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WEEKLY January 14 - 20, 2017

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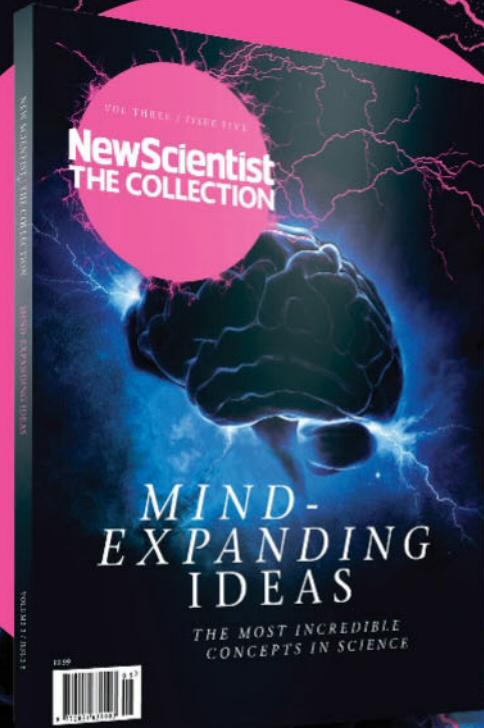
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# Don't break the silence

A new gene-tweaking technique deserves a fair trial

IMAGINE a simple spray that, when applied to crops, kills off pests including insects, fungi and viruses for weeks – but which isn't based on chemical pesticides and doesn't threaten human health or beneficial wildlife. Better still, once it has done its work it will degrade into harmless everyday compounds and fade away.

Does that sound like an environmentalist's dream come true? It should, but it may not be greeted as one – because the spray works by switching off some of the pathogens' genes. It's based on a gene-silencing technique called RNA interference, already used to engineer pest resistance into existing crops. The spray replicates the way such genetic

modification works, but doesn't make permanent changes to the plant's DNA (see page 8).

As yet the spray is nowhere near ready to be commercialised. The main practical obstacle is the cost of making the RNA it contains, which would have to be reduced dramatically. That is feasible if demand from farmers encourages investment in industrialising the process. Once that is established, other uses could be explored, such as boosting productivity or drought tolerance.

Will that be allowed to happen? Anything that smacks of genetic tinkering with the food supply, no matter how minor, safe or green, is virulently opposed by some lobbyists. Their stance is broadly

supported by a public suspicious both of the technology and vested commercial interests.

There are, of course, legitimate concerns that must be allayed before giving the go-ahead. But it is easy to imagine fears being stoked to stifle this technology before it can prove itself. That would be a mistake to add to the long list of those already made over genetic modification, which remains one of our best approaches to the challenges of 21st century food production.

A technique that harnesses genes without actually changing them offers the open-minded on both sides an opportunity to reach a working consensus. It must not be squandered. ■

# Judge not on drugs

EFFECTIVE, safe – and expensive. Last year, NHS England claimed in court that it didn't have the power to offer PrEP drugs, which slash the rate of HIV infection. It lost, but has still not made the drugs generally available. Some of those at risk have now taken matters into their own hands, turning to unorthodox sources (see page 11).

One argument against the NHS supplying the drugs is that many

of those at high risk of HIV wouldn't need PrEP if they used condoms. This is facile. Health services care for real people, not model citizens. We "shouldn't" smoke either, but the NHS funds services to help people quit, in the hope of preventing disease.

The NHS has said the drugs are too expensive, although they will save it money in the long run by avoiding lifelong HIV care. It went

so far as to announce that PrEP would compete for funds with other treatments, such as for children with cystic fibrosis. This was unusual and unwelcome: it's rare for the NHS to publicly pit one cause against another.

That the cash-starved health service should seek to ration or avoid costly new treatments is no surprise. Not everything can be funded. But those decisions should be made on the basis of real clinical costs and benefits – not sketchy ideas of worthiness. ■

## Space blues pose threat

**ISOLATION**, radiation and other dangers could interact to pose a major risk to mental and physical health on long space missions, according to the US National Academies of Sciences, Engineering, and Medicine.

The academies regularly review NASA's research on how being in space affects health. Their latest report looks at eight recent studies on the dangers of long exploratory missions or a Mars trip.

"Two of the most critical issues are the radiation exposure beyond low Earth orbit and the psychosocial effects of confinement and isolation," says Carol Scott-Conner at the University of Iowa, chair of the committee behind the report. She calls them "potential showstoppers" that could cause missions to fail.

Astronauts bound for distant destinations would share a small space with a few fellow crew members, and would be away from friends and family for years. They are also likely to be working hard, with their sleep patterns disrupted, and will lack real-time communication with Earth, all of which could affect mental and physical health.

The report points out that it is hard to foresee and study how these and other challenges may aggravate each other. "It seems like all of the risks could potentially interact," says Scott-Conner.

NASA hopes to use genetic studies to understand each astronaut's susceptibilities. This may make it possible to tailor space travel to take account of individuals' needs.

## Goodbye FM

NORWAY will be the first country to start turning off FM radio, in favour of digital programmes.

The northern county of Nordland is set to stop broadcasting FM radio this week, with other regions set to follow throughout 2017.

Many countries have considered dropping FM, but a combination of ageing equipment and geography mean Norway is particularly keen to replace its analogue FM system with digital audio broadcasting (DAB).

**"Norway currently has five national FM radio stations. With DAB, it could have around 40"**

"Norway has many mountains and valleys that the robust nature of DAB can help with," says Stephen Lax at the University of Leeds, UK. This terrain can distort FM signals. "Additionally, its FM radio infrastructure was coming to the end of its life, so they would have needed to either replace it or fully commit to DAB anyway."



Being up there can get you down

NASA/VICTOR ZELENTOV

## China in ripple hunt

THE search for gravitational waves has a major new player, with China joining the fray.

Predicted by Einstein a century ago, these ripples in space-time were only recently spotted. Last February, the Laser Interferometer Gravitational-wave Observatory (LIGO) team announced the very first detection, traced to a pair of colliding black holes.

Observatories in Italy and Japan will join the search over the next few years, and another is planned

in India. Now China has started construction of its Ngari-1 telescope, which will be seeking out gravitational waves of a specific kind.

Located 5250 metres above sea level in Tibet, Ngari-1 is ideally situated to pick up primordial ripples from the big bang. A team using the BICEP2 telescope at the South Pole had announced their detection in 2014, but it turned out to be noise from dust inside our galaxy.

Ngari-1 is scheduled to be operational by 2021.

## London breaks pollution limit

LEGAL air pollution limits for the whole year were broken just five days into 2017 in London.

European Union rules set a maximum hourly concentration of nitrogen dioxide, which, in towns and cities, mainly comes from road traffic. The rules state that this limit must not be exceeded more than 18 times in one year.

But monitoring by the London Air project from King's College, London, showed that at a site on Brixton

Road, Lambeth, this rule had already been breached by 9 pm on 5 January.

Nitrogen dioxide is linked to heart and lung problems and early deaths. "It's shocking that pollution limits in London have already been breached for 2017," said Penny Woods, at charity the British Lung Foundation. "The mix of these toxic air pollution levels with freezing temperatures poses a serious risk to people with lung conditions and can affect all of our health."

## 60 SECONDS

### Asteroids ahoy

NASA's latest low-cost space ventures will visit the Trojan asteroids that flank Jupiter and the large metallic asteroid, 16 Psyche. Both targets will reveal secrets of the early solar system.

**"Missions will visit Trojan asteroids and 16 Psyche. Both will reveal secrets of the early solar system"**

The two missions, called Lucy and Psyche, were chosen from five finalists for NASA's Discovery programme, which caps mission costs at \$450 million. Previous missions have visited Mercury and the asteroids Vesta and Ceres, and the next launch will be to Mars in 2018.

Lucy will launch in October 2021 and arrive at Jupiter in 2027. It will explore six Trojan asteroids, which orbit at the same distance from the sun as Jupiter, in gravity wells on either side of the gas giant. The Trojans are thought to be remnants from the early solar system, so may hold clues as to how the planets formed.

Psyche will launch to explore its namesake asteroid in October 2023 and arrive in 2030. 16 Psyche appears to be made mostly of iron and nickel rather than rock, which suggests it might be the core of a small rocky world, left over from a collision with another planet or asteroid.

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Flu may have killed 49 swans

### Flu still killing birds

THERE'S no end in sight to the bird flu epidemic, which has struck poultry farms across Europe and the Middle East. Some 800,000 exposed, free-range ducks and geese are set to be slaughtered in south-west France this month to stop the H5N8 virus spreading further.

Meanwhile, nine mute swans carrying the virus have died at a major colony at Abbotsbury in Devon, UK, and 40 more swans

**"Given the pattern of spread, the virus is probably being carried by migrating ducks"**

may also have died from it.

This flu strain has also been killing other bird species, including endangered ones, says the European Food Safety Authority. Infected white-tailed eagles, as well as peregrine falcons, crows and gulls, have been found dead in Europe. These birds may have caught the virus after eating birds killed by flu.

"Given the pattern of spread, and the weather we have seen, I think it is being carried by mallard ducks on the short migrations they make during winter," says Ab Osterhaus at the Research Centre for Emerging Infections and Zoonoses in Hannover, Germany.

NICK ANSELL/PA IMAGES



Choked in just 5 days

### Giant iceberg threat

A massive iceberg, known as Larsen C, seems set to break away from Antarctica, after a long-running rift grew by 18 kilometres in just two weeks during December. The remaining strip of ice holding the iceberg to the ice shelf is just 20 kilometres long. The iceberg is expected to detach in a few months' time, leaving the shelf behind it vulnerable to future break-up.

### Mini-moon mayhem

We used to think a single collision between Earth and a Mars-sized body was responsible for creating the moon. But new simulations show that about 20 smaller impacts over 100 million years could have spawned moonlets, which later merged into a single moon (*Nature Geoscience*, doi.org/bwzx).

### Boozy binge-eaters

This explains the kebabs. The bountiful calories in alcohol should sate our hunger. But mouse research suggests that booze activates brain cells involved in starvation, which seems to be responsible for alcohol-induced overeating (*Nature Communications*, DOI:10.1038/ncomms14014).

### Uber sharing

Taxi app Uber has launched a new service to share travel data with city planners. Uber Movement will give officials and researchers access to anonymised and aggregated data from more than 2 billion trips taken by Uber passengers. It could help with infrastructure planning.

### Pacemaker hack

On Monday, St Jude Medical, now owned by Abbott, was the first biomedical implant company forced to issue a security patch for its pacemakers. The US Food and Drug Administration ruled that people could hack the device, depleting the battery, changing the pacing or administering shocks. The company will soon roll out a software update.

# Gene-silencing farming revolution

Sprays turn off genes without changing DNA

Michael Le Page

DON'T like the look of those roses in your garden? One day you might be able to buy a spray that changes the colour of their flowers by silencing certain genes.

Farmers may use similar gene-silencing sprays to boost yields, make their crops more nutritious, protect them from drought and trigger ripening. The technique could let us change plant traits without altering their DNA.

Gene-silencing sprays that kill pests by disabling vital genes inside them are already in the final stages of development. But it has proved more difficult to create sprays that turn off genes inside plants.

One of the big challenges with plants is that the effects last only a few days. Farmers will not want to apply expensive sprays this often.

Now a team at the University of Queensland in Brisbane,

Australia, has managed to achieve long-lasting silencing of viral genes inside plant cells. The researchers have protected tobacco plants from a virus for 20 days with a single application of their spray. "The approach offers a step change in environmentally sustainable crop protection," says team member Neena Mitter.

It should work for plant genes, too. "This could open up all kinds of plant 'modification' unrelated to insect and disease control," says John Killmer of US-based biotech start-up Apse.

Such sprays would have several advantages. "A spray can be used immediately without having to go through the years involved in development of a genetically modified or conventionally bred crop," says David Baulcombe at the University of Cambridge.

