all women at low risk of complications, and vastly outnumber obstetricians. That means midwives are often the ones who decide whether to call in doctors when a birth seems to be going wrong. If the midwife overseeing your care has a

### “Midwives over-prioritised natural childbirth leading to 12 avoidable deaths”

natural-birth agenda that is at odds with your own, you may be overruled.

As part of its natural birth campaign, the RCM website until recently advised midwives that during births they should “wait and see – let natural physiology take its own time”, and if uncertain they should “trust their intuition”.

Such policies are directly at odds with safety advice to consult

guidelines on how frequently to check the baby’s heart rate, for instance, and to seek second opinions to make sure danger signs are not being missed.

Ignoring such guidelines can be dangerous. A recent inquiry found that three-quarters of the 1136 babies who died or were brain-damaged during birth in the UK in 2015 might have been saved with better care.

Thankfully, the bad RCM advice has now been taken down, although it’s a shame the midwives’ leaders have tried to do this quietly. Their climbdown was only highlighted by safety campaigner James Titcombe, whose own baby died at a hospital run by Morecambe Bay health trust in 2008. Services there were judged by an inquiry to have been run by “musketeer” midwives who overprioritised natural childbirth, leading to 12 avoidable deaths.

Back-pedalling on the quiet means news will spread more slowly to grassroots midwives and schools of midwifery. There is great variation in practice, and while there are many excellent midwives who prioritise safety, there are also those who may resist change.

If the RCM genuinely wants to reduce avoidable bereavements, it should shout about its change of heart from the rooftops. Most people think of medicine as a field where decisions are guided by evidence rather than ideology. That should be true for childbirth too. ■

# The air we breathe

Engine exhaust is a major contributor to pollution in cities. But BASF's innovative engineering and clever catalytic chemistry is helping to produce cleaner air

**W**ith their sporty curves and chrome fittings, few would disagree that classic 1960s cars have the aesthetic edge over modern cars. But beneath the stylish bodywork lies a guilty secret. The toxic emissions from one 1960s car are about equal to those from 100 modern cars.

That's thanks in no small part to the invention of the catalytic converter. In the last four decades, these devices have prevented the release of more than one billion tonnes of pollutants.

But consumers, politicians and activists want more. Modern catalytic converters can reduce more than 90 per cent of the harmful stuff in exhaust fumes. Now scientists and engineers at chemicals giant BASF are working to increase that figure even further to help vehicle makers meet ever more demanding clean air laws.

At the heart of this effort is the catalytic converter, first developed for cars in 1973 by researchers at the US mineral refining company, the Engelhard Corporation. The work was triggered by the 1970 US Clean Air Act which forced car-makers to dramatically reduce harmful emissions.

Catalytic converters are honeycombed

ceramic bodies with a huge internal surface area. This surface is coated with a formulation containing metals, such as platinum, palladium and rhodium, which catalyse various reactions. The first converters oxidised carbon monoxide into carbon dioxide and unburnt hydrocarbons into carbon dioxide and water. Later models, called "three-way" converters, also split harmful NO<sub>x</sub> (nitrogen oxides) into nitrogen and oxygen.

Further clean air regulation has pushed this technology forward. Between 1992 and 2014, a series of European regulations reduced carbon monoxide emissions from new petrol cars by two-thirds and hydrocarbon and NO<sub>x</sub> emissions by almost an order of magnitude.

BASF has been a significant player in these reductions. In 2006, it bought Engelhard and today it is one of the world's leading suppliers of catalytic converters for the automotive industry, employing catalysis scientists worldwide.

These experts are working to cut emissions even further. One recent BASF innovation is a synthetic catalyst called copper chabazite that helps remove 95 per cent of NO<sub>x</sub> from diesel exhaust.

This works in conjunction with urea fed into the exhaust stream, which decomposes into ammonia.

The copper chabazite contains regularly-spaced pores where the ammonia and nitrogen oxide molecules react to form nitrogen and water.

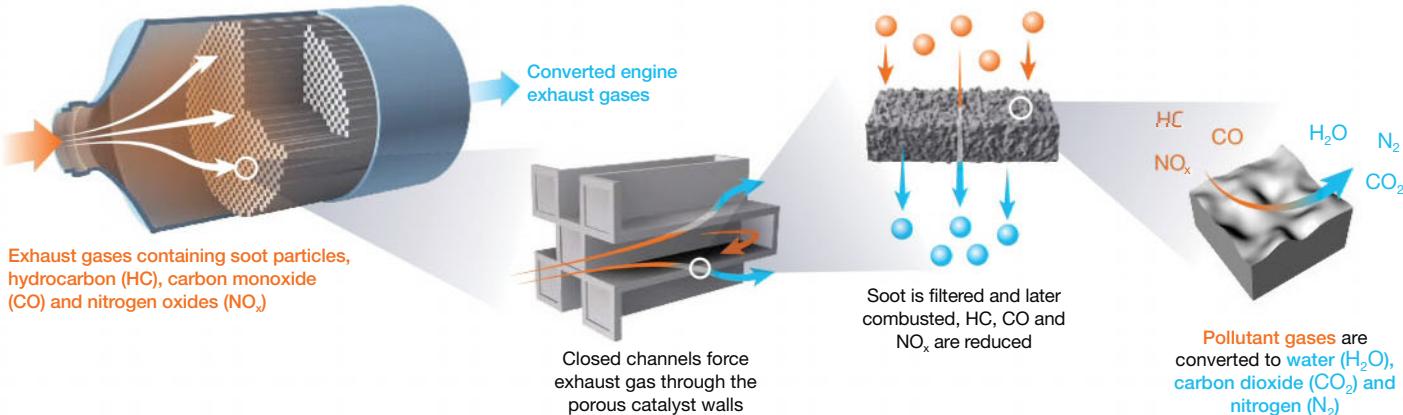
"Copper chabazite provides both the excellent catalytic activity required for the NO<sub>x</sub> conversion, and the structural stability needed for long-term durability," says Ahmad Moini, a member of the team that patented this technology in 2009.

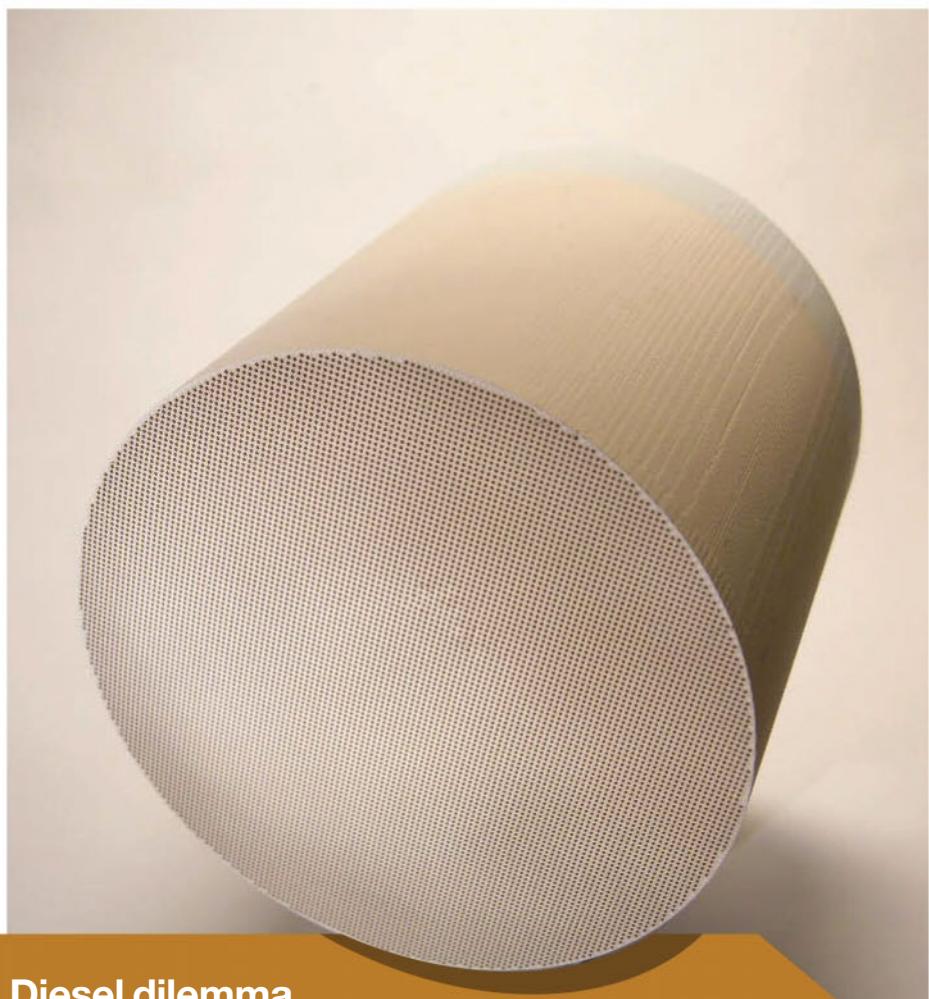
The way catalytic converters are made is important too. At the BASF emissions catalysts facility at Nienburg in Germany, orange robotic arms orchestrate the coating of ceramic bodies in a creamy slurry containing chabazite. The coating takes place in a precise way to ensure the pores in the material are completely and rapidly coated.

It's here that BASF has developed the next generation of converters. Its team has designed these to meet the upcoming

Catalytic converters have prevented the release of over a billion tonnes of pollutants into the atmosphere

## How four-way catalytic conversion works





## Diesel dilemma

Diesel cars have had a mixed press. Not long ago, politicians were promoting their fuel efficiency – diesels produce up to 20 per cent less carbon dioxide than petrol equivalents.

But more recently, they have taken against diesel cars, especially after the VW emissions testing scandal, arguing that the nitrogen oxides they produce are an unacceptable health burden in cities. As a result, the mayors of Paris, Madrid, Athens and Mexico City have announced plans to ban diesel cars by 2025.

Now automotive industry leaders say this is a step too far. "We are seeing some cities proposing aggressive and irrational diesel-bashing moves," says Tilo Horstmann, Vice President BASF Mobile Emissions Catalysts.

Diesel vehicles do emit more NO<sub>x</sub> – on average 16.5 times as much as petrol versions, according to the UK Consumers' Association. However, this masks a huge variation within

the diesel fleet between older and newer cars.

Under European regulations, light diesel vehicles sold since 2014 must emit no more than 80 milligrams/kilometre of NO<sub>x</sub> in lab tests, compared to 500 mg/km for those sold before 2000. The equivalent limit for petrol engines is 60mg/km. From September, tougher standards will cut pollution further, limiting emissions even under real world driving conditions, not just in the laboratory.

But diesel engines are also more fuel efficient. So a fall in sales of new diesel cars will reduce the European Union's chances of meeting its target of cutting average CO<sub>2</sub> emissions of new cars from 130 g/km in 2015 to 95 g/km in 2021.

And therein lies the dilemma, says Frank Mönkeberg, Head of Application Engineering, BASF Mobile Emissions Catalysts. "Without diesel, Europe will not be able to comply with this limit."

European legislation that reduces by an order of magnitude the permissible amount of soot, or particulate matter pollution, that petrol engines can emit.

One way to do this is to fit an additional filter that removes this soot. But BASF scientists have come up with a better solution that combines particulate filtering with conventional "three way" catalytic conversion. Their trick was the catalysis of a tailored porous filter.

The new structure is a honeycomb of long parallel tunnels that allow the exhaust to enter. The gases pass through the tunnel walls where they are broken down in catalytic reactions. The converted gases then pass into another set of parallel tunnels and out of the converter.

The pores in the tunnel walls are too small for soot to enter and this is trapped and later burnt to form carbon dioxide. The new devices are called EMPRO™ Four-Way Conversion catalysts.

BASF had to overcome significant engineering challenges to make these devices. For example, it had to ensure that the filtering process did not significantly increase engine resistance, which would reduce power or increase fuel use. "We achieved that partly by developing a new process to apply our catalyst composition into the porous walls of the filter rather than onto them," says Torsten Neubauer, BASF Vice President Environmental Catalysis Research Europe. The first cars with BASF four-way conversion components hit the market last year.

Another challenge for Neubauer and his colleagues is to cater for hybrid cars. These constantly switch from electric motors to an internal combustion engine, which ends up running at a lower temperature than conventional car engines. So BASF is investigating ways to make catalysts more effective at these lower temperatures.

"We are working with vehicle manufacturers, parts makers and catalyst substrate suppliers to further reduce emissions, including in newer vehicle types," says Tilo Horstmann, Vice President BASF Mobile Emissions Catalysts. "I'm confident that by combining our key competencies, we can provide innovative solutions to drive sustainable motoring to the next level." ■

More at: [www.wecreatechemistry.com](http://www.wecreatechemistry.com)

# APERTURE





## Floating world

THESE black balloons show just how easily scientific principles can be transformed into art.