Gene silencing exploits a natural defence system. When viruses invade cells, the cells cut

up some of the viral RNA to make short pieces of double-stranded RNA, which they use to recognise and destroy any RNA with matching sequences. Without viral RNA, no viral proteins are made, so viruses cannot replicate.

But it's not just viruses that can be targeted in this way. RNA interference (RNAi), as this is

**"A spray can be used immediately without the years needed to develop a new crop variety"**

often called, can also be used to block the production of any protein. Many genetically modified plants work by producing gene-silencing RNA inside their cells, for example to stop apples going brown.

Specific genes can also be shut down in some – although not all – bugs and plants simply by spraying them with ready-made,

double-stranded RNA with sequences matching the target genes. Monsanto, for instance, is developing RNAi sprays that kill pests. Its spray targeting the varroa mites that contribute to the woes of bees is now entering the final stages of development, the firm revealed on 5 January.

Many other teams around the world are trying to achieve long-lasting effects involving gene silencing in plants. Mitter's is the first to publish such results.

In experiments with tobacco plants, her group has shown that its spray's protective effect can last at least 20 days. This was achieved by combining the RNA with clay nanoparticles developed by Mitter's colleague Gordon Xu.

The positively charged clay nanoparticles, made of stacked sheets of common minerals such as magnesium chloride, bind to the negatively charged RNA. Over time, the clay particles react with carbon dioxide and break down, slowly releasing the RNA (*Nature Plants*, doi.org/bwxq).

Plant viruses are a huge problem for farmers around the world and no existing treatments target them directly. Farmers must either grow resistant crop varieties, if they exist, or try to kill the organisms that spread plant viruses, such as aphids. So if the antiviral spray works well in field tests on crops there could be huge demand. "We do believe it will be commercially viable," Mitter says.

The biggest obstacle is cost: while clay nanoparticles are cheap to make, RNA is expensive to create. A few years ago, it would have cost more than \$100,000 to make the gram or so needed to treat a small field. But this is changing fast. Apse, for example, aims to mass-produce RNA for under \$2 a gram. ■



It's a turn-off for the bad guys

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INTUITIOn ROBOTICS



## Home robot helps to keep you on your toes

A ROBOT companion for older people aims to promote activity and tackle loneliness by nudging them to take part in digital and physical activities.

A prototype of the ElliQ robot, made by Israel-based start-up Intuition Robotics, will be unveiled at the Design Museum in London this week. ElliQ is a small desktop device that consists of a stylised domed "body" and a separate detachable screen.

Created in collaboration with Swiss designer Yves Béhar, the robot is able to tilt and turn to indicate what it is doing and encourage a degree of social engagement. Similar to home assistants like the Amazon Echo, people can simply talk to it, and there are visual cues that could be particularly helpful for those with hearing difficulties.

A key purpose of ElliQ is to act as an easy interface to access existing services such as social media, messaging programs, and

audio and video streaming. For example, the device could alert the user that their grandchild has posted a new photo on Facebook, show it to them on the screen, and allow them to comment using speech-to-text technology.

Unlike most other home

assistants, ElliQ can recommend activities of its own accord. It might ask if you're interested in watching a video, for instance, or suggest a walk. It can also act as reminder to take medication.

Having a robot constantly bark suggestions could obviously get annoying, so the device uses machine learning to tailor these nudges to individual preferences. If a suggestion is met with a positive response once, ElliQ

### How about a spot of fresh air?

might try it again. If not, it might opt for a different tack. The device uses cameras and face recognition so it can detect when the user is nearby and direct its "gaze" at them when they speak.

Collecting so much information from a person's surroundings

**"A key purpose of ElliQ is to act as an easy interface to access existing services such as social media"**

raises obvious privacy concerns. Like the Amazon Echo, ElliQ only sends speech to the cloud after hearing its name, so it is not constantly transmitting any sounds it hears. Data captured by the camera remains on the device.

As populations age, companion and carer robots are becoming popular, with previous examples including robotic baby seal Paro and nursing bot Robear.

But Don Norman, director of the Design Lab at the University of San Diego, California, and an adviser on user experience to Intuition Robotics, emphasises that no robot is a substitute for human interaction. Norman, who is 81, says making a device older people will accept requires careful observation of someone's needs. After unveiling the first working prototype of ElliQ, Intuition Robotics plans a trial with older adults in San Francisco to collect feedback and refine the product.

Nick Hawes, a computer scientist at the University of Birmingham, UK, says ease of use is the biggest challenge when designing such robots, especially for those whose physical or cognitive health is declining. "What may be understandable to a 20 or 30-something, just in terms of speech patterns or interface ideas, may not be understandable to an 80-year-old," he says. Ultimately, he says, the most useful would be capable of physical tasks as well as companionship. **Victoria Turk** ■

### YOUR NEW LODGER

**In the market for a robot butler?**  
Home assistants and robots were a major trend at this year's Consumer Electronics Show (CES) in Las Vegas.

Many voice-activated tabletop devices follow in the footsteps of the popular Amazon Echo and Google Home. That includes Emotech's Olly, which uses deep learning to evolve its "personality" to suit its owner, and toy maker Mattel's Aristotle, a smart baby monitor that can play your child a lullaby when they cry.

Other new devices had a more conventionally robot-like aesthetic, such as Mayfield Robotics' Kuri.

**It trundles around your home blinking and bleeping, or else takes on specific tasks, becoming a robotic lawn mower or a security bot.**

But despite the rush of new hardware on offer, existing virtual assistants are still at the fore. Amazon's Alexa has been adopted in everything from cars to fridges and even a humanoid robot, Ubtech Robotics' home companion Lynx. Alexa is also used in consumer tech giant LG's blue-eyed Hub Robot, which connects via Wi-Fi to appliances that control your smart home.

## Mum and baby mammals both like to take sides

MOTHERS prefer to hold their babies on the left. Wild mammals seem to like keeping their young on that side too, at least when fleeing predators.

Now it seems the young of many mammals prefer to approach their mother from one particular side, as well. The explanation may lie in the contrasting talents of each half of the brain.

In mammals, the brain's right hemisphere is responsible for processing social cues and reinforcing relationships. This half of the brain is also the one that receives signals from the left eye.

Some researchers think this explains why human and ape mothers tend to cradle their babies on the left: to better monitor their facial expressions with their left eye – and thus the right brain.

Janeane Ingram at the University of Tasmania, Australia, and her colleagues have now looked at whether infants also prefer to observe their mum from one side. They studied 11 wild mammals, including horses, walruses, three species of whale and two species of kangaroo.

Whenever an infant approached its mother from behind, the team noted whether it was on her left or right side. They recorded almost 11,000 such choices for 175 infant-mother pairs. In all species, the young

approached their mother's right side more often – about three-quarters of the time, on average (*Nature Ecology & Evolution*, doi.org/bwx5). The observations tally with a recent human study, which found that children tended to approach adults in a way that kept them on their left.

Ingram's team found that infants who keep their mother on their left are better able to keep

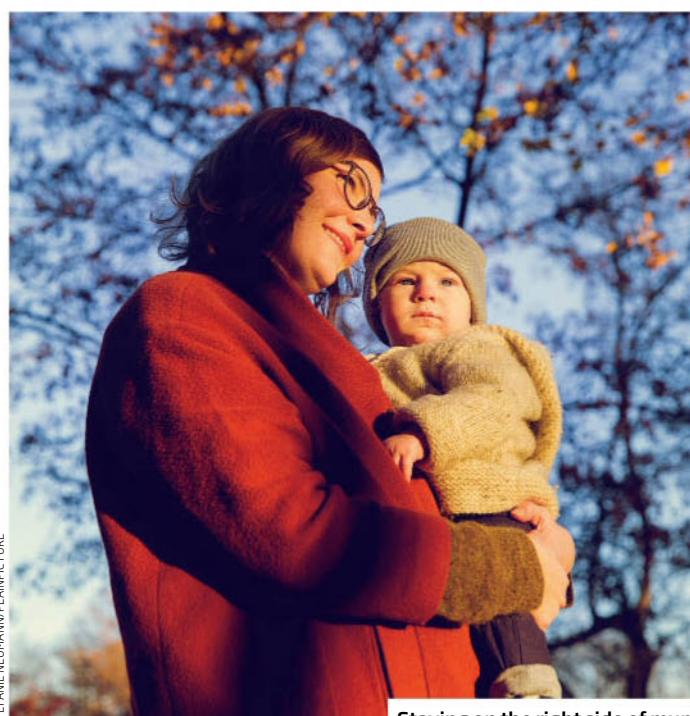
track of her and hence increase their chance of survival. When baby whales and horses move around with their mother on that side, for example, they are more likely to bond with her by rubbing up against her body, and less likely to be left behind by accident.

However, if a threat emerges the positions often reverse, Ingram says. "Infants keep their mother on their left in normal situations such as moving forward or suckling," she says. "But when faced with stressful situations such as when fleeing, mothers prefer their infant on their left side so they can better monitor them."

The consistent use of the right hemisphere in mother-infant interactions across all mammals studied hints that it has an evolutionary advantage, Ingram says.

"If you've got different functions to perform, you can do that more effectively if you allocate different kinds of processing to each brain hemisphere," says Lesley Rogers at the University of New England in Armidale, Australia. "So it makes sense for the right hemisphere to be dedicated to social behaviour."

Some human mums do lose their left-side-cradling preference, Ingram says – it happens once the child becomes more independent with age. Alice Klein ■



Staying on the right side of mum

## Strobe-light star could have eaten a planet

WHEN you are a messy eater, it can take a long time to clean up after a meal. The slow dimming of Tabby's star and the sudden dips in its light may be caused by orbiting debris left over from when it gobbled a planet.

The star KIC 8462852 rose to prominence in 2015, when a team of astronomers led by Yale's Tabetha Boyajian (after whom the star is nicknamed) observed a series of abrupt dips in its brightness, in which

it dimmed by up to 22 per cent before going back to normal.

There are many ideas about what causes the star's blinking, from internal stellar dynamics to swarms of orbiting comets to an enormous alien megastructure.

Things got more complicated in January 2016, when a review of old photographic plates revealed that Tabby's star dimmed by 14 per cent between 1890 and 1989. It faded by another 3 per cent over the four years it was observed by the Kepler space observatory.

Now Brian Metzger at Columbia University in New York and his colleagues have a theory that could

explain both the brief dips in light and the gradual dimming. The group thinks Tabby's star is just returning to its natural state – after a messy meal.

If Tabby's star devoured a planet in the past, the planet's energy would have made the star temporarily brighten, then gradually dim to its original state. Depending on the size of the planet, this event could have happened anywhere between 200 and 10,000 years ago.

As the planet fell into its star, it

could have been ripped apart or had its moons stripped away, leaving debris orbiting the star in eccentric orbits. Every time the debris passes between us and the star, it would block some light, making it seem as if the star is blinking (arxiv.org/abs/1612.07332).

Next time we see the light from Tabby's star dip, Metzger hopes that astronomers will glimpse the signatures of that debris.

A collision like this explains the behaviour of Tabby's star well, says Jason Wright at Penn State University in University Park. "This paper puts a merger scenario on the table in a credible way." Leah Crane ■

**Consuming a planet could explain the star's brief dips in light and its gradual dimming**



Cuts new HIV infections

## Internet drugs are preventing HIV

Clare Wilson

GAY men who defied medical advice seem to have changed the course of the HIV epidemic in the UK – for the better.

Four London sexual health clinics saw dramatic falls in new HIV infections among gay men last year, figures published last month show. This decline of around 40 per cent may be mostly due to thousands of people buying medicines online. Called pre-exposure prophylaxis (PrEP), these drugs cut the chance of catching the virus.

"We need to be very cautious at this stage, but I can't see what else it can be," says Will Nutland at the London School of Hygiene and Tropical Medicine, who has set up a website, called PrEPster, that offers information on how people can give themselves the drug. "Something extraordinary has happened in the last 12 months because of a bunch of DIY activists working off our kitchen tables."

"People say, 'Why don't gay men just use condoms?'" says Mags Portman from the Mortimer Market Centre in London, one of the clinics that has seen large declines in diagnoses. "They do, but not all the time. Straight people don't use condoms all the time either."

The best argument for using PrEP is that it works so well at reducing new infections, says Jason Domino, who has been using the medicine for two years, after a scare when a partner turned out to be HIV-positive. "You're tackling an infection that's hugely expensive to address," he says. "It saves the NHS money."

PrEP has been approved in the UK as a drug for preventing HIV infection in both men and women, but isn't yet available on the National Health Service. To avoid paying £400 a month for private prescriptions of the brand-name drug Truvada, growing numbers are buying generic

versions from online pharmacies in India and Swaziland for £40 a month, through a UK website called I Want PrEP Now.

Until recently, most doctors would have advised against buying any medicines online. While it is legal to buy up to a three-month personal supply, it can seem shady as the medicines are sent through several countries to get around customs laws.

But the doctor's regulatory body, the General Medical

**"The NHS needs to pull its finger out. The cat is out of the bag that PrEP really works"**

Council, recently advised Portman that doctors should be giving their patients information about treatments they cannot offer themselves.

Some sexual health doctors are now actively helping people who source PrEP online, providing blood tests to check the pills are real and urine tests to ensure people aren't getting kidney damage as a side effect.

PrEP use has been rising in other countries, and some cities like San Francisco have seen modest falls in infection rates. In

the UK, however, PrEP use was low until a sudden surge over the past year. This increase coincided with the launch of I Want PrEP Now and PrEPster, and ongoing publicity over a legal attempt to get NHS England to provide the drug.

Greg Owen, who runs I Want PrEP Now, estimates that more than 2000 people buy it through his non-profit website. Doctors mainly recommend that people use his site rather than finding a manufacturer to buy from directly because Owen works with NHS clinics to check the medicines are genuine.

While no one knows how much of the decline in new infections is thanks to PrEP, several doctors say it is probably the main factor. "We are convinced that PrEP is responsible for the large decreases in new diagnoses," Portman said in a tweet about the new figures.

Sheena McCormack of clinic 56 Dean Street says the fall in infection rates seen at their centre is unlikely to be due to greater condom use, as rates of other sexually transmitted diseases such as syphilis were about the same in 2016 as the year before.

Matthew Hodson of the HIV information charity NAM says that while the drop could in theory be down to the preventive impact of wider testing and treatment, that is unlikely because of the timing and rate of decline.

But a Public Health England spokesperson told *New Scientist* that a range of other factors could have caused the fall in new HIV diagnoses. After NHS England lost a court case in November last year, Public Health England said it would make PrEP available, but only as part of a 10,000-person trial to answer outstanding questions about how the drug should be rolled out.

"The NHS needs to pull its finger out and make sure there's a contingency plan for what to do when its 10,000 places fill up," says Nutland. "The cat is out of the bag that PrEP really works." ■

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# Social brains grown in a dish

Andy Coghlan

**BALLS** of brain tissue grown from stem cells are helping us understand why some people struggle to be sociable and others can't rein themselves in.

Alysson Muotri at the University of California, San Diego, and his team have created mini-brains from stem cells taken from the pulp of children's milk teeth. These "organoids" can develop as many as six layers of cerebral cortex – the outer surface of the brain. The cortex houses circuitry governing our most complex thoughts and behaviours, including socialising.

Each mini-brain is roughly 5 millimetres across. "Though they're not as well defined as they are in a real brain, they resemble what you find in an embryonic fetus," says Muotri.

To understand how brain development affects sociability, the team used donated cells from children with autism and Rett syndrome, both of which are associated with impaired communication skills. They also used cells from children with

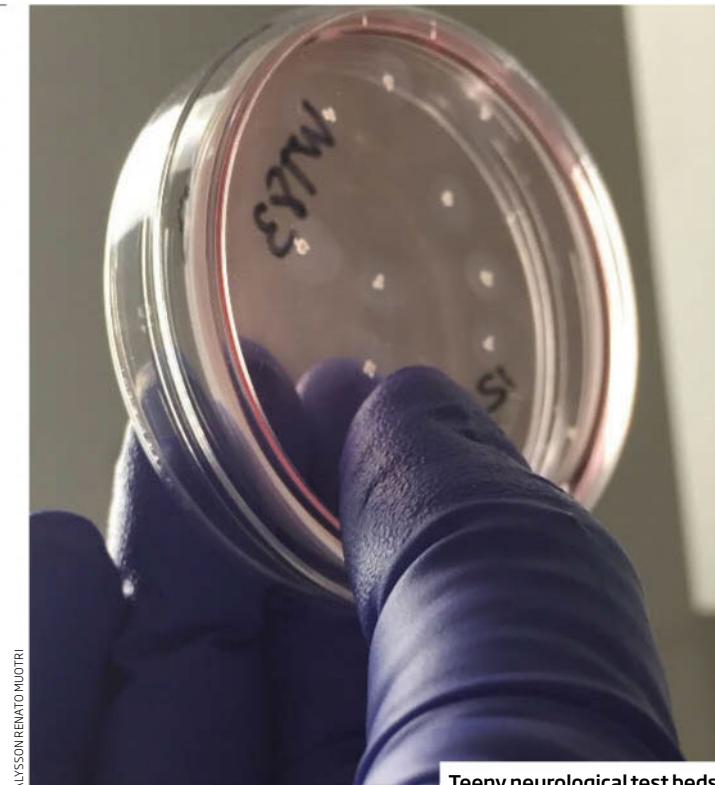
Williams syndrome, a hyper-sociable condition in which people can be unable to resist talking to complete strangers.

The team found that mini-brains grown using stem cells from children with autism form fewer neural connections, while those from people with Williams syndrome have an abnormally high number. "The differences are striking, and go in opposite directions," says Muotri. When the team examined donated brains from deceased people, they found similar patterns.

Research by other teams using organoids suggests that the brains of people with autism may also have a higher number of inhibitory neurons, cells that act to damp down the signals transmitted through the brain.

Muotri will discuss the results and the team's future plans at a conference on stem cells in Olympic Valley, California, this week. Ultimately, he wants to understand how humans evolved to be so social, he says.

The team has already begun comparing human mini-brains with ones derived from bonobo



Teeny neurological test beds

and chimpanzee stem cells.

"The most striking observation so far is that monkey brains mature way faster," says Muotri.

Muotri is also planning to try connecting the organoids to rudimentary sense organs. The team wants to develop eye-like tissue that can sense light, and hook this up to the mini-brains. "We can then stimulate the eye

and see what happens in the brain," says Muotri.

But mini-brains have their limitations, says John Mason at the University of Edinburgh, UK. "The organoids are good for studying the very early stages of brain development, but may not reveal much about later stages on which things like sociality depend." ■

## Baboon speech talents get a hearing at last

**BABOON** grunts and barks have more in common with human speech than we thought. The monkeys routinely produce five of the distinct vowel sounds found in our languages.

Researchers typically link our ability to produce a range of vowels with the low position of the human voice box, or larynx, in the throat. Non-human primates have a high larynx, hence are incapable of

producing many vowel-like sounds.

But according to Joël Fagot at Aix-Marseille University and Louis-Jen Boë at the Grenoble Alps University, both in France, this standard explanation is wrong.

Fagot, Boë and their colleagues have analysed 1300 baboon vocalisations, recorded at a primate research centre in Rousset-sur-Arc in southern France. They extracted vowel-like sounds from the calls and ran them through computer software to identify the key resonant frequencies, or "formants".

The lowest two formants are known to give a reasonable indication

of the position of the tongue, and can help computers to classify the associated vowel sound.

The team discovered that male and female baboons each produce four vowel-like sounds. Females produce one that males don't, and vice versa, so in total there are five distinct vowels. They correspond to the second syllable in "roses", and the vowel sounds in "you", "thought", "trap" and "ah" (*PLoS One*, DOI:

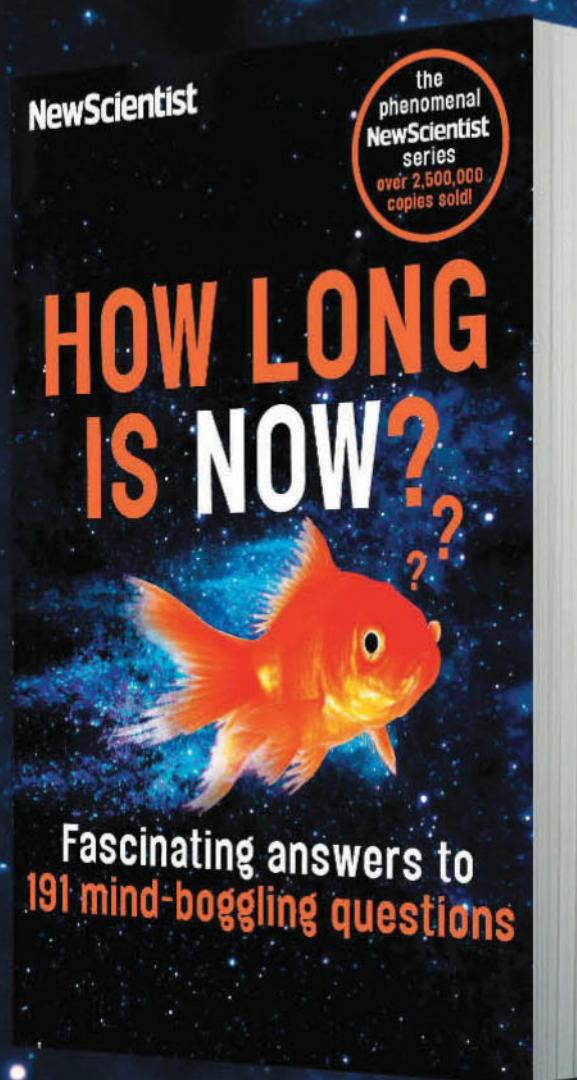
**"Major features of spoken language may originate with the common ancestor of monkeys and humans"**

10.1371/journal.pone.0169321).

The findings raise fresh doubts about the link between the position of the human larynx and the origin of speech, says Fagot. He thinks important features of spoken language may have originated as far back as the common ancestor of monkeys and humans, which lived about 25 million years ago.

But Johan Bolhuis at Utrecht University in the Netherlands says that the work, in fact, provides additional evidence that even with the "speech machinery" present, animals do not automatically evolve language. Colin Barras ■

# WHY ARE DOGS' NOSES WET?



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ALAN THORNTON/GETTY



## To catch a thief, red-handed

Timothy Revell

PETTY criminals had better watch out. Now there's a computer vision system that can detect suspicious behaviour in CCTV footage as it happens. The tech can then alert operators to intervene, and save the footage in case it is needed for evidence.

Researchers on the P-REACT project say the surveillance technology could help catch criminals in the act. It could also help relieve police of "digital evidence overload" by highlighting video clips most likely to be relevant to investigations.

"If a camera at a gas station picks up suspicious activity, the footage will be sent to the cloud, people at the gas station will be alerted, and nearby cameras will be told to look out for the criminals too," says vproject coordinator Juan Arraiza at Vicomtech, a research foundation in San Sebastian, Spain.

P-REACT tracks people's movements to work out whether

they are simply walking along a street, for instance, or doing something dodgy. Its algorithms have been trained on sample scenes of people fighting, chasing someone or snatching a bag. They had to be finely tuned to identify these activities: hugging can look like fighting, while running can be mistaken for giving chase.

The first tests of P-REACT were run last year in a carefully controlled environment, with actors playing the roles of petty criminals. In this idealised set-up

**"The system caught every play-acted crime - though it may have more difficulty in a real-world scenario"**

the system reacted flawlessly, catching every play-acted crime – though it may have more difficulty in a real-world scenario. The technology was presented at the International Conference on Imaging for Crime Detection and Prevention in November, with more extensive field trials planned for the future.

Meanwhile, aspects of the technology are already being rolled into tools for police to use. Dublin-based company Kinesense is developing products that will give police access to CCTV clips selected by the P-REACT system. "One of the biggest challenges police face is digital evidence overload," says chief technology officer Mark Sugrue. "P-REACT solves this by letting the camera send only important clips."