To create his work, Lithuanian artist Tadao Cern tied pairs of balloons together and filled them with gases of different densities. The ones floating at the top contain helium and the lower ones air. Each pair is sealed in a glass tank filled with a mixture of helium and air. The relative densities of the gases inside the balloons and inside the tanks allow the balloons to float, one above the other, seemingly fixed in place. The effect is strangely disconcerting.

Next Cern went supersized, making his own giant balloons from PVC that stretched up to 3 metres in diameter. Below, you can see some of his smaller home-made ones, each 1.2 metres across and filled with helium and heavier sulphur hexafluoride.

Cern says he wants the balloons to create a sense of playfulness, while also creating a sense of temporality since they will eventually burst.

"When you get into a room filled with hundreds of them floating in the middle of the room, it feels like you're in a virtual computer simulation," he says. Rachel Baxter



### Artist

Tadao Cern

tadaocern.com



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If we want to protect the world from jihadist terrorism, we need to understand who and what we are fighting.

Peter Byrne reports from Mosul, Iraq

# ROOTS OF TERROR

MERA MIRONOVA rides Humvee shotgun through Mosul's shattered cityscape. It is late January 2017. Iraqi prime minister Haider al-Abadi has just declared east Mosul liberated from three years of rule by Islamic State, or ISIS. Most jihadist fighters are dead or captured, or have crossed the Tigris to the west, digging in for a final stand. Left behind, biding their time, are snipers and suicide bombers.

Much of the population has fled to refugee camps on the outskirts. Those who stayed look lost and dazed. Men pull corpses out of houses destroyed by air strikes. Others cobble together street-corner markets, selling meat and vegetables imported from Erbil, 80 kilometres and another world away.

Few women are visible. Mironova stands out, dressed in combat trousers and a Harvard sweatshirt, wisps of blonde hair escaping her blue stocking hat. Despite travelling in an armoured car, she's clearly not a combatant. She's a social scientist, and her job is not to fight, but to listen, learn and record.

We stop for breakfast at My Fair Lady, a ramshackle restaurant that was a favoured eatery of ISIS fighters. The Iraqi special forces soldiers accompanying us say it has the best

pacha in town – steaming bowls of sheep brains and intestines stuffed with rice, with slices of black, fatty tongue and boiled oranges. Mironova orders a pizza.

A week later, a suicide bomber detonates himself at the entrance to the packed restaurant, killing the owner and several customers.

"The United States does not have a real counter-terrorism strategy," says Martha Crenshaw. Faced with continued waves of jihadist terror attacks, in the conflict zones of Syria and Iraq but also closer to home, the West seems at a loss to know what to do. Crenshaw is something like the doyenne of terrorism studies, with a half-century career studying the roots of terror behind her. She occupies an office at Stanford University just down the hall from Condoleezza Rice, the former US national security advisor who was an architect of the "global war on terror" declared after the attacks of 11 September 2001. "There is a vast amount of money being thrown into the counter-terrorism system and nobody is in charge," Crenshaw says. "We do not even know what success might look like. We are playing a dangerous game of whack-a-mole: terrorists pop up. We try to beat them down, hoping they will give up."

In July, al-Abadi was back in Mosul, this time to declare the final liberation of Iraq's second city. Near-saturation bombardment of the centre by the US Air Force and a casualty-heavy, house-by-house offensive led by Iraqi forces had eliminated most of the fighters holding the city where the leader of ISIS, Abū Bakr al-Baghdadi, had proclaimed its

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## DEVOTED TO THE CAUSE

What makes someone prepared to die for an idea? This is a question that concerns anthropologist Scott Atran of the University of Oxford's Centre for Resolution of Intractable Conflicts. Research he has led in some of the most embattled regions of the world, including in Mosul, suggests the answer comes in two parts. Jihadists fuse their individual identity with that of the group, and they adhere to "sacred values".

Sacred values are values that cannot be abandoned or exchanged for material gain. They tend to be associated with strong emotions and are often religious in nature, but beliefs held by fervent nationalists and secularists, for example, may earn the label too. Atran has found that people in fighting groups who hold sacred values are perceived by other members of their group as having a spiritual strength that counts for more than their physical strength. What's more, sacred values trump the other main characteristic of extremists: a powerful group identity. "When push comes to shove, these fighters will desert their closest buddies for their ideals," he says.

Atran argues that individuals in this state of mind are best understood, not as rational actors but as "devoted" actors. "Once they're locked in as a devoted actor, none of the classic interventions seem to work," he says. But there might be openings. While a sacred value cannot be abandoned, it can be reinterpreted. Atran cites the case of an imam he interviewed who had worked for ISIS as a recruiter, but had left because he disagreed with their definition of jihad. For him, but not for them, jihadism could accommodate persuasion by non-violent means.

As long as such alternative interpretations are seen as coming from inside the group, Atran says, they can be persuasive within it. He is now advising the US, UK and French governments on the dynamics of jihadist networks to help them tackle terrorism. Laura Spinney

caliphate in 2014. The liberation came at a huge price. Mosul lies in ruins, and tens of thousands of civilians are dead or wounded. Almost one million residents have been displaced from their homes.

The price has been paid not just in Mosul. In June, 206 civilians were killed in bombings and other attacks carried out or inspired by ISIS in Iraq, Afghanistan, Syria, Egypt, Iran, Australia, Pakistan and the UK, where radicalised ISIS supporters murdered eight in an attack near London Bridge on 3 June. A couple of weeks earlier, on 22 May, a 22-year-old British Muslim named Salman Ramadan Abedi detonated an improvised bomb laden with nuts and bolts at the entrance to the Manchester Arena, killing himself and 22 others, many of them children.

Why? Religious fanaticism? Groundless hate? Perverted ideology? Victory in the war on terror requires us to know what and who exactly we are fighting.



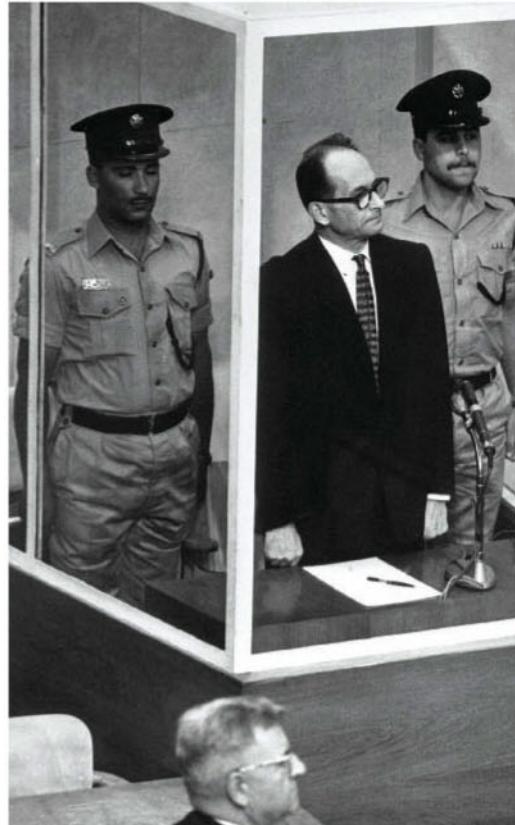
After breakfast, we accompany Iraqi commandos into abandoned houses that had been used by ISIS, wary of booby traps. We stare into darkened, steel-barred rooms used as jails for sex slaves and "kafirs", Muslims who fell afoul of ISIS. We inspect the labels on tin cans, torn cookie packaging and empty bottles of Scotch whisky.

The soldiers scoop up photographs, checkpoint passes and slips of paper with names and phone numbers. Mironova bags religious tracts written in Arabic and Russian. Many of ISIS's foreign fighters in Iraq and Syria are Chechynes and Tajiks. Someone hands Mironova a diary written in Russian. She reads out loud, translating a letter written by a woman to her jihadist lover.

"We are made only for each other, our marriage is sealed in heaven, we are together in this life and the afterlife, God willing. When you left, I counted the days until I got you back, my beloved. Now you are going to the war again; you may be gone forever. I will count the days until we meet again, my beloved Zachary." Following the letter, the woman had penned a recipe for a honey cake that requires a creamy milk not obtainable in Iraq. Jihadists dream of comfort food, too.



During the 1980s, Marc Sageman worked as a case officer for the CIA, operating armed cells resisting the Soviet occupation of Afghanistan.



The unremarkable Nazi bureaucrat Adolf Eichmann embodied the "banality of evil"

Now a forensic psychiatrist specialising in criminality and terrorism, he has been investigating what makes a terrorist for decades.

In his 2004 book *Understanding Terror Networks*, Sageman examined the motivations of 172 jihadist terrorists as revealed primarily in court documents. His conclusions fitted with decades of jail interviews and psychological studies showing that terrorism is neither solely reducible to ideological or religious motivations, nor to personality disorders. "Terrorism is not a personality trait," says Sageman. "There is no such thing as a 'terrorist', independent of a person who commits an act of terror."

That presents a problem for efforts to profile, identify and interdict individuals at risk of turning to terrorism, a central plank of anti-radicalisation programmes such as the UK's "Prevent" strategy (see "Nip it in the bud", page 34). Democratic societies cannot keep an eye on everyone, and what they are looking for may not even give any obvious sign of its existence.



BETTMANN/GETTY

Crenshaw's influential paper "The causes of terrorism", published in 1981, summed up decades of observations of terrorists and their organisations, ranging from 19th century Russian anarchists to Irish, Israeli, Basque and Algerian nationalists. The outstanding common characteristic of individual terrorists, she concluded, is their normality. In her 1963 book *Eichmann in Jerusalem*, political theorist Hannah Arendt noted the same thing about the "banal" Nazi concentration camp bureaucrat Adolf Eichmann.

People who commit terrorist acts are usually embedded in a network of familial and friendship ties with allegiance to a closed group, be that tribal, cultural, national, religious or political. Historically, the conditions for the murder of innocents by terrorism or genocide have occurred when one group fears extinction by another group. Ordinary people are motivated to "kill people by category" through their own group identity.

Viewed from inside the group, that can

Vera Mironova (centre) is one of few researchers on the ground in Iraq

seem rational: terrorists are brave altruists protecting the group from harm by powerful outsiders. Terrorist acts are warnings to the out-group, demanding that certain actions be taken, such as withdrawing a military occupation or ending human and civil rights abuses. Terrorism is a militarised public relations ploy to advance a grander scheme – a political tactic, not a profession or an overarching ideology.

But the vast majority of people who might share the same sense of grievance or political goals are not motivated to kill and maim the innocent. Criminologist Andrew Silke at the University of East London has conducted many interviews with imprisoned jihadists in the UK. "When I ask them why they got involved, the initial answer is ideology," he says. "But if I talk to them about how they got involved, I find out about family fractures, what was happening at school and in their personal lives, employment discrimination, yearnings for revenge for the death toll of Muslims."

Yet this is not a popular view with counter-terrorism agencies, he says. "The government does not like to hear that someone became a jihadist because his brothers were beaten up by police or air strikes blew up a bunch of civilians in Mosul. The dominant idea is that if we concentrate on, somehow, defeating the radical Islamicist ideology, we can leave all of the messy, complicated behavioural stuff alone."



Mironova trained as a mathematician, game theorist and behavioural economist. A fellow at the Harvard Kennedy School, she is one of few researchers to venture directly into



PETER BYRNE

combat zones to examine the roots of jihadist terror. Her work has been funded variously by the US National Consortium for the Study of Terrorism and Responses to Terrorism (START), George Soros's Open Society Foundations, the United Nations and the World Bank.

During extended stays in Syria, Iraq and Yemen over the past five years, Mironova has built up trust networks in a politically diverse spectrum of insurgents, including "radical"

"We are playing a dangerous game of whack-a-mole with the terrorists"

and "moderate" jihadists and ISIS members and defectors. She moves easily through the clogged frontline check points surrounding Mosul with the permission of the Iraqi military. She stays close to her protectors, careful not to cross the ethical line of "doing no harm" that separates academic research from intelligence gathering.

By seeing things through the eyes of the fighters, Mironova aims to model what drives them, and how their individual motivations affect group behaviours and vice versa. She reads Arabic, but employs local translators in the field. She interviews fighters and civilians in hospitals, refugee camps and on the front lines face to face and via telephone or Skype.

Iraq as a whole is mainly Shia, but Mosul is largely Sunni; ISIS practices an apocalyptic form of the Sunni faith in a region wracked by social and economic catastrophe. Many civilians in the areas under their control collaborate, willingly and unwillingly, with ISIS. Some share their houses with fighters. Some work in ISIS factories, building homemade rockets, cutting and welding steel for jail bars and armour plates for tanks. Some escape into refugee camps. Some marry fighters. Some join sleeper cells.

In "The causes of terrorism", Crenshaw observed that it is often the children of social elites who first turn to terrorism, hoping to inspire the less-privileged masses to approve a radical change in the social order. Many Jihadist organisations are led by upper middle class intellectuals, often engineers. Al Qaeda's leader Ayman al-Zawahiri is a medical doctor; Abu Bakr al-Baghdadi reportedly has a doctorate in Islamic studies.