Sean Gaines at Vicomtech says P-REACT could also help prevent profiling based on race or age, as it only analyses movement, and isn't subject to the biases that might influence a CCTV operator's decisions. "Our algorithms do not take appearance into account, only actions matter," he says.

Teo de Campos at the University of Brazil says that technologies like P-REACT "help the operator in a surveillance room to focus on relevant cameras or even in relevant regions of images". Similar systems may already be in use in some places, he says, but the details are often kept secret.

Although P-REACT and systems like it can help pick out unusual behaviour, they can't actually tell if an act is criminal, points out Marcos Nieto at Vicomtech. That particular job should be "left for the human beings". ■

## Miniature brain discovered in girl's ovary

A TUMOUR containing a small brain has been found growing on the ovary of a 16-year-old girl in Japan.

The 10-centimetre-wide tumour was discovered when the girl had surgery to remove her appendix. Inside the tumour, doctors found clumps of hair, and a 3-centimetre-wide brain-like structure covered by a thin plate of skull bone.

Closer analysis revealed that it was a small version of a cerebellum, which usually sits underneath the brain's two hemispheres. A mass on one side resembled a brainstem – the structure that normally joins to the spinal cord (*Neuropathology*, doi.org/bwxr).

About a fifth of ovarian tumours contain foreign tissue, including hair, teeth and muscle. These normally benign tumours are named teratomas after the Greek word *teras*, meaning monster. One theory is that they arise when immature egg cells go rogue.

Brain cells are often found in ovarian teratomas, but it is extremely unusual for them to organise themselves into brain-like structures, says Masayuki Shintaku at the Shiga Medical Centre for Adults in Japan, who studied the tumour.

"Neural elements similar to that of the central nervous system are frequently reported in ovarian teratomas," says Angelique Riepsamen at the University of New South Wales in Australia. "But structures resembling the adult brain are rare."

The miniature brain even developed in such a way that electric impulses could transmit between neurons, just like in a normal brain, says Shintaku.

Sometimes ovarian teratomas with brain cells in can lead to personality changes, paranoid thoughts or seizures if the immune system recognises the tissue as foreign and starts to attack both it and cells in the brain. The girl didn't have any such symptoms. The tumour was removed without complications and she has recovered well. Alice Klein ■



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# Electric shocks help depression

Sally Adee

**PREPARE** yourself for a shock. Zapping the brain with electricity really does seem to improve some medical conditions, and might be useful for treating depression.

Transcranial direct current stimulation (tDCS) uses electrodes to send a weak current across the brain. Thousands of studies have suggested that stimulating brain tissue like this can help treat a range of conditions including tinnitus, depression and stroke.

However, replicating such studies has been difficult, and two recent analyses found no evidence that tDCS is effective, leading some to say the technique is largely a sham.

"There are too many folks out there right now who are using electrical brain stimulation in a cavalier way," says Michael Weisend, at Rio Grande Neurosciences in Santa Fe, New Mexico. "At best it has an effect that's poorly understood, at worst it could be dangerous."

Now an extensive review has pinpointed the conditions that are most likely to respond to tDCS treatment. Jean-Pascal Lefaucheur at Henri Mondor Hospital in Paris, France, and his team sifted through all the tDCS

studies so far. Unlike the two previous analyses, this one didn't lump together studies of variable sizes and designs. Instead, the team chose only studies that were placebo-controlled, used tDCS as a daily medical treatment, and involved at least 10 participants.

This revealed that tDCS seems to reliably improve the symptoms of depression, addiction and craving, and fibromyalgia. It also uncovered that the technique does not work for tinnitus, and

that tDCS may actually have a negative effect in people who have had a stroke (*Clinical Neurophysiology*, doi.org/bwwn).

"It is really the type of work that could push the field further," says Roi Cohen Kadosh at the University of Oxford.

But the study is unlikely to be enough to move tDCS into mainstream clinics any time soon. Most of the studies reviewed in the analysis had fewer than 25 participants. In contrast, a single trial of a new antipsychotic drug, for example, may involve 18,000 volunteers.

For now, "possibly or probably effective" is the best label tDCS can hope for, says Weisend. "The community needs to push for bigger trials."

However, the findings do shed light on how tDCS treatment might change. The analysis identified factors that influence the effectiveness of treatment, such as the position of the electrodes, the thickness of the skull and the subject's brain chemistry. For example, if someone is taking serotonin-boosting antidepressants, tDCS may affect them differently. This suggests that tDCS treatment will need to be tailored specifically to each individual. ■



Current thinking

**Carbon rips up chemistry textbooks**

at the Free University of Berlin who synthesised and studied the molecule, called hexamethylbenzene.

Typically, this compound resembles a ship's wheel, consisting of six carbon atoms arrayed in a hexagonal ring, with extra carbon-atom arms protruding from the ring's outer edge. In an experiment in 1973, German chemists took away two of the compound's electrons, and evidence suggested that the positively charged version then collapsed in on itself and formed a pyramid. In this arrangement, there are six electrons available to connect the top of the pyramid to the five carbons in the rest of the ring and the extra arm, Malischewski says. But no one double-checked the molecule's shape, until now.

It is an unusual, unstable arrangement that exists only at low temperatures inside extremely acidic liquids. So Malischewski spent six months tinkering with a potent acid to produce the compound and derive a few milligrams of crystals that could then be viewed using X-rays.

The X-ray diffraction pattern showed the unmistakeable five-sided pyramidal shape (*Angewandte Chemie*, doi.org/f3s9kw).

Quantum calculations and other experiments suggested a six-bond carbon atom was possible, but the

crystal structure serves as photographic proof, says Dean Tantillo at the University of California, Davis. "It sheds light on the nature of bonding and the limits of our understanding of organic chemical structures," he says.

In normal temperature and humidity, the molecule would break down immediately, so it is unlikely to have any practical applications, such as producing new types of carbon nanotubes.

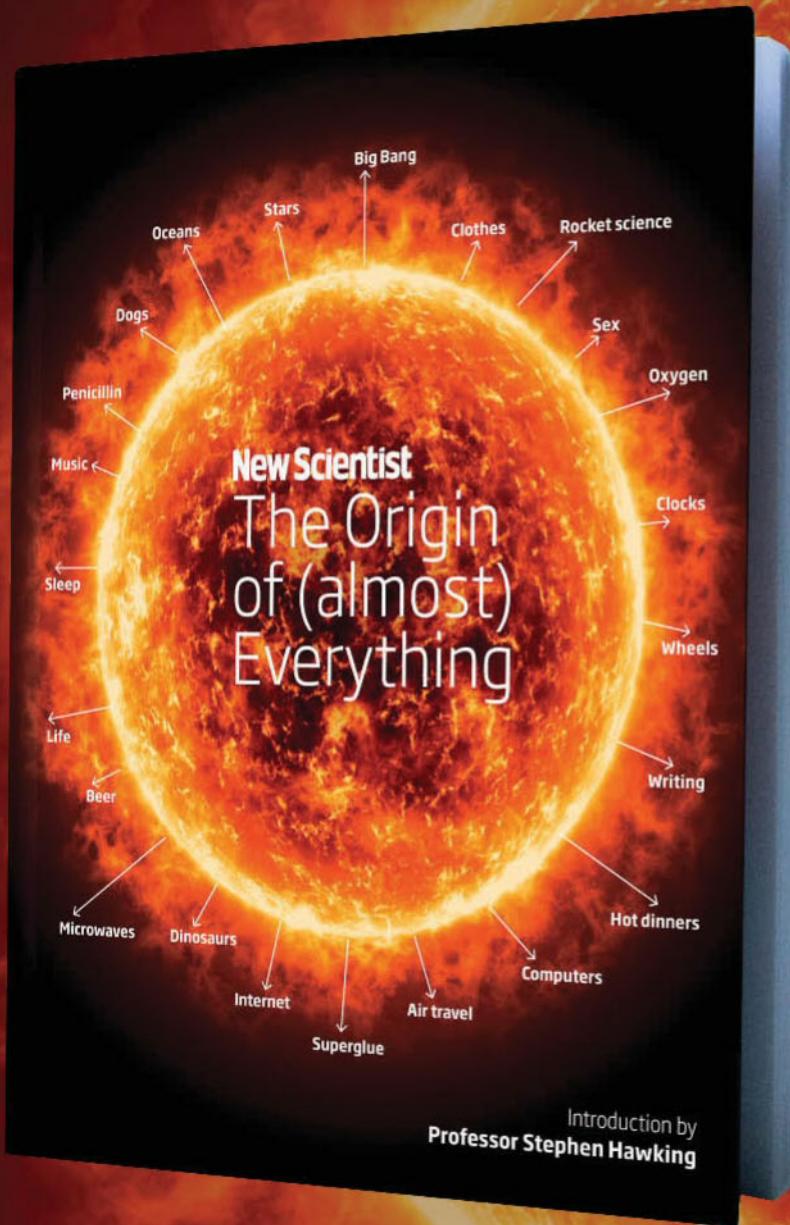
But Malischewski says he was just intrigued by the question of whether the molecule could even exist. "It is all about the challenge and the possibility to astonish chemists about what can be possible," he says. Rebecca Boyle ■

**"It is all about the challenge and the possibility to astonish chemists about what can be possible"**

**TEAR** up that old textbook. A pyramid-shaped carbon molecule that contradicts one of the most basic chemistry lessons we learn at school has been studied for the first time. It contains a carbon atom that bonds to six other atoms instead of the four we have been told carbon is limited to.

Atoms form molecules by sharing electrons. Carbon has four electrons that it can share with other atoms. But in certain conditions, carbon can be stretched beyond this limit, says Moritz Malischewski, a chemist

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## Trunk trick lets elephants grab almost anything

A CAPTIVE African elephant called Kelly has helped shed light on one of nature's great mysteries: how elephant trunks can grip and carry a diverse range of objects.

Jianing Wu at Georgia Institute of Technology in Atlanta and his colleagues offered Kelly items of food in four different sizes - powdered bran, cubed bran, cubed swede and cubed celery. "We wanted to know how she would grab food items of different size," says Wu.

They offered the food on a table that measured the downward force of her trunk as she gripped items, and took detailed measurements of the trunk's manoeuvres.

Kelly's secret was her ability to create a kink at any point along her 2-metre-long trunk. The kink acted like a joint that subdivided her trunk into two sections: a long section that supported the weight of the appendage and a short tip pointing vertically downwards for dexterous gripping. This allowed her to exert exactly the right amount of downward pressure to grip an object.

Kelly could reduce the downward force for particularly delicate objects by making the vertical part of her trunk shorter - and increase the force by making the vertical section longer.

Wu, who presented the results at the annual meeting of the Society for Integrative and Comparative Biology in New Orleans last week, hopes to build a small prototype artificial gripper based on the same principles.

## Oxytocin surge preps chimps for battle

IS THE fabled "cuddle hormone" really a "warmone"? Oxytocin levels surge in troops of chimpanzees preparing for conflict with rival groups.

The finding is at odds with the prevailing image of oxytocin as something that helps strengthen bonds between parent and infant. But given its ability to strengthen loyalty, oxytocin could also be a warmonger.

hormone that helps chimps cooperate against an enemy.

Catherine Crockford at the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany, and her colleagues monitored two rival groups of chimpanzees in the Taï National Park in Ivory Coast between October 2013 and May 2015, collecting chimp urine samples after various forms of interaction. Oxytocin levels in the

samples surged whenever chimps on either side prepared for confrontation.

"There's logic behind this when you consider behaviours that help mothers form a bond of trust with their offspring, then physically protect them from threats," says Crockford (*PNAS*, doi.org/bwst).

The findings echo research that reported oxytocin levels were raised in teams of human volunteers when they were pitted against each other in games.

## Med diet good for older brains

FOLLOWING a Mediterranean diet may help prevent your brain from shrinking.

"As we age the brain shrinks and we lose brain cells, which can affect learning and memory," says Michelle Luciano at the University of Edinburgh, UK.

But by studying 401 people in their 70s, her team has found that the brains of those who adhered more closely to a Mediterranean-style diet shrank significantly less over a period of three years (*Neurology*, doi.org/bwwh).

A typical Mediterranean diet contains a large proportion of vegetables, fruits, olive oil, beans and cereal grains, moderate amounts of fish, dairy products and wine, and only small amounts of red meat and poultry.

"This study adds to the body of evidence that suggests the Mediterranean diet has a positive impact on brain health," says Luciano.

## Brain expands to remember faces

NO NEED to feel overwhelmed by an ever-growing social circle. Your brain can keep up with new faces, thanks to one region that continues to grow into adulthood.

The fusiform gyrus is thought to play a role in recognising faces, something adults are better at than children. Brain scans of 47 people of different ages found - after taking into account overall brain sizes - that adults had 12.6 per cent more solid brain matter in this area than children did (*Science*, doi.org/bwwg).

It is thought that almost all brain remodelling occurs during adolescence or earlier, but surprisingly, expansion of this area seems to happen later in life, says Kalanit Grill-Spector at Stanford University, California.

## This giant goose was quite a fighter

**FIGHT or flight?** A giant goose that lived on a Mediterranean island between six and nine million years ago had wings built for combat.

Weighing 22 kilograms, *Garganornis ballmanni* might be the biggest member of the duck, goose and swan family ever to have lived. It stood perhaps 1.5 metres tall.

Its fossilised bones have been found at Gargano and Scontrone in central Italy. During the Miocene, this area consisted of islands populated by unique species.

*Garganornis*'s wing bones are short for its size, suggesting it couldn't fly. But an analysis led by Marco Pavia at the University of Turin, Italy, shows that the carpometacarpus bone – equivalent to the hand bones in humans – has a rounded lump called a carpal knob. This adaptation is seen in other birds that fight over territory, including some ducks and geese and the extinct Rodrigues solitaire, the closest relative of the dodo.

"It's covered over with hard skin, so it becomes a really effective weapon," says Julian Hume of the Natural History Museum in London.

*Garganornis* might have been a forest-dwelling herbivore, and would have had to fight for territory – the most likely reason for the adaptation, says Hume (*Royal Society Open Science*, DOI: 10.1098/rsos.160722).



STEFANO MAUGERI

## Cosmic radio burst tracked back to a dwarf galaxy

WE'VE followed a fast radio burst home. It's still unknown what causes these barrages of radio waves, but at least we now know where one of them comes from – a dwarf galaxy billions of light years away. This knowledge should give us a way to study their origins.

Fast radio bursts (FRBs) are powerful radio signals that flash from distant space for milliseconds and then disappear without a trace. They have been blamed on everything from black holes to extraterrestrial intelligence.

Only 18 FRBs have ever been detected, and of those, only one has been observed to repeat: FRB 121102. Now, a team of astronomers has used a collection of radio telescopes around the globe to pinpoint its origin.

"It is absolutely nailed down," says Shami Chatterjee at Cornell University in Ithaca, New York. "Even two months ago, I did not think we could tell this full story, and now we can."

The team located the FRB about 100,000 times more precisely than previous attempts with

individual telescopes, letting them unambiguously associate it with a dwarf galaxy about a tenth of the diameter of the Milky Way, more than 2.5 billion light years away (*Nature*, doi.org/bwss).

FRB 121102 could come from a bright region around a black hole in the centre of its host galaxy that spews radio waves as it vaporises gas and plasma.

But the researchers' preferred explanation is that it is caused by the remnants of a supernova being energised by a young, rapidly spinning neutron star.

## Transistor that's stretchier than skin

WEARABLE tech is getting flexible. A new transistor can be stretched to twice its length without losing conductivity, making it ideal for use in devices worn on the body.

A team led by Zhenan Bao at Stanford University made the stretchy transistors by confining conductors inside an incredibly thin, flexible polymer material. After 100 stretches the transistors showed no signs of cracking, meaning they could be attached to body parts that constantly move. To demonstrate this, the team made a simple device that is worn around the knuckle of a finger and controls a small LED light (*Science*, doi.org/bwsr). A real-world application of the technology could be in "electronic tattoos" placed on the skin to collect basic health information like heart rate or temperature.

"The skin of humans can stretch up to 70 per cent. If the electronics can't do that as well you have a problem," says Niko Munzenrieder at the University of Sussex, UK. "There have been other attempts at creating stretchy transistors, but this team has managed to make them in a cheap and easily replicated way. That's really cool."



## Black holes could blow star chunks

THE Milky Way's supermassive black hole could be chewing up stars and spitting planet-sized pieces back out at us. If so, chunks of stars may be hurtling across the universe at incredible speeds.

Occasionally, a star passes close enough to get caught by our galaxy's central black hole and spaghettified – stretched into a thin noodle by the powerful gravitational field. Clumps the size of planets could then coalesce under their own gravity.

Those clumps, with masses ranging from around that of Neptune to several times that of Jupiter, are

then flung away from the black hole at speeds of up to 10,000 kilometres per second, suggest simulations by James Guillochon and Eden Girma at Harvard University.

The pair calculated that one out of every thousand free-floating planet-sized bodies should be formed in this way, although they would be difficult to detect. Their results were presented at the meeting of the American Astronomical Society in Grapevine, Texas, last week.

"This is a way to transport entire worlds from one corner of the universe to another," says Guillochon.

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## Nip it in the bud

Legalising pot could lead to a powerful marijuana lobby. Can we stave off Big Cannabis, asks **Clare Wilson**

CANNABIS is going legit. This year, Canada will become the latest country to join a small but growing number of regions where it is legal to smoke marijuana.

But some fear that this global trend could lead to the plant's growers and sellers taking control of the market to maximise profits and recruit new users, and fighting any controls on its sales and marketing techniques. One worry is that, left unchecked, the cannabis industry might become as rich and powerful as the tobacco and alcohol industries did in the last century.

"The marijuana industry is where tobacco was in about 1890," says Stanton Glantz at the University of California, San Francisco. "Tobacco went on to develop immense political power, hire lawyers and lobbyists and dominate regulators."

Canada offers an alternative

approach, one in which public health is at the forefront. Under plans published last month, cannabis would be as tightly regulated as tobacco or alcohol. Is this enough to halt the rise of Big Cannabis?

In the West, the case for legalising cannabis has been gaining ground for some time. It has long been the most widely used recreational drug, yet in

**"The marijuana industry is where tobacco was in about 1890. It went on to develop immense power"**

most parts of the world it is criminalised. This ruins lives, wastes police time and fills jails.

Over the past two decades, various regions have legalised medical marijuana and some have begun to decriminalise its recreational use, too. While

cannabis is still illegal in the US at the federal level, for example, it will soon be possible to smoke pot without getting arrested in eight states and Washington DC.

Several other countries have also decriminalised it in some way, including Portugal and Spain (see map, below).

For many across the political spectrum, the trend toward legalisation is a rare, welcome instance of policymakers aligning laws with common practice. Yet some worry that enthusiasm for this change shouldn't mean we allow a free for all.

The warnings come from some surprising corners. Steve Rolles of the pro-legalisation UK think-tank Transform spoke against legalisation in Ohio in 2015. "The whole tenor of the campaign was unethical and highly dubious," he says. If passed, the state ballot would have given 10 investors



BLARGABLE/REUTERS

control of the state's marijuana market – the same people who were bankrolling the measure.

People also objected to the campaign mascot. "Buddie" was an anthropomorphised marijuana plant with a bud for a head and a superhero's body, complete with bulging pectorals and a cape. It toured college campuses urging students to vote Yes.

Critics said it could appeal to children and pointed to similarities with the controversial "Joe Camel" cartoon used to advertise Camel cigarettes in the 1990s. The measure failed.

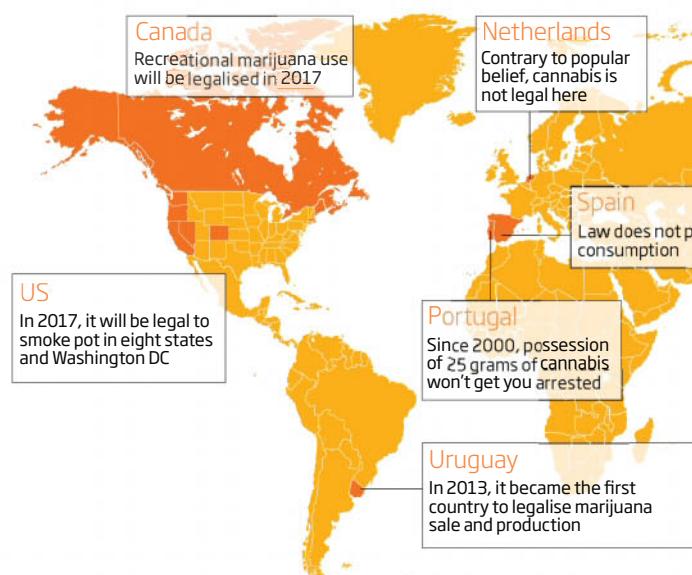
Why the concerns, if cannabis is safe? While addiction is less common for cannabis than with drugs such as heroin, some people do become heavy users and cannot quit. It can also sometimes trigger a psychotic episode or even longer-term problems such as schizophrenia.

In Colorado, where cannabis was legalised for recreational use in 2014, some people have unintentionally eaten enough to end up in hospital with temporary psychosis.

Colorado responded to these

### Green light

A growing number of regions have legalised or decriminalised the recreational use of cannabis





Herbal medicine

incidents by tightening its rules for food products containing cannabis to make it clear how much is equivalent to a single “serving” of 10 milligrams of THC, the compound that gets you high. Either the food itself must be marked with these servings, such as with products like cannabis-laced chocolate, or where that isn’t possible, such as for bulk products like pot granola, it must be packaged in single servings.

## Mainstream marijuana

This episode may have helped shape Canada’s proposed guidelines, which require products containing cannabis to state the product’s strain and potency. Such “dosage” labelling is especially useful for food products, like chocolate and brownies, says Rolles, who advised the task force set up to figure out how best to legalise cannabis.

That’s not just to avoid people eating them by mistake but also because new users or those who normally smoke it may not know that the effects of cannabis take longer to appear if it is ingested.

“You need to have clear warnings that effects develop over two hours, so don’t re-dose before that point,” says Rolles.

The Canadian guidelines also go a lot further. All cannabis products – however they are ingested – will have to be sold in plain packs, which must carry health warnings. It would be sold in shops, but it couldn’t be advertised or subject to promotions. That’s important, says Beau Kilmer of RAND, a global policy research organisation, because for-profit companies will naturally prioritise profit over public health. “They’re going to be making most of their money off the heavy users and they’re going to be working hard to maintain the heavy users,” he says.

To prevent this, other public health measures in Canada’s proposals include price controls and a cap on the maximum potency of any product. These steps help protect not only the heavy users, but young people, who are thought to be most vulnerable to any ill-effects. It’s the same way many countries

## THE PROHIBITION PARADOX

While cannabis is relatively safe, some users experience ill effects, including addiction and schizophrenia. That’s not an argument against legalisation, says Steve Rolles of the UK drugs think-tank Transform – in fact, it’s precisely why it needs to be legalised.

For one thing, a legal, regulated marketplace should make cannabis less accessible to teenagers. Legalisation tends to go hand-in-hand with minimum age limits for use, similar to how most regions legislate alcohol. Some marijuana will still be accessible to teens, as happens now with booze, but it should be thinner on the ground as high street shops start to put illegal dealers out of business.

Another benefit of legalisation is a return of milder strains of marijuana. Currently, illegal dealers have no incentive to sell these as the stronger

stuff is more lucrative. This is why the strength of the average joint sold on the street has risen over the past few decades from 3 per cent THC – the compound in that gets you high – to about 15 per cent. “It’s like going to a pub and being obligated to drink vodka when you just want a beer,” says Rolles.