But the work of Mironova and others shows that the local ISIS rank and file is more down-to-earth: disenfranchised people struggling ➤

## NIP IT IN THE BUD

Deradicalisation programmes are the bedrock of counter-terrorism strategies in many countries. They aim to combat extremism by identifying individuals who have become radicalised, or are in danger of becoming so, and reintegrating them to the mainstream using psychological and religious counselling as well as vocational training.

In the UK, some 4000 people are reported to the government's anti-terror programme Prevent every year. The majority - 70 per cent - are suspected Islamic extremists, but about a quarter are far-right radicals, and that number is growing.

Critics fear that these programmes criminalise and stigmatise communities, families and individuals. In addition, there are questions about who governments collaborate with for information and whether public servants should be obliged to report potential radicals.

There is also very little evidence that the programmes work. Most fail to assess the progress of participants, and rates of recidivism are rarely studied. In a recent report, the UK parliament's human rights committee warned that the government's counter-extremism strategy is based on unproven theories and risks making the situation worse.

The key to combating extremism lies in addressing its social roots, and intervening early, before anyone becomes a "devoted actor" willing to lay down their lives for a cause, says Scott Atran at the University of Oxford's Centre for Resolution of Intractable Conflicts (see "Devoted to the cause", page 32). "Until then, there are all sorts of things you can do." One of the most effective counter measures, he says, is community engagement. High-school football and the scouts movement have been effective responses to antisocial behaviour among the disenfranchised children of US immigrants, for example.

Another promising avenue is to break down stereotypes, says social psychologist Susan Fiske at Princeton University. These are not necessarily religious or racial stereotypes, but generalised stereotypes we all hold about people around us. When we categorise one another, we are particularly concerned with social status and

competition, viewing people of low status as incompetent, and competitors as untrustworthy. Throughout history, violent acts and genocides have tended to be perpetrated against high-status individuals with whom we compete for resources, and who therefore elicit our envy, says Fiske.

Fiske's group has found ways to disrupt stereotypes by making people work together to achieve a common goal, for example. Trivial contact involving "food, festivals and flags" won't cut it, she says. It has to be a goal people care about and are prepared to invest in, such as a work project or community build. Here, success depends on understanding the minds of your collaborators - "rehumanising" them.

### CHANGING PERSPECTIVES

Tania Singer of the Max Planck Institute for Human Cognitive and Brain Sciences in Leipzig, Germany, thinks brain training could achieve similar effects. Social neuroscientists have identified two pathways in the brain by which we relate to others. One mobilises empathy and compassion, allowing us to share another person's emotions. The second activates theory of mind, enabling us to see a situation from the other's perspective.

Singer's group recently completed a project called ReSource, in which 300 volunteers spent nine months doing training, first on mindfulness, and then on compassion and perspective taking. After just a week, the compassion training started to enhance prosocial behaviours, and corresponding structural brain changes were detectable in MRI scans.

Compassion evolved as part of an ancient nurturing instinct that is usually reserved for kin. To extend it to strangers, who may see the world differently from us, we need to add theory of mind. The full results from ReSource aren't yet published, but Singer expects to see brain changes associated with perspective-taking training, too. "Only if you have both pathways working together in a coordinated fashion can you really move towards global cooperation," she says. By incorporating that training into school curricula, she suggests, we could build a more cohesive, cooperative society that is more resilient to extremism. Laura Spinney



to eke out a living for their families in war zones. Foreign fighters tend to be more ideologically driven, and most motivated by factors beyond group identity to make the ultimate sacrifice (see "Devoted to the cause", page 32).

Some militants seek to avenge the deaths of friends and relatives from US drone attacks, Shia militias, Iraqi police or US and British special operations forces. But as the sex slaves and Scotch suggest, jihadist fighters do not focus exclusively on heavenly rewards, or even hatred or revenge. Not everyone wants to die. Jihadist brigades in Iraq seize oil and vehicles, which they transport to high demand markets in Syria seeking to maximise profits. They often distribute gains from their looting and business operations communally.

Many of their adherents are purely economic actors, recruited with offers of competitive salaries, health insurance and benefits paid to their families should they be killed in battle. Mironova surveyed a cohort of Iraqi women who had encouraged their husbands and sons to join ISIS in order to get better family living quarters. Some recruits just need a job.

In Iraq and Syria, there are more than 1000

Militants may be motivated by revenge or the promise of heavenly rewards – but some just treat jihad as a job

and the effectiveness of counter-terrorist actions is hard to find. START's Global Terrorism Database, based at the University of Maryland, records details of terrorist incidents as reported by English-language media. It does not record counter-terrorist actions. Crunching event-based data from START's media sources can reveal statistical patterns in terrorist attacks, including how frequently certain groups attack, numbers of fatalities and types of targets and weapons involved. The Mapping Militant Organizations database, hosted at Stanford University, includes data relevant to the political environments that nurture terrorism, but also relies on English-only news reports and selected academic journals.

Neither database includes acts of terror committed by states, except for Islamic State. The definitional boundaries between insurgency and terrorism and state repression are vague. Militant actions directed against soldiers can be recorded as terrorism, while lethal police actions or government-initiated attacks on civilians are regarded as acts of war, or collateral damage, and so ignored.

Classified data is no more comprehensive: about 80 per cent of top-secret intelligence is drawn from open sources, including media reports. Raw data that contradicts policy or that tarnishes the military is often under-reported or ignored by field officers who are more concerned with living to fight another day. There is censorship, too: a recent investigation by *Military Times* reports that since 9/11, the Pentagon has failed to publicly report about a third of its air strikes in Iraq, Syria and Afghanistan, omitting an estimated 6000 strikes since 2014.

Relying on such imperfect sources can obscure the real motivations and root causes behind events. "The problem is that the press usually has a completely wrong narrative about the perpetrators that is only corrected in the evidence presented at the trials," says Sageman. National Security Agency files leaked by Edward Snowden reveal that the NSA has trouble hiring Arabic and Pashto speaking intelligence analysts who understand the cultures they monitor. Military intelligence agencies focus more on locating and killing terrorist suspects than on understanding sociological motivations.

Cabayán praises Mironova's "brave" style of research, and the data from the ground that ➤



REUTERS/VALIS KONSTANTINIDIS

radical Islamist, moderate Islamist, and non-sectarian brigades seeking to recruit militants to their brand of insurgency. In Mironova's models, their behaviour is determined by resource constraints, much as capitalist enterprises thrive and die. Groups compete to attract the best fighters. Those with low budgets may choose a radical religious line to attract foreign fanatics who are not as professional as fighters motivated by money, but will work for just room and board. Such models suggest that although the roots of violent jihadism might be expressed as religious fervour, they are anchored in more mundane, utilitarian – and perhaps solvable – causes.



"When the politicians demonise ISIS as evil, hormones flood the brain with danger signals," says Hriar Cabayan. "We forget how to think scientifically. We need to get inside the heads of ISIS fighters and look at ourselves as they look at us."

Cabayán runs the Pentagon's Strategic Multilayer Assessment (SMA) programme. His counter-terrorism unit taps the expertise of a

volunteer pool of 300 scientists from academia, industry, intelligence agencies and military universities. They convene virtually and physically to answer classified and unclassified questions from combatants, including special operations forces fighting ISIS in Syria and Iraq. The result is a steady stream of white papers largely concluding that the US counter-terrorism strategy – decapitating insurgency leadership, bombing terrorist strongholds – is counter-productive.

Reliable information on terrorist attacks



ZUMA/REX/SHUTTERSTOCK

## NETWORK EFFECTS

A key feature of jihadist groups is their use of social networks to propagate their ideas. "If you can disrupt those connections, that's probably your best shot at stopping people from becoming terrorists," says J. M. Berger at the International Centre for Counter-Terrorism in The Hague and co-author of *ISIS: The state of terror*.

He believes that the advent of social media has not only increased the number of people extremist groups can reach, but also the potency of their message, because it allows them to circumvent safeguards against revisionism and hate speech. Those most susceptible to the propaganda, his research suggests, are not the chronically poor or deprived, but people experiencing uncertainty in their lives – recent converts, young people who have just left the family home, those with psychiatric problems.

Extremist groups are adept at fomenting collective uncertainty, for example by provoking hostility between ethnic groups. At the same time, they present themselves as upholders of clear and unwavering values, an attractive message to individuals who are undergoing potentially destabilising transformations. Through social networks, those experiencing uncertainty can learn about and even enter into contact with extremist networks.

The G7 recognised this with its recent statement that it will "combat the misuse of the internet by terrorists". But this is easier said than done, says Berger. "It's easy to demand social media companies do something about extremism, but much harder to define what they should do in a way that is consistent with the values of liberal democracies." Laura Spinney

it brings. At the SMA meeting in March this year, the question was whether the physical defeat of ISIS in Mosul would eliminate the threat. Sixty scientists, including Mironova, examined the problem from a variety of perspectives. Their unequivocal answer was no. Events so far bear out that prediction.

There is no easy solution to the problem of terrorism, says Cabayan, because neither terrorists nor counter-terrorists are entirely rational operators. "The words 'rational' and 'irrational' make no sense," he says. "People behave emotionally, illogically. Human societies are complex, adaptive systems with unpredictable, emergent properties."

Many strands of evidence now suggest that terrorist and counter-terrorist systems are a single system governed by feedback loops; the actions and tactics of one side continually evolve in response to the actions of the other, as in a wrestling match. From this perspective, ISIS's trajectory can be calculated only retrospectively, in response to events.

It is an agile trajectory. Statistical models built around what is known of the frequency and casualty counts of insurgent and terrorist incidents in Syria and Iraq show the jihadists as Davids and conventional armies as lumbering Goliaths. The extremist groups can fragment and coalesce with relative ease: they are "anti-fragile", strengthening under attack. They are not wedded to charismatic leaders, but are self-organising networks that can operate independently of a single node of control, and have a ready source of new personnel.

**The West's counter-terrorism strategy has failed to get to the root of the problem**

The complex, evolving nature of the groups suggests that the US strategy of increasing troop numbers in Iraq, Syria and Afghanistan won't protect against jihadism. That conclusion is borne out by studies of the effects of troop "surges" in Iraq in 2007 and Afghanistan in 2012, both of which appear to have increased terrorism. "Real complex systems do not resemble static structures to be collapsed; they are... flexible, constantly respun spider webs," in the words of a 2013 SMA study of insurgency.

Drone strikes aimed at decapitating terrorist cells are likely to fail too. A 2017 study by Jennifer Varriale Carson at the University of Central Missouri concluded that killing high-profile jihadists is "counter-productive, if its

**"Human societies are complex, unpredictable, adaptive systems"**

main intention is a decrease in terrorism perpetrated by the global jihadist movement". In July 2016, *The Georgetown Public Policy Review* reported a "statistically significant rise in the number of terrorist attacks [in Pakistan] occurring after the US drone program begins targeting a given province".

The drone strikes follow laws of unintended consequences, says Craig Whiteside of the Naval Postgraduate School in Monterey, California. "Killing a charismatic leader may inspire a potent posthumous charismatic appeal, or cause splintering that results in otherwise suppressed extreme factions rising in prominence."



CHIP SOMODEVILLA/GETTY IMAGES

The effects are felt in Manchester as well as Mosul. In her most recent book, *Countering Terrorism*, Crenshaw writes, "Western military engagement has reinforced the jihadist narrative that Muslims everywhere are targeted. It may have made ISIS more determined to inspire rather than direct terrorism. Nor has military action blocked jihadist organisations [in Iraq and Afghanistan] from regrouping, regenerating, and expanding."

The evolving nature of the message means it is difficult to combat by broadcasting counter-narratives. Social networks ensure the message feeds back rapidly to disenfranchised sympathisers in the West (see "Network effects", left). Data scientists from the Naval Postgraduate School have studied Twitter feeds from ISIS strongholds before and after the US began bombing them in late 2014. Before the bombing campaign, the tweets focused ire on near enemies: local mayors, imams, police and soldiers. As the bombs dropped, the tweets went international, calling for the destruction of Western governments and civilians.

During the next three years, ISIS fighters or ISIS-inspired lone wolves targeted innocents in Brussels, Paris, Orlando, San Bernardino, Nice, Manchester and London. Atmospheric changes in social media reflect changes in the ground-level politics of insurgency, and specifically a willingness to export terrorism abroad. In the words of the sister of Abedi, the Manchester attacker, he "saw the explosives America drops on [Muslim] children in Syria, and he wanted revenge".

Terrorist groups are seldom defeated by military force; they either achieve political solutions, or they wither away because grievances are solved or dissipate, or they alienate their supporters through excess brutality. Conversely, the US-led bombings of civilians in Fallujah and Mosul in Iraq and Raqqqa in Syria, and the atrocities now being committed by the Iraqi liberators against ISIS suspects and their families, risk creating a new round of Sunni grievances.