In fact, this is exactly what happened during alcohol prohibition in the US in the 1920s; bootleggers mainly sold spirits because they were easier to transport and made more profit.

In Colorado, where cannabis has been legal since 2014, you can now buy marijuana in a range of strengths, and it’s all clearly labelled. For this reason, Rolles says Colorado’s approach is better than prohibition. But it may not do as much to protect users (see main story).

regulate alcohol, which like cannabis can be taken in modest quantities without too much risk but has potential for abuse.

Could Canada’s guidelines help other regions decriminalise cannabis without inviting industry excesses? California, the most populous state in the US, voted for recreational use last year, but its regulations are still being thrashed out.

But Canada and the US have very different outlooks, says Keith Humphreys at Stanford University: Americans have long been more in favour of unfettered capitalism and against

**“They’re going to be making most of their money off the heavy users and they’ll work hard to keep them”**

government interference. Controls on advertising are seen as clashing with companies’ rights to free speech, for example.

There’s also a difference in how cannabis legalisation comes about. In Canada, legalisation comes from the government, with public health a priority, after the

public elected a prime minister who vowed to carry it out. In the US it stems from state ballot propositions, initiated by activists and funded by medical marijuana businesses or venture capitalists, who may then go on to influence drafting of state laws. That was palpable in the ballot to legalise recreational cannabis in Ohio.

The state-by-state approach in the US may be the only thing keeping TV and radio stations from accepting and running cannabis advertisements, as they need a federal licence to operate. “It’s an ambiguous situation for the big corporate players,” says Glantz.

Still, with California’s recent vote to legalise – along with three other states – Humphreys predicts they will soon come flocking. “It’s a massive market,” he says. “That’s an earthquake in terms of how the US handles this plant.” And then someone will have to figure out how to regulate the markets.

One thing is clear: that will need to happen soon. “Once that very wealthy powerful industry is fully established it’s going to be hard getting it back in its cage,” says Glantz. ■

# Wildlife's new saviour?

Beijing's ivory ban is great; shark fins and tiger bones must be next in its charge for the moral high ground, says **Richard Schiffman**

CHINA made a New Year's resolution that caused elephant lovers around the world to rejoice: the government said it is to shut the domestic ivory market in 2017.

Poaching experts estimate that up to 70 per cent of all illicit ivory passes through China. It is turned into statues and trinkets, which are sold as status symbols to its growing middle class or exported.

The news is a game changer, says elephant behaviour expert Joyce Poole. Poole's finding that poaching destroys not just individual elephants but their family and social structure was instrumental in the decision of the global wildlife authority CITES to ban the ivory trade in 1989. Sadly, that ban flopped, due in large part to China's failure to comply, or even admit culpability. During a trip to Beijing in 2013, officials told Poole that China had no role in the poaching crisis.



Since then, however, China has changed its tune. Under growing pressure from a world incensed by the slaughter of tens of thousands of African elephants a year and fears of extinction, China's leader Xi Jinping vowed in 2015 to end the ivory trade. In a joint statement, US president Barack Obama promised to do the same. But until last week, China – unlike the US – hadn't committed to a concrete plan and timetable to accomplish this.

I was among sceptics who wondered if China's vague vows were a delaying tactic to buy time for the lucrative trade. We were wrong. The proposed speed of the shutdown – by the end of the year – is dizzying. And there can be little doubt that the authoritarian regime will largely succeed. This won't end the ivory trade, but it will deal it a serious blow. It will also put pressure on other ivory trading nations to shut up shop.

## Show us the data

Transparency must triumph when a clinical trial ends in death, says **James Randerson**

IT IS incredible that a year after a clinical trial of an experimental painkiller ended in a volunteer's death, it is still not possible to fully learn all the lessons that could make drug research safer.

BIA 10-2474, developed by the Portuguese drug company Bial, was being tested in humans for the first time in Rennes, France.

Things began to go wrong on 10 January when one participant, a 49-year-old man, developed problems with his speech, vision and swallowing, going into a coma and dying a week later.

He was the first of six people to get a cumulative 250 milligram dose. Another four of the six also had neurological symptoms.

Scans showed brain damage. Two have yet to fully recover. Bial and Biotrial, the firm that ran the trial, point out that they followed a protocol approved by France's medical regulator, the National Agency for the Safety of Medicines and Health Products (ANSM). They say that nothing seen at lower doses in people or from animal research could have allowed them to predict what would happen, and that the man who died had a pre-existing

**'Despite repeated requests, the drug-maker has not released full trial data or all its pre-clinical research'**

condition that might explain why he reacted so badly to the drug.

Last month, I was at the British Pharmacological Society's annual meeting when Bial made public some human data from the trial for the first time. It revealed that 10 other volunteers who got lower doses experienced neurological side effects including dizziness and blurred vision, but it stressed these were "mild and transient".

Under questioning, Bial also said it had not included key data when deciding to move to the dose that would prove fatal.

At the moment, we have to take Bial's assertion that the severe reactions were unpredictable

Global ivory prices have been falling for over a year, since it became clear that the world's tolerance was running out. China was growing weary of being a pariah, seen as killing off one of the world's most beloved species.

This is part of an encouraging pattern. China would like to be viewed as a moral leader on the environment, especially now that US president-elect Donald Trump looks poised to throw in the towel on critical issues like climate change. But before we grant China the Nobel Peace Prize for ending its war on wildlife, there are a few matters it must address.

Beijing should shut its shark fin market and end sale of rhino horn and pangolin scales. Tiger and bear farms should also close, says Born Free USA's Adam Roberts.

Still, credit where credit is due. "I am sure the elephants would wish me to thank the Chinese premier and his government on their behalf," says Kenya's wildlife chief Richard Leakey.

Because of China's bold action, elephants may have dodged the extinction bullet – for now. In a world famished for good news that is very good news indeed. ■

Richard Schiffman is a US journalist who writes about conservation and the environment

largely on trust. Despite repeated requests, it has neither released full trial data nor a dossier of pre-clinical research. It seems the authors of an ANSM report had access to this information, but it was not made public.

Which means other experts can only second guess how the authors reached their conclusions. Only by studying all details will the wider community be able to judge if anything could have helped predict the outcome.

Until transparency triumphs, the safety of participants in other clinical trials remains at risk. ■

James Randerson is based in London

## INSIGHT US politics

BLARGABLE/REUTERS



Experts not welcome

# US politicians put own whims above science

Lisa Grossman

THE US Congress is back in session, and it seems they have had enough of experts, too. Last week, the new Republican-led House of Representatives passed two bills that will effectively remove evidence-based reasoning from the process of drafting new regulations and how they are enforced. The bills could undermine everything from rules about clean water to the Endangered Species Act, although both bills must still clear the Senate to become law.

Their supporters speak of cutting through bureaucracy and increasing transparency, but the provisions could give Congress licence to shut down or ignore research designed to support regulations.

In the US, before a regulatory agency can write regulations, it must first analyse the problem at hand and figure out several plausible ways to address it. These must meet scientific standards like peer review.

This kind of evidence-based analysis underpins all basic public health and safety regulations in the US, including clean air, clean water and

other environmental protections. Congress is sending the message that it doesn't have to care about any of that – members will just vote according to whether they like something or not.

The House passed the first bill on 4 January. Called the Midnight Rules Relief Act of 2017, it would let Congress hold a single vote to overturn all regulations finalised in the last 60 legislative days of the Obama administration – effectively turning the president's four-year term into a three-and-a-half-year term.

That's because the past 60 legislative days would take us all the

**"Instead of being forced to bury climate regulations one by one, Congress could put them in a mass grave"**

way back to 17 May 2016. About 200 measures passed since then will be on the chopping block, from ones governing who can access classified matter or special nuclear material to rules about the safety and effectiveness of antimicrobial soaps.

A similar law already endangers the Obama administration's final works:

the Congressional Review Act, which allows law-makers to vote on late-breaking regulations one by one. What's dangerous about the Midnight Rules Relief Act is that instead of being forced to vote on them individually, Congress could in effect bury them all in a mass grave.

The Regulations from the Executive in Need of Scrutiny Act passed just a day later, forming a perfect complement to Midnight Rules. According to the REINS Act, all regulations that will cost more than \$100 million must be approved by both chambers of Congress within 60 days of being proposed. It will allow the years of painstaking research that go into writing regulations to be ditched, on the basis of simple political whims.

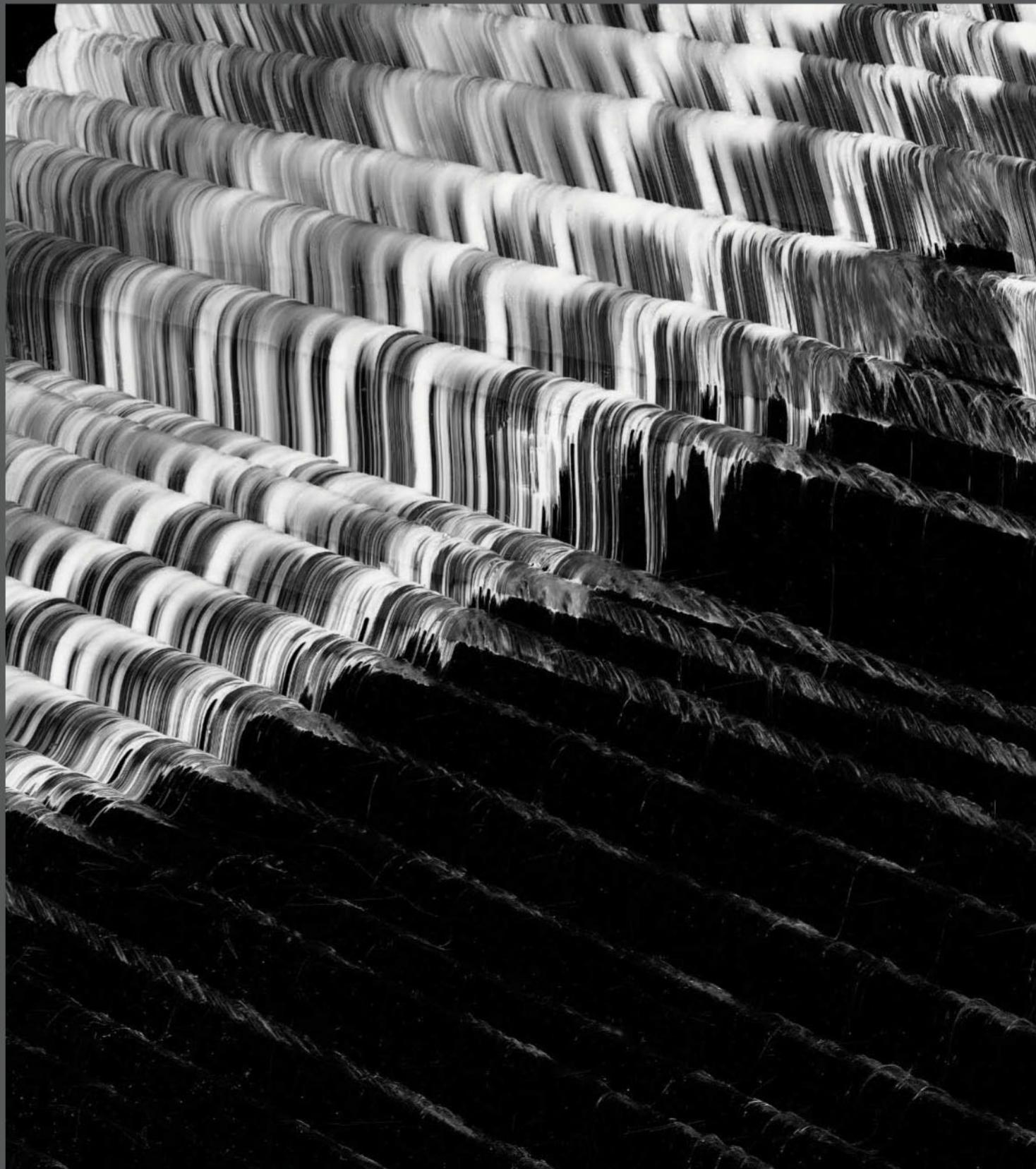
For example, if the oil industry is worried that emissions regulations will harm its bottom line, it can lobby Congress to annul them with a simple vote – or just delay long enough for the 60-day window to close.