According to a Pentagon-funded meta study of public opinion polls taken during 2015 and 2016, the "vast majority" of Muslims in Iraq and Syria do not support ISIS. But those who do cite religion or ideology far less than social, economic and governance grievances. And in Mosul, the study said, 46 per cent of the population believed coalition air strikes were the biggest threat to the security of their families, while 38 per cent said ISIS was the greatest threat.



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If Iraq's economic and social infrastructure continues to deteriorate, a global war on terror that has to date cost \$4 trillion will continue – and more civilian lives will be lost to jihadist attacks in the countries involved and the West. "The Sunnis in Iraq have a genuine grudge," says Cabayan. "They were left out of the Shia-dominated government that we set up; they are under attack, nobody is protecting them. We can and should provide off-ramps for defeated ISIS members – safety, jobs, civil rights. If not, after the fall of Mosul, we will be facing ISIS 2.0."

The counter-productive strategies go both ways. The immediate effect of civilian casualties in terror attacks is generally to undermine the ability of the attacked population to perceive the grievances of

#### The grievances of local populations inspire terror attacks around the world

the attacking group as genuine, and to strengthen the political desire to hit back militarily. Retired US Navy captain Wayne Porter was naval chief of intelligence for the Middle East from 2008 to 2011. He is convinced that the "only solution" to terrorism is to deal with its root causes.

"The only existential threat to us from terrorist attacks, real or imagined, is that we stay on the current counter-productive, anarchically organised, money-driven trajectory," says Porter, who now teaches counter-terrorism classes to military officers at the Naval Postgraduate School. "Our current counter-terrorism strategy, which is no strategy, will destroy our democratic values."

When ISIS is driven from west Mosul in July, Mironova is back on the battlefield, gathering more data about the fate of families accused of collaborating. Extrajudicial punishment of Sunnis by Shia and Kurdish forces is causing fear and resentment, and fuelling ISIS, which is far from defeated.

"ISIS is like H<sub>2</sub>O. It can be in several states: ice, water and vapour," she says. "In Mosul, it was ice. We melted it. Now it is water, flowing into the countryside, seizing towns. It can vaporise to live and fight another day." ■



MCP/REX/SHUTTERSTOCK

Peter Byrne is a journalist based in northern California. His book, *The Science of ISIS*, will be published next year



# The anything factory

Now we can build with atoms, we can make all kinds of miracle materials – can't we?

James Mitchell Crow reports

**W**HY cannot we write the entire 24 volumes of the *Encyclopaedia Britannica* on the head of a pin?" When the fabled physicist Richard Feynman posed the question during a famous speech in December 1959, he was not looking for an easy-to-carry version of the illustrated reference guide. He was drawing attention to the problem of manipulating things on a vanishingly small scale.

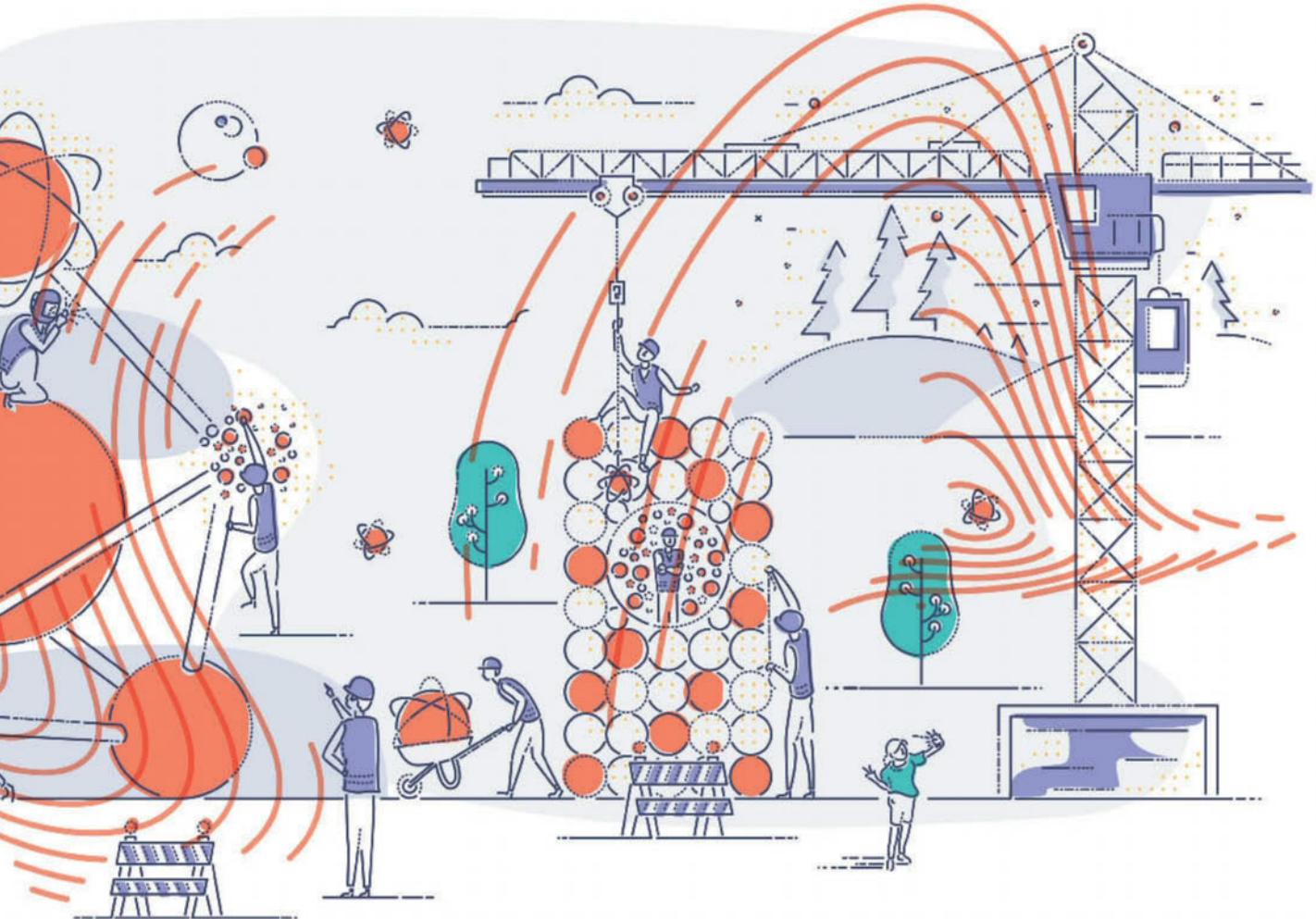
As he warmed to his theme, Feynman dared to imagine that we might one day build with

the building blocks from which all the known matter in the universe is made. "I am not afraid to consider the final question as to whether, ultimately – in the great future – we can arrange the atoms the way we want; the very atoms, all the way down!"

In this vision of atomic Legoland, we could build all manner of wonder stuff. We could make silicon's successor, a material that would allow us to keep stuffing ever more computing power into tiny devices. We could come up with a substance that would beef up our

puny solar cells or supercharge the ultimate battery, so we could store all that clean energy. We might even trigger chemical reactions that are impossible today (see "Elusive chemistry", page 40).

The trouble with that vision is that atoms are ridiculously minuscule, so much so that more than a million iron atoms would fit on to the head of a steel pin. And yet, in the bowels of giant brushed-steel contraptions that bring to mind steampunk machines, we have begun to nudge individual atoms around by the



thousand, and with astonishing precision. Now we just have to figure out where to put them.

For most of human history, we made do with the stuff nature gives us. Then we found ways to enhance it, taking metals and adding a dash of other elements to create alloys like steel – materials that have given us everything from cutlery and the kitchen sink to the jet engine. We have even managed to engineer materials that can control the flow of electrons, creating the microchips that power your smartphone and laptop.

But for the most part, we are still limited by what we can dig out of the ground – and that's holding us back. No matter how craftily we combine the available ingredients, we can't seem to crack the recipe for inexpensive thermoelectric materials to scavenge waste heat, for example. Commercial solar panels still max out at 20 per cent efficiency. Magnets for electric car motors rely on elements whose supply is anything but reliable. And batteries, as anyone who has watched their phone die at a crucial moment will know, have plenty of room for improvement.

To create stuff with whatever properties we happen to desire, we need to build novel materials from scratch – and that means building with atoms, as Feynman dreamed of almost 60 years ago.

### Grasping the atom

He was still around to see the beginnings of the “great future” when, in the early 1980s, Heinrich Rohrer and Gerd Binnig at the IBM Zurich Research Laboratory in Switzerland invented a powerful new kind of microscope. It took advantage of a bizarre phenomenon of quantum mechanics called tunnelling, in which particles do things they shouldn't be able to, according to classical physics. Rohrer and Binnig spotted that when you place a metal stylus an atom's width away from a sample and apply a voltage, electrons tunnel across the gap. This creates a tunnelling current that, crucially, varies exponentially with the size of the gap. By reading the current while slowly scanning the stylus tip across the sample, you can map its surface, atom by atom.

Scanning tunnelling microscopy meant we could see atoms for the first time, opening our eyes to the world of the very small. But seeing was just the start.

It soon became clear that the microscopes could pick up atoms and move them around. Lower the tip close enough and short-range electrostatic forces called van der Waals forces grab the atom beneath, which means you can drag it along by moving the tip across the surface. Lift the tip away and the atom stops in its new position.

By 1989, a team at IBM Research Almaden in California were nudging 35 xenon atoms into place on a nickel surface to create the world's smallest logo. It was an impressive demonstration, but still a long way from manipulating many thousands of atoms, which is what we need to do to conjure up new materials.

That remained something of a pipe dream until last year, when Sander Otte at the Technical University of Delft in the Netherlands and his colleagues went one better – or 59,965 better, to be precise.

Having noticed that chlorine ions were easy to push around on a copper surface, they wrote an algorithm to automate the scanning and shuffling of 60,000 of them. The result was a memory device that stores data by positioning individual chlorine atoms into patterns to

## "We are on the verge of manipulating atoms according to our hearts' desires"

encode each bit. If scaled up to 1 square centimetre, their 1 kilobyte rewritable chip would hold about 10 terabytes of data, orders of magnitude better than the best comparable chips around today.

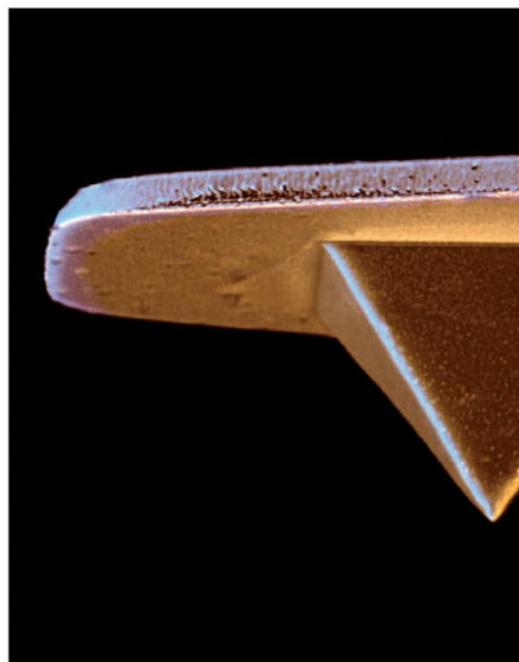
More importantly, Otte's achievement is a proof of principle, one that suggests we are on the verge of being able to manipulate atoms according to our hearts' desires. "The notion we can move atoms around now means we can basically start to design materials the way we want them, rather than being limited to the materials nature gave us," says Otte.

He is aware of the size of the task. One of the biggest problems is that you'd have to assemble about  $10^{23}$  atoms to make a single gram of material. Using a microscope to painstakingly drag each one into place,

layer by layer, would take forever. So while we figure out how to move atoms more efficiently, we should be concentrating our efforts on applications where moving a few atoms has a big impact, says Otte.

Take the chips inside your phone. Each has billions of transistors that function like a tap, turning the flow of electricity on and off. Transistors are now so small they are prone to leak even when off, which wastes power, generates heat, and in turn stop the chips running at maximum speed. If you could only modify the handful of atoms that make each transistor function, stopping the leaking, you would boost the performance of the whole device. Indeed, doing so will probably be crucial if we want to maintain Moore's law of shrinking transistor size.

For this particular application, scanning tunnelling microscopy may not be our best bet, because it can only manipulate surface atoms. That's not a problem when building a material from scratch, but you can't reach inside an existing slab of semiconductor to shuffle its atoms about. A new technique, scanning transmission electron microscopy, might do the trick. This fires an electron beam as fine as a single atom through a material to image its internal crystal structure – but it so happens that the beam sometimes nudges single atoms about. Several teams are now looking to exploit this effect to assemble



materials with atomic precision.

Even if they pull it off, there is a more daunting problem: we don't have a clue where we should put the atoms we move. If you're aiming to create materials with particular properties, you can't just randomly arrange atoms and hope for the best. Nor is there time for trial and error. Instead, you need a way to simulate new materials, which is exactly what Stefano Curtarolo is striving to do at the Duke University Center for Materials Genomics in Durham, North Carolina.