The House has passed a version of the REINS Act every year for the past 10 years, but it has never made it through the Senate. In the past, there was the threat of a presidential veto. Donald Trump has indicated he will offer no such resistance once in office.

The passage of both acts doesn't bode well. Congressional zeal to strip science out of the rule-making process is part of a larger global trend: replacing scientific expertise with the vagaries of politics. ■

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# APERTURE





## Carbon cascade

CARBON is the building block of life as we know it, but this image reveals that the element is also a universe unto itself.

Artist Charles Lindsay created this magnified image by suspending carbon in water and manipulating it using electricity, vibration, temperature changes and infrared light - a process he calls "a hybrid between a kind of drawing and photography".

"Surface tension, microscopic dirt, ambient humidity and temperature play a role in the final results," he says. The image appears in his book, *Carbon*, published last year.

Lindsay came across the intriguing patterns of carbon suspensions while experimenting with photograms, a method of producing images with light-sensitive materials instead of a camera. He placed his carbon suspensions on clear substrates and then digitised them using an image scanner.

"The images maintain this illusion of scientific photography," he says. "Even though we know better, we read photographs as truths, and there's a power in that."

Lindsay, who studied exploration geology before becoming an artist, was the first artist in residence at the SETI Institute, which hunts for extraterrestrial intelligence, and is now the director of this art programme.

He wonders whether distant, alien worlds could harbour life made of silicon or some other element - places where the carbon that is so vital on Earth would be just a footnote. Leah Crane

### Photographer

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JONATHON KAMBOURIS/GALLORYSTOCK

# Germ warfare

Tired of fighting over housework? Penny Sarchet dishes the dirt on how clean you really need to be

HATE housework," said the late Joan Rivers. "You make the beds, you wash the dishes, and six months later you have to start all over again."

If only. I can't stand a dirty kitchen sink, a grubby bathroom or cobwebs hanging from the ceiling, so I spend precious hours every week cathartically cleansing.

The doubts set in 18 months ago when I moved in with my boyfriend. It didn't take us long to discover that we're in opposing corners when it comes to housework – he's dirty but tidy, while I'm clean but messy. He suddenly had to deal with my clutter spread all over his dining table and sofa, while I nursed a growing preoccupation with the art of disinfection.

We have learned to live with each other. And my new position of compromise has led me to question some of my preconceptions. Is cleaner necessarily better? I'd heard in a vague sort of way that perhaps it's not; that an obsession with the elimination of germs might be behind many a modern malady. But what did the science say? I set out to see whether there might be such a thing as too much cleanliness.

We're bombarded with seemingly contradictory information about being clean. Good hygiene helps ward off countless infections and illnesses, that much is clear. But then there are the bacteria that turn out to be good for us; the whispers that some ingredients in our cleaning products might be hurting us; the hypothesis that too much hygiene is behind rising rates of allergies and other disorders.

On that last point, something definitely seems to be out of whack. More than 150 million people in Europe are thought to have allergies, a number that's rising. By the

2020s, half of all Europeans could have at least one. Food allergies are becoming more common, especially in children. Between 1997 and 2007, there was an 18 per cent rise in children who had one in the US – now nearly one in every 25. Then there is asthma. Between 1971 and 1991, the number of family doctor consultations for the condition quadrupled in the UK, while appointments for allergic rhinitis – inflammation of the nose in response to things like pollen and dust – more than doubled.

It was back in 1989 when David Strachan, then an epidemiologist at the London School of Hygiene and Tropical Medicine, first proposed his hygiene hypothesis. He suggested that modern lifestyles, with their lack of unhygienic exposure, mean we catch fewer infections in early childhood, and that this predisposes us to developing allergies.

## Too much hygiene

Some of the evidence is fascinating. Children who grow up on farms seem to be healthier, as are children whose parents wash dishes by hand rather than using a dishwasher, and those who have a dog (my personal hygiene nightmare). But as a lover of cleanliness, the study that turns my stomach the most is a 2014 paper that found that children are less likely to develop precursors to asthma if, in their first year, they're exposed to particles from cats, mice and cockroaches.

Many of us have embraced the idea of a link between a little bit of dirt and good health, perhaps eager for an excuse to cut down on the housework. "This wonderful idea that we've become too clean for our own good, whatever that means, has just stuck," says

## Can I stop washing?

No! Washing your hands with soap and water has been shown to cut the incidence of respiratory ailments and diarrhoea. Do it before and after cooking, before eating, after using the toilet, and after touching animals or rubbish. As for the daily shower, there is no evidence for claims that it is to blame for the rise in asthma and eczema. Children who wash daily seem to be healthier – and any bacteria you lose during washing are rapidly replaced.

Sally Bloomfield at the London School of Hygiene and Tropical Medicine.

There's just one problem: things probably aren't that simple. In recent years, thousands of studies have linked changes in the microorganisms living inside our bodies to everything from allergies and asthma to obesity, depression and Alzheimer's disease. This emerging understanding of what's known as our microbiome suggests that rather than there being a clear distinction between "clean" and "dirty", we have a complicated relationship with bacteria. Being exposed to some kinds is good for us, to others not. Figuring out which is which is difficult.

One thing is becoming clear – it's diversity that counts. A 2015 study of nearly 400 infants in Germany hinted as much, when researchers found no direct link between their chances ➤

of developing asthma or allergies, and their caregivers' personal and home cleanliness.

What did make the difference was their exposure to bacteria. Several studies show that healthier people tend to host a wider range of microbes. Western lifestyles may have adverse effects on this diversity, which was found to be 40 per cent lower than that detected in an isolated, traditional hunter-gatherer society. And while I can't help wrinkling my nose when I see a parent pick a dropped dummy off the street, suck it clean, and then hand it back to their child, a 2013 study found that these infants were less likely to develop asthma or eczema. The organisms in their saliva were also different from the ones inhabiting infants whose parents would never do such a thing, prompting the researchers to suggest that the protective effect is down to the transfer of beneficial microbes from parent to child.

There is now also evidence for why living on a farm is so good at reducing allergies – the bacterial components in farm dust suppress inflammatory immune responses. This seems to indicate that the hygiene hypothesis is in need of revision. "It's not infections so much as exposure to a wide variety of bacteria that helps control the development of our immune systems," says Dennis Ownby, an allergy and immunology specialist at Augusta University in Georgia.

## Mixed messages

When we are exposed to these beneficial microbes is also crucial, and the most important time seems to be early childhood. "It is probably very important to take children, starting at a young age, outdoors and let them play on the ground," says Ownby. So if you're old enough to be reading these words, I have some bad news. By the time we are adults, our microbiome may be largely set. According to current thinking, the cut-off is as early as 3.

So any suggestions that shirking the chores – or your personal hygiene – during adulthood could increase your diversity of good bacteria are spurious. After all, while we may lack a full understanding of which bacteria are good for us and how, we are more clued up on the ones that are unequivocally bad.

For example, there are about 17 million cases of food poisoning a year in the UK, caused by microbes including *Norovirus* and *Campylobacter*. Many cases are picked up in restaurants, but a study of 18 European countries suggests that nearly a third of food-borne outbreaks occur inside our own homes.



JULIETTE GUILLERMO/PICTURETANK

## Is the 5-second rule real?

Not even close. On contact with a surface, food picks up bacteria in less than a second. So should you eat it? If you've dropped it where dogs have been defecating, probably best not to. But if you're proud of keeping your kitchen floor so clean you could eat off it, it's probably no harm to put this into practice.

## Should I wash food?

Raw fruit and vegetable yes – but chicken, no. Nasty *Campylobacter* bacteria are often found on chickens, and washing is likely to splash them further around your kitchen, giving them a ride to your mouth via your hands. Just make sure you cook the chicken through properly and disinfect preparation surfaces.

"I've seen houses that are absolutely, completely filthy," says Lisa Ackerley, a food safety adviser at the British Hospitality Association, who has gone into homes to swab for bacteria as part of her work. "It's easy to say we're too clean, but who's got the evidence?"

Filth has consequences. About 50 per cent of chickens in the UK carry *Campylobacter*, the country's most common cause of food poisoning, and the bacteria can easily transfer from the raw meat to your hands or a chopping board. Seen in this light, Bloomfield says, anything that encourages people to cut back on habits like handwashing is dangerous.

But while being too slovenly stands a good chance of giving us diarrhoea, neither do we want to be too clean. In particular, you might want to cut back on antibacterial handwashes and laundry detergents. Not only might some of these have less benefit in the home than advertised, there is some evidence they might contribute to bacteria becoming resistant to antibacterials and even antibiotics. There's also growing concern about indoor pollution connected with overzealous use of certain household products (see "Would it kill you to do a little cleaning?", opposite).

Right, so being too dirty could hurt me, but so could being too clean. What's a girl to do?

## Should I vacuum?

It depends. Regular vacuuming with a high-filtration machine is recommended for people who have asthma, or an allergy to dust mites or other indoor substances, or who don't want any judgement from visitors. If none of this applies, the dust bunnies won't bite.

The good news is that there might be a science-approved hygiene sweet spot. Bloomfield and Ackerley are among a growing group of experts who advocate "targeted hygiene". This has been a well-known strategy since the 1950s, says Bloomfield, but it was limited to hospitals and industries like catering, pharmaceuticals and cosmetics – anywhere it's important to "identify critical points for transmitting infection".

The suggestion now is that targeted hygiene should be the strategy behind everyone's basic housework. "It's still important to be hygienic in the places and at the times that matter," says Bloomfield. But instead of striving for a sterile home, we need focus only on removing harmful bacteria, from important surfaces, at critical times.

Most of the cleaning should focus on doorknobs, light switches and the bathroom – anything we touch a lot. It's also crucial to thoroughly clean everything you use while cooking. That includes all surfaces, chopping boards and utensils that come into contact with raw meat, as well as unwashed dirty vegetables, whose bacteria can give you food poisoning just as raw chicken can. The most important advice is to wash your hands, after cooking, before eating and after using the toilet.

But beyond that? Well, Joan Rivers fans can take heart: cleaning the walls, floors or the furniture really can wait six months. If you're not allergic to dust mites, vacuuming is entirely optional. And you can forget about making the bed – especially if you're allergic to dust mites. Mites need a humid atmosphere to survive, so leaving the covers open in the morning might help to kill the beasts.

It all seems great news for my relationship: as long as I can encourage my boyfriend to be clean in the right places, I needn't fear for my health. And in return, I can take comfort ➤

## WOULD IT KILL YOU TO DO A LITTLE CLEANING?

There's increasing evidence that the chemical mixtures we use to clean our homes create indoor pollution. "Most of our exposure to hazardous pollutants occurs indoors, and a primary source of these pollutants is our everyday consumer products," says Anne Steinemann at the University of Melbourne in Australia.

This includes air fresheners, shampoos, soaps, scented candles, laundry detergents and cleaning products. There is no legal requirement for these products to list all their ingredients, and while the compounds they contain may each have individually been tested for toxicity, we don't know how dangerous they become when mixed.

Ironically, many of the pollutants seem to come from ingredients to make the products smell clean and fresh. When fragrance compounds like limonene and other terpenes get into the air, says Steinemann, they can react with ozone to generate compounds such as formaldehyde, which is carcinogenic.

How we build modern homes compounds the problem. "What we've done to our housing is to seal it to prevent energy loss," says Stephen Holgate at the University of Southampton, UK. The problem is worst in the most efficient homes. "Ventilation is very low, and chemicals can accumulate in the air and dust."

Cleaning products aren't the only source of pollutants – paint, wood resins and chemical treatments on soft furnishings like carpets contribute too – but we clean our

homes far more often than we refurbish them.

Steinemann suggests switching to edible cleaning substances such as vinegar, bicarbonate of soda and lemons. Air purifiers are no help; they remove large particles of allergens, such as dust and pet hair, rather than small fragrance chemicals.