Curtarolo has developed a rapid-fire method for testing the chemical stability and physical properties of predicted atomic arrangements, quickly assessing combination after combination without stepping into a chemistry lab. The approach has already met with some success. This year, his collaborators made two of the materials that Curtarolo's computers had flagged as potential magnets – and showed they were indeed magnetic. It was the first time computer modelling had predicted magnetism in a new material. Other researchers are using the approach to hunt down better battery materials and home in on the best recipe for solar cells.

But even Curtarolo is not yet able to run simulations at the scale of individual atoms. His new magnets were mixtures of three chemical elements that arrange their atoms in a regular, repeating pattern – a much more manageable problem for a computer to tackle. Predicting the properties of a material atom

## ELUSIVE CHEMISTRY

A drop of this, 3 grams of that; give it a stir and watch it bubble. Until now, chemistry has been akin to cookery, a matter of seeking the right recipe for the substance we were after.

Leo Gross and his colleagues at IBM Research Zurich are helping to pioneer a more surgical approach. Using a microscope that can nudge atoms around (see main story), Gross is triggering reactions by removing single atoms from molecules.

Scanning tunnelling microscopes work at very low temperature, which means we can use them to create and probe highly reactive molecules that

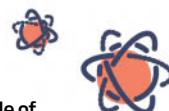
would otherwise remain mysterious, says Gross. That could help us master the catalytic production of polymers, drugs and other molecules we rely on every day. More importantly, perhaps, "we can start to build elusive molecules that cannot be made by any other means," says Gross.

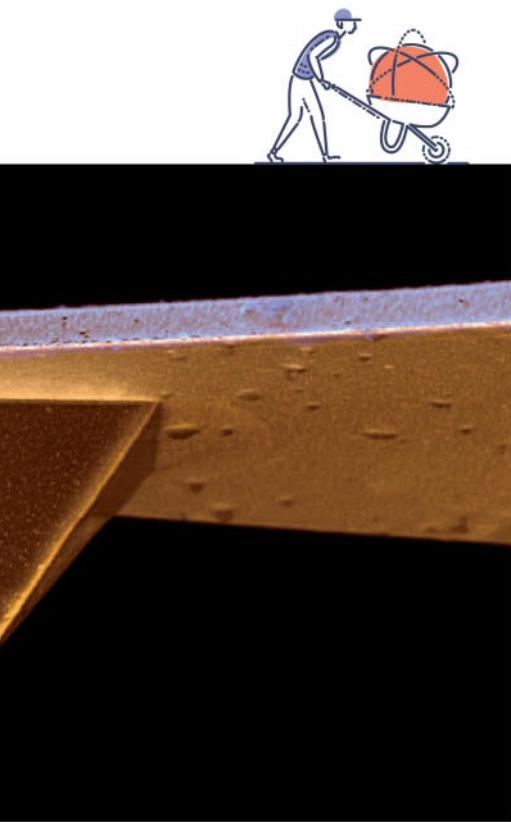
He is already doing it. For 60-odd years, chemists had tried and failed to make an exotic molecule called triangulene, a flat cluster of carbon atoms resembling a tiny triangular flake of graphene. This year, Gross and his team finally succeeded (see picture, right), using their scanning tunnelling microscope to

selectively rip a couple of hydrogen atoms from a precursor molecule.

Triangulene has no immediate use, even though it boasts some interesting electronic properties. But the feat of its creation could have big implications for chemistry.

"After so many decades of rigorous research, the chance of finding new important reactions are quite limited," says Diego Peña, an organic chemist at the University of Santiago de Compostela in Spain, who has been collaborating with the IBM team. With this atomic surgery, we appear to have started discovering them again.





EYE OF SCIENCE/SPL

**Tipped for greatness: designed to "see" atoms, scanning microscopes can move them too**

by atom requires ridiculous amounts of computing power, and right now we simply don't have it.

So is Feynman's dream is destined to remain just that? Not quite. Because it turns out that the very atom-nudging contraptions we might use to make our miracle materials could come to the rescue, helping us build a device that can do the intensive simulations required to find the right atomic arrangements.

What we need is a quantum computer – a device that exploits the weird properties of quantum mechanics to achieve the sort of processing power classical computers can only dream of. The concept is simple enough. In a regular computer, a transistor is in one of two binary positions, either on or off. But a quantum property like the spin of a quantum bit, or qubit, can be up, down, or in a superposition of both. Harness that behaviour to perform calculations, and you have a device that can consider many possible solutions to a problem at once. Link two qubits together, and the system can be in four states simultaneously. Link three, and you get eight states. The processing power grows exponentially.

Link 300, say, and you'd have a system more powerful than all the world's computers combined. For certain problems, not least

simulating how large numbers of atoms interact to generate a material with particular properties, that power would be a game changer. "A quantum computer would be a quantum leap of the kind of simulations we could do," says Curtarolo.

The problem is that we don't yet have a practical quantum computer, although it's not for want of trying. Google is developing a device based on aluminium circuits cooled until they become superconducting, while Microsoft wants to use "topological qubits" – elusive quasiparticles conjured on 2D surfaces that would maintain the required quantum state without too much fuss.

Michelle Simmons and her team at the University of New South Wales in Australia, on the other hand, are banking on the power of atom-nudging. They are using scanning electron microscopes to carefully place single phosphorus atoms on to silicon, with each phosphorus atom forming one qubit.

The reason they prefer this approach is that the computer-chip industry is already familiar with silicon. "We believe it will be much easier to manufacture a full-scale processor chip than for any of the leading designs, which rely on more exotic technologies," says team member Andrew Dzurak. They might just be right, but first they must prove they can do it.

"When we proposed it back in 2000, a lot of people thought it wasn't possible to control the world at that level – the technology just didn't exist," says Simmons. So they had to invent it. The first problem was a sticky one. Phosphorus and silicon form such a strong bond that you can't use a scanning tunnelling

microscope to nudge phosphorus atoms across a silicon surface. Instead, the team found a workaround: they coated the silicon with a non-stick hydrogen surface, then used the microscope to pluck off just the hydrogen atoms covering the sites where they wanted the phosphorus atom to go. It worked perfectly.

Having overcome several more engineering problems, in 2012 Simmons and her colleagues demonstrated a functioning transistor made from a single phosphorus atom in a silicon circuit. They followed it up three years later by demonstrating a two-qubit system, consisting of two phosphorus atoms connected to form a logic gate. Now they have funds to

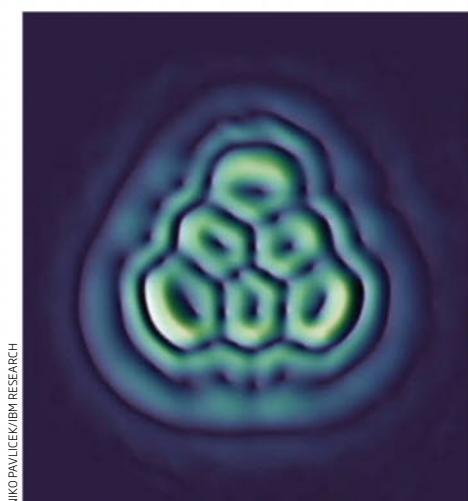
## **"The solution is a device capable of churning out recipes for miracle materials"**

build a 10-qubit device within five years.

Ultimately, they want to produce a quantum computer with a whopping 1024 qubits. As Otte's nanoscale memory chip has shown, with a fair wind it's possible to shuffle tens of thousands of individual atoms, so Simmonds should be OK. Having mastered manipulating individual atoms, her challenge now is to design the surrounding circuitry to form a fully functioning quantum device.

But even once we have quantum computers churning out recipes for miracle materials, for Otte, Curtarolo and anyone who wants to build from the atom up, one last challenge will remain: scaling up. A decent-sounding strategy would be to use scanning microscopes with multiple tips working in parallel. But in practice, the very sensitivity that allows the tips to manipulate single atoms makes them too vulnerable to vibrations. "There are four-probe machines, but that's just four times as hard to use as a one-probe," says Otte. "Scaling that up to 1000 times is just incredibly difficult."

Then again, scanning microscopes were never developed with industrial processing in mind. "I think it just requires other people with a different background and philosophy to pick this up and to start to think about it," Otte says. "I think it should be possible to come up with new ideas." ■



**No one had ever made the exotic molecule triangulene until we learned to nudge atoms**

James Mitchell Crow is a consultant for *New Scientist* based in Melbourne, Australia

# Trip advisor

Psychedelic drugs promise excellent treatments for ailments of the psyche, **Robin Carhart-Harris** tells **Graham Lawton**, but doing the research is a high-wire balancing act



## PROFILE

Robin Carhart-Harris is head of psychedelic research at Imperial College London's Centre for Neuro-psychopharmacology

**O**NE of the last times I saw Robin Carhart-Harris, I was absolutely off my head on MDMA. On a Monday morning. He knew, because he was the one who gave it to me. He scanned my brain, put me through some psychological tests, and talked to me for what felt like hours about how I was feeling. I remember him being calming and patient. Then again, I was on drugs.

Today I'm completely straight, but he is still calming and patient. It's a character trait that must come in handy when you spend hours sitting with people who are having powerful psychoactive experiences. He has probably clocked up as many hours doing this as any scientist since the heyday of psychedelic drug research in the 1950s and 60s.

I tell him I need a checklist of the drugs he has studied. "You've done MDMA. You've

## "Listening to someone on a high dose of psilocybin can be transformative"

done DMT. You've done LSD. You've done psilocybin." "Yes, that's it," he says. I realise I need to clarify: "I don't mean you, personally." He gives me a knowing look.

Carhart-Harris is rapidly becoming the poster boy for the long-awaited, and often proclaimed, psychedelic renaissance. The story has been told many times – about how, back in the day, scientists started testing LSD and similar drugs as treatments for mental conditions including depression and addiction. About how they got positive results, but were crushed by the establishment. And about how a group of mavericks is on the verge of bringing psychedelics back. The story resurfaces every couple of years, but the renaissance never actually happens. This time it feels different.

One big reason is Carhart-Harris. Psychedelic research often has a slight whiff of patchouli oil about it, but he doesn't. I have just watched him give a presentation about his research on using psilocybin to treat people with major depressive disorder that had not improved with antidepressants. He was every inch the objective, steely scientist, dispassionately describing how he gave a dozen people with treatment-resistant depression large doses of psilocybin, and how this treatment appears to have succeeded for five of them. He talked about serotonin receptors and functional brain imaging; he presented data, and models of how the drug might work. He was, in short, really sciencty.

But talking to him afterwards, he admits

his performance is carefully calibrated. "It is deliberate; I do it because I believe that's the way to do it. You're walking a fine line, where on one side you have the hippies and on the other side the conservatives. I actually have more sympathy for the hippy perspective, but I've learned that you need to be very vigilant of that coming across in presentations and in papers, because when people see that, they think 'advocate'. You know – biased." He tells me that presenting the data soberly is what makes it most compelling.

For psilocybin, the data is compelling enough to warrant a much larger clinical trial, says Carhart-Harris, but on that front he has hit the same snag as many a psychedelic researcher before him: money. Leaving aside other costs, just synthesising medical-grade psilocybin is staggeringly expensive.

At this point, the usually positive 35-year-old shows signs of exasperation. "It is frustrating. I think funders are risk-averse; they see potential reputational hazards. I often entertain the idea of presenting a slide listing all the funding bodies that I've gone to that have said no, but then I thought I'd just come across like a dick, so I don't do it."

Lack of funding is what halted the psychedelic renaissance in the past, Carhart-Harris says, but he is determined not to let it happen to him. "I can't help but feel that the breakthrough will come, because I just have such conviction in psychedelics." The next stage of the trial will go ahead, he tells me, albeit in a stripped-down form. "My feeling is that psilocybin has major areas of superiority over SSRIs [selective serotonin reuptake inhibitors such as Prozac], and unless there's some curveball, I think it's an inevitability that psilocybin will be licensed as a treatment."

### Existential truths

However, there's a deeper question about psychedelics that may fall by the wayside as a result of funding constraints. Curing depression is Carhart-Harris's day job, but what really fires him up is understanding the psychedelic experience and what it tells us about ourselves. "Psychedelics are useful, yes, but I also have conviction in them as tools to fundamentally understand the mind and the brain."

That is one reason why Carhart-Harris and his colleagues sit with the trial participants as they go through psychedelic therapy, and interview them extensively afterwards. Listening to somebody who is on a high dose of psilocybin can itself be a transformative

experience, he says. Subjects frequently describe profound feelings of connectedness – within themselves, to others and to nature – as well as blissfulness, insight and disintegration of the self, or ego. Afterwards, they talk of emotional release and catharsis. Even people who have a bad trip feel changed for the better afterwards, Carhart-Harris says.

When people are under high doses, he says, they're not unhinged. "They're very, very lucid. It's like you're in the company of someone who is incredibly wise and seeing things from afar, seeing the bigger picture. I've come to believe that in the vast majority of cases these are insights about fundamental truths. Existential truths. And that's had a profound impact on me."

Oops, was that a glimpse of his inner hippy? He soon bottles it up. "Part of our agenda is to demystify some of the wooliness around the psychedelic experience and the tendency to characterise it in mystical or metaphysical terms. There's nothing metaphysical about it. It's very real. And very human."

Exactly how these experiences can lift people out of depression is not clear. "The mechanism... we don't know. We have ideas," he says. But the benefits could be broader than just as a specific treatment. Carhart-Harris also has data suggesting that a single dose of psychedelics can make anybody more open to experience, less authoritarian, more politically liberal, and more connected to nature and other people. No wonder the conservatives want to shut this down, I think to myself.

So should a psilocybin trip be on everyone's bucket list, I ask. The steely man of science returns. "No. There's a truth that can be realised by psychedelics, but absolutely you can realise it via other means. The value isn't in the psychedelic, it's in the truth, you know? That's why I would never want to promote psychedelic use. I think it's a useful tool, but it's not a sure deal, and things can go awry."

I'm dying to ask whether he is speaking from personal experience, but I know from previous conversations that he will neither confirm nor deny. And he has places to be, so I let him go.

A few days after our interview, I contact Carhart-Harris's office to talk about a photo shoot, and I discover he's gone to Peru to witness an ayahuasca ceremony in the jungle. That is about as removed from the clinical setting of his research as it is possible to get. But I suspect he will be in his element. ■

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Robin Carhart-Harris will be speaking at New Scientist Live in September ([live.newscientist.com](http://live.newscientist.com))

# Day of the dark

Humans have always hunted for meaning in total eclipses. Just don't forget to enjoy them too, says **Stuart Clark**

*American Eclipse: A nation's epic race to catch the shadow of the moon and win the glory of the world* by David Baron, Liveright

*Eclipse: Journeys to the dark side of the moon* by Frank Close, Oxford University Press

*In the Shadow of the Moon: The science, magic, and mystery of solar eclipses* by Anthony Aveni, Yale University Press

*Totality: The great American eclipses of 2017 and 2024* by Mark Littmann and Fred Espenak, Oxford University Press

ON 21 August, a total eclipse of the sun will be visible across a narrow track crossing the US from Oregon in the west to South Carolina in the east. It will be one of the most widely observed celestial events of recent times.

There was a time when a total eclipse of the sun had the power to stop wars or change the course of history. These days you could be forgiven for thinking them mere opportunities for tourism – none more than the one to take place next week. And yet...

Already dubbed the “great” American eclipse, the event has inspired at least four new books. Which you choose will depend on what you want: historical insight, a comprehensive guide to the nuts and bolts of observing these events, or vicarious tales of other people’s eclipse experiences – both anecdotal and historical.

A total solar eclipse is without doubt a spectacular wonder. The excitement as the moon creeps across the sun turns into

something more primal as all colour drains from the surroundings. The disappearance of the light is no re-run of sunset, when the atmosphere imparts a rosy glow on the twilight. Instead, yellow sunlight slides into an other-worldly silver sheen unlike anything else you will ever witness.

Then the moment of totality arrives and more wonders are revealed: the extraordinary darkness of the moon’s silhouette and the gossamer threads of the sun’s atmosphere that reach out from behind it. But the best is saved for last. The delicate beauty of totality is merely an act. As the sun returns with the so-called diamond ring effect, we are given a searingly bright reminder of the power of our star.

The uniqueness of the eclipse experience turned journalist David Baron into an “umbraphile” or shadow-lover, who will pretty much travel anywhere to stand in

the shadow of the moon and witness another total eclipse.

His quest to discover if others felt the same led him to the US Library of Congress and the archives containing the personal correspondences of astronomers.

**“Excitement turns into something more primal as all colour drains from the surroundings”**

His engaging narrative, *American Eclipse*, is the result.

Baron tells a lively tale that places eclipse science in the historical context of the Wild West. (The eponymous eclipse is the one of 1878.) There’s the brutality of a frontier lynching, the annoyance of lost railway luggage and the beauty of the astronomical event itself.

In the moment of totality, there is a sense of epiphany, a revelation that seems to promise some sort of meaning. Frank Close captures



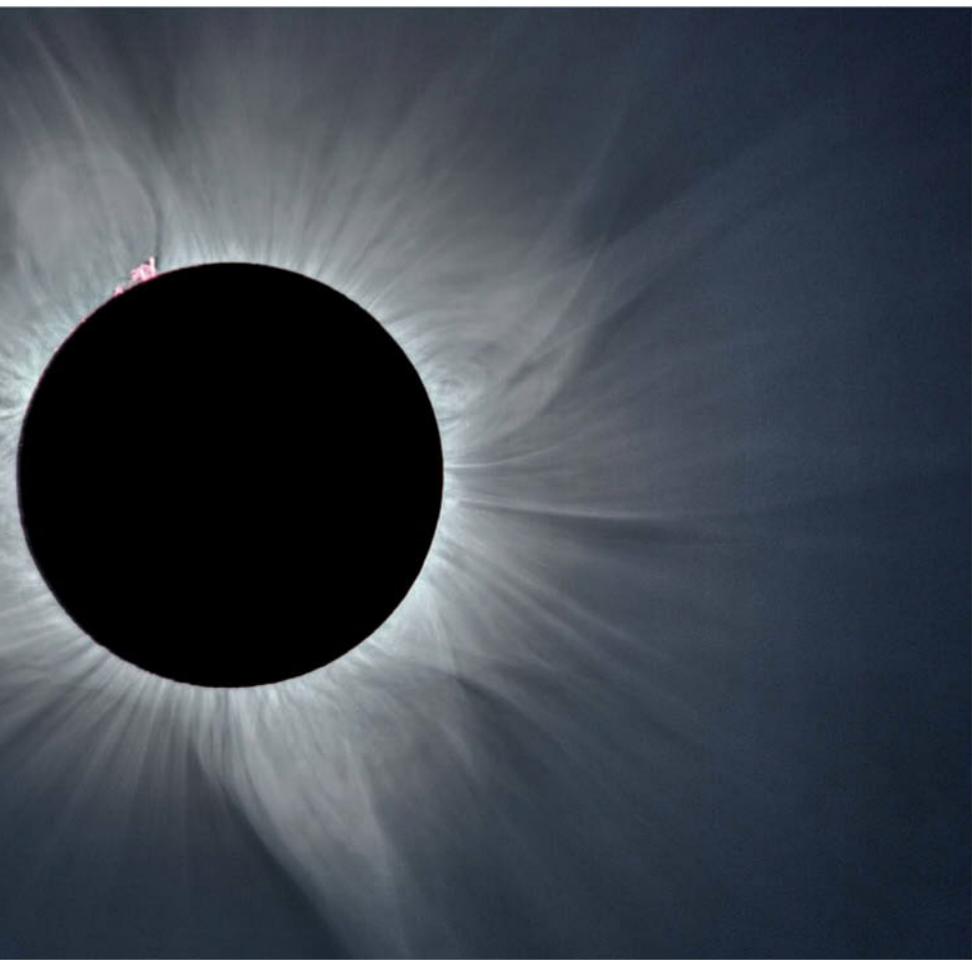
this sentiment in his light and friendly travelogue, *Eclipse*. Although his imagination was sparked by a teacher who showed him a partial eclipse of the sun in 1954, it took another 45 years for him to glimpse a total solar eclipse. While the 1999 event that crossed Cornwall was mostly obscured by cloud, it served to inspire Close’s own series of eclipse expeditions.

The understated narrative hook here is the author’s wish to solve the mystery of Joshua’s illusion. This biblical story comes from the Old Testament and tells how an eclipse in 1131 BC was accompanied by the moon apparently backtracking through the sky.

From everything we know about the moon’s orbital motion, this could never have happened. Close becomes convinced that it is



MOHAMMAD ABU GHAOSH/XINHUA/EYEVINE



JUAN CARLOS GASADO/STARFARCEARTH.COM/SPL

an optical illusion produced by clouds and looks for anything that could account for the story. Finally, Close himself observes two eclipses under the right conditions, and while it requires some pretty heavy exaggeration to tally Close's split-second observations with the biblical story, *Eclipse* is a shining example of scientific curiosity at work.

*In the Shadow of the Moon* by Anthony Aveni offers an even deeper view of historical eclipses. The most academic in tone of the four, Aveni's authoritative but accessible text is the clearest statement of the way our perception of eclipses has changed over the centuries. Searches for astrological meaning almost certainly predate the written record. In the 19th century, they gave way to

scientific efforts to study the sun's atmosphere. Aveni highlights the quest to find significance in eclipses and quotes 18th-century minister Joseph Lathrop, who sought to bridge the scientific and religious divide by saying that eclipses were "a natural emblem of moral change, in which a soul is brought out of the darkness of sin and into the marvellous light of purity, pardon and peace".

Today, the meaning we assign to eclipses is a more complex mix. Thanks to eclipse tourism, millions can just revel in the sheer awe of the moment, regardless of their level of science education. The scientific significance of eclipses, meanwhile, is dwindling. There's still some research to be done on the corona, the sun's outer atmosphere. Historically, eclipses have been a boon to

#### How we see eclipses has changed dramatically over the centuries

researchers in this field. Nowadays, however, much of this work is done via satellite.

The millions who turn out for the occasion must remember to never look directly at the sun without using specially treated glass or protective eclipse glasses: your eyes could be permanently damaged. Such kit is widely and cheaply available online, but do check that it conforms to safety standards. This is such an important point that Mark Littmann and Fred Espenak devote a whole chapter to eye safety in *Totality*. Out of the four books discussed here, theirs is the most thorough on the practicalities of viewing an eclipse. They devote many chapters to photographing

and the weather prospects for the August event. It's a great reference book: basically, if you can't answer your questions here, then you may not be able to answer them at all. *Totality* also covers, as its subtitle makes clear, another impending total eclipse, on 8 April 2024, its path tracking from Texas to Maine.

The only danger of books like this is that the inexperienced reader can feel overwhelmed with all the things they are "supposed" to be looking for during an eclipse.

#### "In the moment of totality comes a sense of epiphany, a revelation that seems to promise meaning"

Constantly hunting for the phenomenological minutiae, they risk missing the experience.

Some years ago, while I was doing research for my book *The Sun Kings*, I was struck by a passage from astronomer Warren de la Rue. He was writing about his expedition to the 1860 eclipse in Spain. His scientific objective was to capture the first photograph of the totally eclipsed sun. He succeeded. The result can be seen in the Royal Astronomical Society, and the camera is in the Science Museum, both in London.

But the achievement came at a cost, and de la Rue wrote that if he were ever lucky enough to witness another total eclipse, he would forego science simply to witness the spectacle.

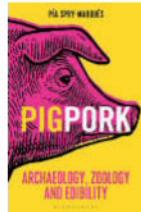
I think this is the best advice for those seeing their first eclipse. Leave the camera and the checklists at home. There are only two things you need to do to prepare. First, get yourself to the path of totality. Even a 99 per cent partial eclipse is nothing compared with a total eclipse. Second, buy those eclipse glasses. Then, on the day, empty your mind and let the power of nature amaze you. ■

Stuart Clark is a consultant for *New Scientist*

# A porker of a paradox

Are pigs for eating or petting? **John Bradshaw** on a human dilemma

*Pig/Pork: Archaeology, zoology and edibility* by Pía Spry-Marqués, Bloomsbury Sigma



PIGS might once have rivalled dogs for the title of humanity's best friend. While one in three of the hunter-gatherer societies that survived into the 20th century kept dogs, an impressive one in 10 kept pigs as pets. The women of the Maring people in New Guinea treated their piglets like their own babies. The Hokkien of Taiwan fed their pigs on papaya and plums – though these “pets” were destined to be sacrificed to the gods.

Like dogs, pigs were sometimes buried with their owners, showing more than a culinary relationship. Although pet pigs are fashionable in the West, we are less devoted to them than our forebears were, to judge by the 300,000 abandoned annually by owners in the US.

There have been hundreds of books about dog history, but few about the domestic pig, so Pía Spry-Marqués's *Pig/Pork* fills a key gap. As an archaeologist, she anchors her account in the pig's journey from wild boar to tame porker, including recent upsets in the conventional account generated by analyses of DNA.

After those upsets, the new consensus is that, like dogs, wild pigs domesticated themselves around 11,000 years ago by scavenging around human settlements in what is now Turkey. However, domestication was a slow, haphazard process. For

the first few thousand years, the domestic strains kept one trotter firmly in the wild, interbreeding with wild counterparts before settling into the forms (and breeds) that we know today.

There's also an intriguing link between the domestication of pigs and cats. Both turn up unfeasibly early in Cyprus, too far from Turkey for either to have swum there. The implication is that both must have been carried there in ships. An unusually small type of wild boar – hence probably on the way to domestication – appears in the archaeological record around 11,500 years ago. This may have been a feral population, beginning with a few pigs that escaped from one of the

earliest settlements on the island.

Similarly, the story of the domestication of the cat, once thought to have begun in Egypt some 6000 years ago, was thrown into disarray by the discovery of a cat buried in Cyprus in the same grave as its owner 3000 years earlier. As with the pig, DNA

## “Are pigs intelligent, resourceful animals that deserve respect, or bacon and chorizo machines?”

placed the initial domestication of the cat (on the adjacent mainland) closer to 10,000 years ago.

The book's title reflects our contradictory feelings about the domestic pig. Are they intelligent,

resourceful animals that deserve respect, or bacon and chorizo machines? There is even a handful of recipes for dishes based on pork products at the end of each chapter, although the final one is surprisingly lacking in meat.

The book also contains much history and some sociology. A chapter is devoted to religious prohibitions on eating pork, adherence to which has undoubtedly protected believers against the parasites that can be caught from eating the meat raw or underdone. However, Spry-Marqués is sceptical that the bans were based on any awareness of this connection.

Pork is by no means the whole story: pig byproducts turn up in unlikely places, including biodiesel, make-up, antifreeze, bone china, glue, even the brake shoes on German trains. Today, we must also take account of the impact pigs and their excrement have on global warming. But as born recyclers, it's an impact that pigs could offset by making short shrift of the West's mountains of wasted food.

As an ethologist, I was slightly disappointed to find little about the way pigs think, feel and perceive the world when there is so much recent research. Donald Broom's intriguing experiments, demonstrating how pigs learn to use a mirror to find food, get a mention, but that's it. Even so, *Pig/Pork* is an intriguing trot through our long partnership with our porcine pals. Someone better qualified than me should try the recipes though. ■

**Our complex relationship with pigs started more than 11,000 years ago**

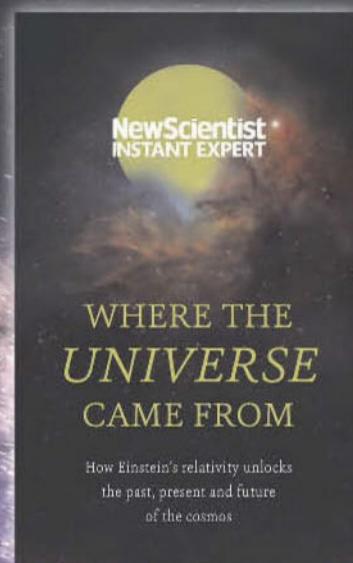
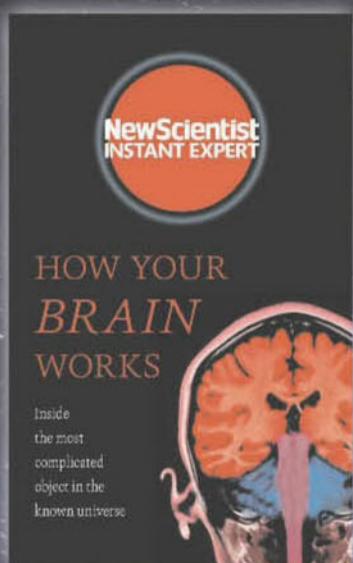


VINCENT MUSI/NATIONAL GEOGRAPHIC CREATIVE

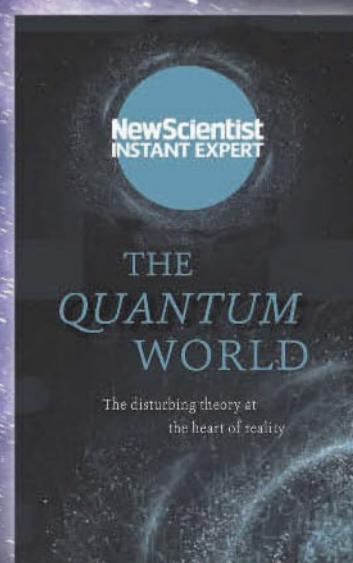
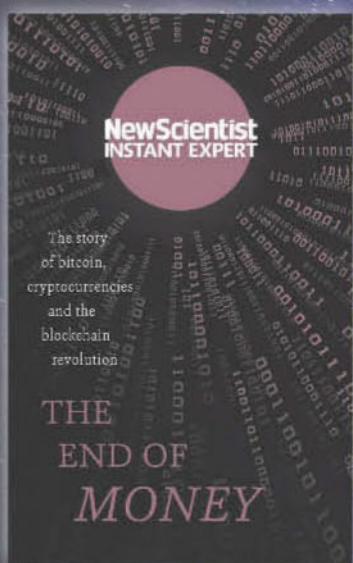
John Bradshaw is the author of *The Animals Among Us: The new science of anthrozoology* (Penguin Press)

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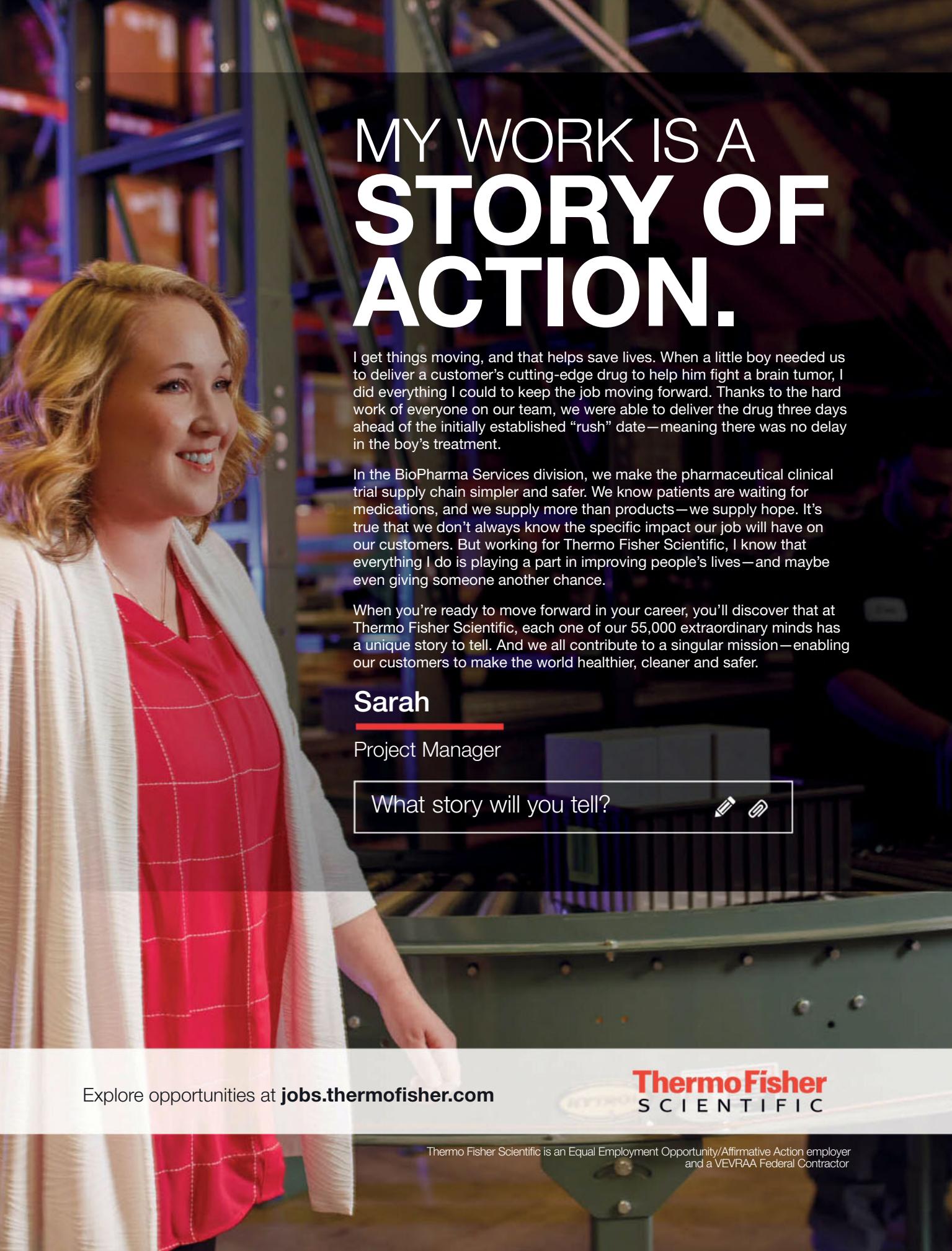
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**Q: Have 10 or more peer-reviewed publications?**

**Q: Have at least 5 peer-reviewed publications as first author?**

**Q: Have you shown prominence through awards, invitations to speak at major scientific meetings, or other recognition?**

**Q: Do you have expertise in one of these fields?**

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**EDITOR'S PICK****Don't recycle, break the cycle of poverty**

*From Carl Zetie,  
Waterford, Virginia, US*

You mention work on food sachets that can be recycled (22 July, p 39). That would solve entirely the wrong problem. People who can afford only single sachets are trapped in a cycle of poverty, because daily sachets are much more expensive than the same

amount of product in a larger bottle. They can never save up enough to buy a larger bottle, because their daily lives are too expensive. As the writer James Baldwin put it: "Anyone who has ever struggled with poverty knows how extremely expensive it is to be poor."

If they could somehow get that first bottle, they'd have all the ketchup or laundry detergent they needed, and money to spare for other necessities. It's a classic poverty trap. You break the cycle by getting poor people off single sachets, with something as simple as gifting them the first bottle and helping them put money aside for the next. Or help people to set up buying clubs to make communal purchases in bulk and share the savings. The beauty of these ideas is that they help poor people and solve the ecological problem caused by billions of sachets.

**How would green disinvesting work, then?**

*From Alec Cawley,  
Penwood, Berkshire, UK*

Andrea Needham proposes we withdraw investment from fossil fuel stocks (Letters, 29 July). Why does this put any pressure on the companies to be greener?

Yes, it will lower the stock price, but while earnings hold up this gives them, as Bob Cory points out on the same page, a superlative stock-price-to-earnings ratio. It may devalue the executives' stock options, but if they're canny they will arrange bonuses based on the price/earnings ratio.

Stock market movements have little effect on the long-term actions of a company. By all means deny it new capital from rights issues and bond sales, so it can't invest in new fossil projects. But it might be better to hang on

to the stocks and demand big dividend payments, sucking the capital out of the company and reducing its capacity to reinvest.

**My own personal energy policy, for the kids**

*From Roy Harrison,  
Verwood, Dorset, UK*

Michael Le Page concludes that politicians need to hear loud and clear that they must do more to boost renewable energy (5 August, p 22). True, but the downside of this message is that it fails to encourage ordinary people to do what they can. It makes them think it's the politicians' job.

But there are things we can do and should be encouraged to do, not by financial incentives, but because it gives our children the best start in life. This is something that, in other spheres, parents go to enormous lengths to achieve.

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## "Memo guy got fired for being closed-minded. Ignoring hundreds of years of discrimination"

Shifty Girl responds to Twitter ire over a man being fired after "advancing harmful gender stereotypes" (12 August, p 5)

Buying efficient electrical appliances, having better house insulation, choosing the most efficient car and installing solar panels are relatively modest sacrifices. So are avoiding unnecessary gadgets, food from far-flung places and flying.

By any reasonable assessment of the effects of uncontrolled climate change, preserving the climate is far more important for your children's future than their education. A world changed by climate will be ravaged by economic collapse and war. Is that what you had in mind for your beautiful baby granddaughter?

### Solar panel valeting is a thing, maybe not good

From Philip Bolt,  
Kirriemuir, Angus, UK  
John Davnall is surprised that he doesn't see businesses offering to

wash his solar panels (Letters, 5 August). His hopes (or perhaps fears) have been realised.

I have had several offers to wash my panel array for about £100 a splash. I have declined as I've been told by installers that panels are treated with a dirt-repellent coating. We have 30 to 40 pea fowl, who delight in perching on the ridge tiles and defecating on the panels. But there is no sign of persistent stains nor of loss of function.

We've just had our 6-year-old array retrofitted with control units that allow each panel to function separately. This avoids the issue of splats knocking out chains of cells.

A further benefit is that this has an internet connection, so we can monitor the array in real time or reprise the recent output. This provides more entertainment than many TV programmes.

### You can drop the drones for counting penguins

From Dave Hoy,  
Cadney, Lincolnshire, UK  
You report the use of drones and artificial intelligence to count birds (29 July, p 7). Back in 1969, I was at the British Antarctic base then called Halley Bay.

We were fortunate enough to have a large emperor penguin colony on the sea ice nearby. Estimating numbers was difficult because the penguins were constantly moving.

We used a meteorological balloon to carry a camera high enough to take a photo of the whole colony, blew this up onto the largest photo paper we had and drew a grid of squares. Instead of AI we enrolled our cook, who was laid up with a bad back. The task of counting the birds in each square was not comfortable, as

the bunk rooms were well below freezing most of the time. Gin and tonic helped.

### When is it really OK to stop taking antibiotics?

From Philip Welsby,  
Edinburgh, UK  
Jessica Hamzelou discusses whether it may be a good idea to stop taking antibiotics once you feel better (5 August, p 25). But the proper question is: "when should I, with my particular infection, stop taking the antibiotic I have been prescribed?"

The outcome of these three interacting factors is dependent on initial circumstances.

Doctors must decide on length of treatment. They and those who issue guidelines for doctors have to act like bookmakers, but using policies of "the greatest good for the greatest number" and "first ➤

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do no harm". For some bacterial infections, even starting an antibiotic may hardly be worthwhile. Sore throats or uncomplicated lower urinary tract infections in non-pregnant women spring to mind.

In other infections, such as tuberculosis, stopping early will be disastrous. In yet others – for example, complicated urinary tract and respiratory tract infections – over-long treatments can breed resistant strains.

In theory, the duration of each course of antibiotic should be determined individually. In practice, doctors have to assess the odds from series of patients and, like bookmakers, have to assume that they will not win every single bet. Oh, and some bookmakers are better than others...

## The benefits of escapism for prisoners and for all

*From Robert Gallop, Sydney, New South Wales, Australia*  
Jo Marchant writes that if awe can be reliably induced, it can quiet self-interest, fold us into the social

collective, make us more ethical, generous, humble and charitable, leave us happier and less stressed, and calm the fight or flight response (29 July, p 33).

So inducing awe seems an ideal approach for those who are most lacking in these attributes, and who are also most deprived of awe: our prison populations.

Could society reap multiple benefits simply by taking prisoners to IMAX theatres?

## Another view of the Common Fisheries Policy

*From Michael Wigley, Timsbury, Hampshire, UK*  
You paint a rosy and distorted picture of the EU Common Fisheries Policy (29 July, p 23). The CFP has been an ecological disaster from the start.

Fish quotas were ostensibly invented to conserve fish by restricting the number of each species a fishing boat could catch. Unfortunately, you cannot tell what type of fish you have caught until you haul in the net, by which time the fish are dead. So millions of dead fish are thrown back,

often more than are landed under a given quota. As far back as 1991, the EU knew what the problem was – but did nothing about it for decades.

With Brexit, we have the chance to get rid of some EU stupidity – but could introduce our own.

We need to make sure our scientists and politicians introduce a modern system of sustainable marine reserves and no-catch zones as, for example, New Zealand has done.

*The editor writes:*

- The CFP does have problems, but it's the least bad thing on offer for the seas around the UK – particularly now that it is starting to be informed more by science.

## Don't be so optimistic about evolution

*From Eric Kvaalen, Les Essarts-le-Roi, France*  
Fred Pearce celebrates the optimistic view of ecologist Chris Thomas that we are entering a new age of creative evolution (5 August, p 44). But so far, we've seen nothing of the sort.

Perhaps new species are being created as existing ones spread out too far to maintain their integrity. Maybe there are some changes in species' behaviour, colour or size.

But we don't see new anatomical features. If we lose elephants, we will no longer have animals with similar tusks. If we lose gorillas, no new species will quickly become as strong.

Real innovations don't pop up overnight in evolution. Maybe if we wait a million years...

## Robots should swim like dolphins or tuna do

*From Stephen Johnson, Eugene, Oregon, US*  
Leah Crane says a nanorobot that could swim through blood mimics the front crawl stroke, "the fastest way for humans to swim" (29 July, p 8). But the fastest human technique is "underwater dolphin kick", with arms stretched out ahead in a streamline.

This is so efficient it is restricted to no more than 15 metres per length in competitive swimming, to prevent the sport from evolving into an underwater event. Michael Phelps used it, and a fin, in his "race" against a shark.

*The editor writes:*

- Yes: the front crawl is the fastest freely allowed in competition.

## For the record

- The researchers looking at Rylands' bald-faced saki monkeys eating termite mound mud concluded that they do it to absorb organic toxins in their diet (1 July, p 10).

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TOM GAULD



## SIGNAL BOOST

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### Bring astronomy home

SIXTY years ago, the Royal Observatory Greenwich stopped stargazing and became a museum and science centre. It set out to inspire the next generation of astronomers, and to illuminate the rich history of astronomy that, since the 17th century, had taken place atop the hill in Greenwich Park in south-east London.

This year, Royal Museums Greenwich has launched an appeal to bring astronomy back to the heart of Greenwich by installing a set of modern telescopes in the Altazimuth Pavilion at the Royal Observatory. The building itself, in need of conservation, is being restored by the museum to the best condition possible. The historic instruments currently housed in the upper floor of the small building will be removed, given the care and attention they need, and conserved in the museum's collections.

The appeal provides an opportunity to transform the observatory into a working institution once more. The fundraising target of £50,000 would allow the museum to purchase new instruments capable of photographing and videoing the wonders of the universe. In order to engage as wide an audience as possible, the equipment will enable these views to be live-streamed to the world online and shared with schools and the public through the Peter Harrison Planetarium and workshops at the observatory.

The equipment would also allow the capture of data on alien planets orbiting distant stars and chemical analyses of nebulae, which could be shared widely and used by university students.

With your help, the astronomers at the Royal Observatory Greenwich can throw the doors to the cosmos wide open and inspire and excite people all over the world.

**Brendan Owens, Astronomer at Royal Observatory Greenwich**

Help us bring astronomical research back to the home of time and space by visiting [rmg.co.uk/telescopeappeal](http://rmg.co.uk/telescopeappeal).

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**IT'S** a job opportunity that comes with a big responsibility: saving an entire planet. Have-a-go heroes are abuzz with the news that NASA is hiring a planetary protection officer. Feedback is already encouraged to apply, given the rich history of journalists with a side gig in saving the world, from Clark Kent to Peter Parker.

We're therefore disappointed to discover that the role involves saving aliens from Earth instead of the other way round, by sanitising spacecraft "that may intentionally or unintentionally carry Earth organisms and organic constituents to the planets".

The job listing contains no mention of costumes, but surely nobody would begrudge the planetary protection officer arriving in a cape - and perhaps also a pair of tourmaline-studded wonderpants (12 August)?

A FURNITURE catalogue has Ian Napier scratching his head with its offer of an "Octagonal Pine

Cube", which it promises is "both traditional and contemporary with a touch of exotic". More than a touch, thinks Ian.

Despite Feedback's hopes that it might be possible to cube an octagon, given a few extra spatial dimensions to play with, our mathematically minded colleagues howl in protest. Yet a regular cube extended into the fourth dimension does indeed have eight sides, each appearing as a cube in our three-dimensional world.

Such an object would have the unique selling point that it could be rotated in hyperspace to reveal seven additional cubes, allowing you to sell many different, coloured ornaments in just one convenient, hyperdimensional package.

**WE'VE** seen the future and it's in Teesside. Stephen Jorgenson-Murray says: "You can tell immediately what

era the town of Billingham was built in by the fact its main pubs are The Astronaut and The Telstar." If only the trend continued, he says, we could be drinking in the Roboticist's Arms or the iPhone and Dongle.

AT THE other end of the scale, we've been stuck in many a pub filled with old fossils, though not the type suggested by The Sir Richard Owen in Lancaster.

Joshua Thompson reports he was trapped here during the diluvial era of December 2015, when it survived the floods that wiped out many other pubs in the area. What better place to watch history in the making?

"YOU can add the newly reopened Rayleigh Arms in Terling, Essex, to the list of scientific greats that are commemorated by pubs," says Mike Letch. This was named after the local landowners, the Strutt family, who took the title of the Barons Rayleigh "and went on to produce the Nobel prizewinner John William Strutt, 3rd Baron Rayleigh of Rayleigh scattering fame, among other things".

Sadly, legacies don't always turn out as intended. Mike reports that the Strutt family coat of arms - seen hanging outside the pub - bears what can only be described as an imaginative depiction of a lion, which "gave rise to the pub's local nickname, The Monkey's".

FEEDBACK'S colleagues are gearing up for New Scientist Live, our gargantuan, trailblazing festival of ideas at the ExCeL centre in London next month. "I notice the following entry in your recent previews of this year's event," writes Robert Ford, declaring "Sunday: The Border Between Life and Death."

"I'm sure we've all experienced Sundays like that," he says.

**PREVIOUSLY**, Feedback reported the boundless occupancy apparently offered by the Infinity housing estate in Royston (29 July).

"I was surprised that you should feel disappointed that the developers

called their neighbouring site Affinity," says Crispin Piney. Surely this fulfils a useful service to navigation and driver safety in the area, he says, because under affine transformations, sets of parallel lines (such as roads) remain parallel.

"This is important to local drivers, as we know parallel lines have the property of meeting at infinity."

AND another driver who might benefit from such corrective measures: "I spotted a graphic recently on the side of a Belfast courier service vehicle," writes James Russell, "advertising delivery 'to Finaghy and beyond'."

**READER** Howard Bobry "is not alone in living in a town with interesting signage", reports Fred Nind (29 July). He says that in the Stirling village of Killin at the western end of Loch Tay, you can find Killin Cemetery, Killin News and the local cafe, Killin' Time.



YOU can't make an omelette without breaking a few eggs, and nor can we share the especially delicious example of nominative determinism sent in by Jenny Narraway without breaking our many promises not to run any more of these. "The president of the Dutch poultry producers union is one Hennie de Haan," says Jenny, which she tells us can be translated as Mr Chicken Rooster.

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

## Seasons in the sun

In August in England, eight weeks after the summer solstice, the direct heat from the sun on a fine day feels much hotter than it does in April, eight weeks before the solstice, although its elevation is the same. I understand that the air temperature will be warmer, but why does the radiation feel more intense? Or is it an illusion?

(Continued)

■ Your previous answers explained why air temperatures are higher in August than April, but not why radiation feels more intense.

Earth's orbit is not quite circular, and the distance between Earth and the sun is 0.6 per cent greater in August than it is in April. The inverse square law tells us that in August the sun's radiation is actually 1.2 per cent less intense than it is in April, but this difference is too small for us to notice.

However, we also receive black-body heat radiation from our solid surroundings. The surface temperatures of these solid surroundings such as the ground, walls and trees are typically 10°C (or 3 per cent) higher in August than in April.

To quantify the effect of thermal lag and radiation from the surroundings, enjoy an alfresco glass of red wine in the fading heat of the day. Then try it in the hours before dawn.

David Craig  
Edinburgh, UK

Radiation from the sun is more than matched by convection to the air. Face the sun and your bare skin receives heat by radiation. The sun delivers about 1400 watts of energy per square metre ( $\text{W}/\text{m}^2$ ) to Earth, but the atmosphere absorbs and reflects much of this.

On a very good day in the UK perhaps 300  $\text{W}/\text{m}^2$  will reach the ground. Your face presents about 0.03  $\text{m}^2$  to the sun, so will receive about 9 watts of solar heat. When your skin and the air temperatures are both around 25°C you don't lose heat to the

### "A car gets very hot when left in the sun, but only on a hot day when heat is not lost by convection to air"

air, but on a cool 10°C day your face will lose about 5W, and substantially more if there's a breeze. Also your face will radiate 3W to nearby cold walls if they are at 5°C.

A car gets very hot when left in the sun, but only on a hot day when heat is not lost by convection to the air. Just like the car, your skin is only interested in the total energy balance, so don't strip off in the spring.

Hugh Hunt  
Trinity College, Cambridge, UK

■ Skin contains thermoreceptors – nerve cells that variously detect heat or cold within particular temperature ranges, as well as changes in temperature. Perceived temperature is the

brain's response to the sum of information received from these receptors. So, for example, direct radiation from the sun will

### "In August, after months of warmth, the air humidity is higher than in April, which makes you feel warmer"

quickly heat up the skin and produce a warm response to the increasing temperature.

This is mitigated by other receptors responding to the temperature of the air touching the skin (warmer in August than in April), and also any breeze or convection currents that might be taking heat away from the skin and producing a cooling response.

A likely further factor is that in August, after months of summer warmth, the air humidity is higher than in April, which makes the body feel warmer because the cooling induced by sweating is less effective.

The feeling of a hotter sun is therefore an illusion because the brain does not detect it in isolation – it is responding to the other factors as well.

Richard Swiffe  
Darmstadt-Eberstadt, Germany



I found this strange plant – or is it a fungus (see photo)? Can anyone identify it?

Milo Seal  
Seattle, Washington, US

## TURNING OVER A NEW LEAF

I'm puzzled by beech trees. They are deciduous and their leaves turn bronze in the autumn, but they don't fall off the tree. Instead, they hang on until spring when other plants are putting out their new leaves. How do these trees benefit from this different approach to deciduousness?

Tony Leggatt  
Fortrose, Ross-shire, UK

## OL' BLUE EYES

I'm told that blue-eyed people find coping with dazzling sun more difficult than brown-eyed people do. Why? Or if it's untrue, what difference, if any, does eye colour make?

Samuel Yorke  
London, UK

## This week's questions

### LIFE IN THE DOME

When we were hiking the Oyster Dome Trail in Whatcom County near Puget Sound in Washington,

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At the heart of the 'image'