### GREEN AIR

If you can't bear knocking off on the cleaning, one solution might be the humble houseplant. We've known for more than a decade, thanks to NASA research into crewed space flight, that plants can absorb organic chemicals like benzene and formaldehyde from the air. Last year, a team tested how well five common houseplants remove mixtures of organic compounds from the air of a sealed chamber. The winner turned out to be *Guzmania lingulata*, a type of bromeliad often seen in offices, which could absorb high amounts of each of the eight substances tested.

But a single sad perennial in your living room isn't going to do much. "In a house where you've got chemicals that are quite toxic, even to plants," says Holgate, "I doubt it will make much of a difference."

At the last count we had 16 plants in our flat, but I take his point. Until NASA furnishes the specifics, Holgate suggests opening the window. "It's rare to see houses with windows open today. In the old days, ventilating your house was an everyday activity, but that doesn't happen in the UK any more."

## THE UPSIDE OF CHAOS

There might be a “sweet spot” for how much cleaning you need to do to maintain good hygiene (see main story), but the evidence for how much mess is good is thinner on the ground.

Some studies suggest that surrounding yourself with meaningful objects helps you define and connect with your home – but too much clutter can get in the way of cooking, cleaning and freedom of movement.

But trouble with clutter might go beyond safety hazards. Evidence suggests that working women who describe their homes as cluttered or unfinished have stress hormone patterns that may be less healthy. Other studies have suggested a link between disorganised, cluttered homes and worse health in children.

But the most frequently cited research shows that the tidiness of our surroundings influences our behaviour. You may have heard that tidier desks encourage healthier snacking, while messier desks make you more creative. These claims are based on a 2013 study that invited participants to do a range of activities while sat in either an ordered or disordered room. Its findings suggested that people behave more conventionally when in a tidy environment – more often picking the option labelled “classic” on a menu, for example. And those sat in messy rooms came up with more creative ideas – in this instance, new ways to use ping-pong balls.

In short, the research provides ammunition for both sides – those of us who struggle to defend our messiness and the ones urging better organisation. Converts to Japanese lifestyle guru Marie Kondo’s decluttering guidelines may tell you that a tidy home is a less stressful one. But I’ll see your Kondo and raise you one A.A. Milne, who said that “one of the advantages of being disorderly is that one is constantly making exciting discoveries”.



FOOD AND DRINK/REX/SHUTTERSTOCK

that being tidy might not be the be-all and end-all either (see “The upside of chaos”, left).

Beyond the basics, it seems there is one big thing we can do to improve our health beyond worrying too much about the state of our homes: leave them more often. “We don’t spend enough time outdoors,” says Bloomfield.

Preliminary findings hint that spending more time doing social sports and other outdoor activities can help restore a healthily diverse microbiome. Exposure to soil may be key, says Ownby. “We all end up ingesting between 50 and 60 milligrams of soil a day,” he says. Gardeners get about twice that amount.

It’s all quite pleasingly wholesome and old-fashioned: boost your health by getting out in the open air. Use cleaning products, but not so many that your home fills with pollution, and open the windows after you do.

We’re trying to put it into practice. It’s certainly nicer to spend time in a well-aired flat, and I now eye air fresheners and antibacterial soaps – not to mention the recent proliferation of antibacterial air fresheners – with suspicion. I’m even seeing pets in a new light. The thought of having a dirty animal in my home used to fill me with dread, but I’m beginning to revise my views, much to the delight of my dog-loving boyfriend.

## Does the washing-up really need a rinse?

Absolutely. Detergent and soap don’t kill bacteria – they simply help detach dirt and germs, meaning they’re still there on the surface. If you simply wipe your dishes with cloth and detergent, all you’re doing is wiping the microbes around. So rinse with plenty of water, preferably hot.

But despite what the studies say, I’d still really like to get a dishwasher before too long, and no microbiome hypothesis is likely to change my mind there. In the words of one of my friends, who is pretty unequivocal about her own household preferences: “Anyone who tells me I need to handwash all my kids’ dishes can get bent.” ■

Penny Sarchet is biomedical news editor at *New Scientist*

# EARTH'S GHOSTLY GUARDIAN

Our planet's protective magnetic field appears impossibly old, finds Marcus Woo



EARTH SCIENCE AND REMOTE SENSING UNIT, NASA JOHNSON SPACE CENTER

**I**T IS Earth's silent defender. Without it, a constant onslaught of charged particles would bombard our planet's atmosphere, changing its chemistry and disrupting our electronic infrastructure. Assuming any of that stuff was even there to disrupt. In Earth's infancy, our guardian may have prevented the sun's action from stripping away the protective bubble of gas surrounding our planet entirely, and so allowed life – and eventually intelligent life – to flourish.

This silent defender is Earth's magnetic field, a force field whose source lies in the churning molten iron that forms the planet's core. Electrons flowing through this fluid generate an electric current, which in turn creates a magnetic field. The core is a giant, self-sustaining electromagnet: a dynamo.

That's been the general story for decades. But over the last few years, it has run into a problem. Evidence is mounting that the dynamo could only have emerged comparatively recently. At the same time, geological clues show that the magnetic field has existed for most of Earth's 4.5-billion-year history. This contradiction – an ancient magnetic field without anything to power ➤

it – is forcing us to rethink our planet's insides.

With apologies to Jules Verne, we will probably never journey to the centre of the Earth. Our planet's core is a hellish domain as hot as the sun's surface, with pressures several million times greater than at sea level. But that hasn't stopped us from opening a window onto it. Seismic wave measurements, computer models and lab experiments that mimic the core's extreme conditions all provide a reasonable picture of how things work in Earth's deepest reaches.

This picture says that, in the beginning, our planet was a hot agglomeration of smaller rocks and debris captured from the early solar system. Iron, the densest element in the newborn planet, slowly sank to the centre where the high temperatures melted it. Next, thermal convection, the same process that occurs in a pot of roiling water, kicked in. Cooler, denser iron in the outer part of the core sank, while the hotter, lighter stuff rose, kicking the magnetic dynamo into action.

Then came a slight complication. At some point, Earth had cooled sufficiently to allow some of the core's molten iron to solidify. Because of the way physics works under such extreme pressures, the core began to freeze from the inside out. According to most estimates, this process started about one billion years ago. Today, the inner core is a solid iron ball about 1200 kilometres in radius that is growing ever larger as Earth continues to cool. Surrounding it is a layer of liquid iron 2000 kilometres thick, mixed with some nickel and a smattering of lighter elements like sulphur and oxygen.

Fortunately, the freezing kick-started another effect that kept the magnetic dynamo

humming. As the inner core grows, it expels the lighter elements. The same thing happens when salt water freezes. The salt doesn't fit into the ice's crystal structure, so it gets pushed out, leaving freshwater ice surrounded by extra-salty water. Similarly, inside Earth, the solid inner core is almost pure iron, surrounded by molten iron with a higher concentration of impurities. These make the liquid less dense, so this lighter stuff nearest the inner core rises, while the heavier, iron-rich material above sinks. This sets the outer core churning in a process known as compositional convection.

### Shaken all about

So it seems that one way or another, the dynamo has been kept turning for most of Earth's history. But it's here we encounter the most recent twist in this magnetic tale. In the past few years, researchers have begun to doubt whether the first part of the story, thermal convection, could ever have happened – and if it did, whether it would have been strong enough to power the magnetic field. "If you want to rely on thermal convection alone, then we're in trouble," says David Stevenson at the California Institute of Technology.

The problem lies in the way heat travels. Convection requires layers of differing temperatures: in a pot of boiling water, the bottom is hotter than the top. This can only happen because water doesn't conduct heat that well. Conduction quickly equalises temperatures throughout a substance, making convection impossible. And this is where the material in Earth's core may

## SOME FOREIGN FIELD

WHILE our magnetic field appears to predate life on Earth, the claim that planets need magnetism to be habitable is far from clear-cut.

We've long assumed that the field blocks the solar wind, which is full of charged particles that can strip Earth of its atmosphere. But some researchers have suggested almost the opposite. The magnetic field, they say, might instead act as a huge sail that catches and absorbs these charged particles, which then harm the atmosphere.

And even if the magnetic field were essential for life on Earth, what does that mean? Many scientists describe a planet

as habitable just because it's Earth-sized and the right distance from its star for liquid water to exist. It's tempting to add a magnetic field to that list of requirements. But that's too simplistic.

"Planets are extremely diverse," says David Stevenson at the California Institute of Technology. "In the landscape of possibilities, I see extraordinary richness." This may be promising when it comes to searching for extraterrestrial life, but makes it difficult to reduce our understanding of planets to just a few parameters. "The magnetic field," he says, "is just one of the tunable knobs in this rich landscape."





CARL JOHNSON/DESIGN PICS/PLAINPICTURE

The stunning polar auroras owe their existence to Earth's magnetic field

not conform to expectations. "There's a growing amount of evidence that the conductivity of the core is higher than we thought," says Peter Olson at Johns Hopkins University in Baltimore, Maryland. The result is renewed controversy, says Francis Nimmo at the University of California, Santa Cruz. "Five years ago, everyone thought they knew the answer."

The debate reopened in 2012, when two independent groups used computer models to predict that the liquid iron core was twice as conductive as previously thought. Early last year, researchers in Kei Hirose's group at the Tokyo Institute of Technology in Japan measured the thermal conductivity of iron under pressures comparable to those in the core. Their results matched the predictions, suggesting that Earth's magnetic field can only have emerged with the first solidification of the core less than one billion years ago.

Except it can't have done. "We know Earth's magnetic field existed long before then," Nimmo says. In the past, magnetic minerals in molten rock aligned with the field. When the molten rock froze, it recorded the field's presence. In 2015, Nimmo was part of a team that found such prehistoric compasses inside our planet's oldest rocks, implying that a field existed as far back as 4.2 billion years ago. That would predate the first evidence of life on Earth, consistent with the idea that a magnetic field is essential not only for life to get started but also for a habitable planet to arise at all (see "Some foreign field", left). Their results are still disputed, but the evidence is stacking up that the magnetic field is at least 3.45 billion years old. That points to a substantial gap when neither type of convection could have sustained the dynamo.

So what did? Stevenson and others think they have identified the culprit. It's a process similar to compositional convection, but one that doesn't involve solidification of the inner core. As the outermost layers of the liquid core cooled, the lighter elements that were dissolved in the iron would have precipitated out. After rising out of the liquid core, these elements would have been absorbed into the mantle, the largely solid region that forms the bulk of Earth, leaving behind denser liquid iron. This would sink, triggering convection.

Stevenson and Joseph O'Rourke, also at Caltech, argue that the most important light element in this process is magnesium. It's abundant and doesn't readily dissolve in iron. Because of its insolubility, magnesium would be the first element to precipitate out once the molten iron in the outer core started to cool,

either forming like frost at the boundary with the mantle, or else gently snowing up from deeper in the outer core.

But magnesium's insolubility in iron also poses a problem: how did it get into the core in the first place? To achieve this you need heat, says Stevenson. Lots of it. One way to generate this heat is via collisions with other space rocks. Such impacts were common in the early solar system – it's likely that a particularly massive one gouged a chunk out of Earth that eventually became the moon.

Hirose has a different idea. Instead of magnesium, he favours silicon. It's even more abundant, he says, and would therefore be likely to dominate deep in the planet. His experiments also show that silicon dioxide crystallises easily in the core, without the need for any external processes. "So far, the silicon dioxide story is most feasible," he says. Hirose's lab is now including magnesium in their experiments to better determine its role.

Some researchers have even suggested that convection may not drive the dynamo at all. Instead, Earth's wobbling rotation could jostle the molten iron. Or the moon's gravity could

## "Magnesium could snow up towards the mantle from inside Earth's core"

tug the liquid core in the same way it causes ocean tides. "There's a group of people that are enthusiastic about the idea, but I would say it's probably not mainstream," says Bruce Buffet at the University of California, Berkeley.

At the moment, everything's up in the air. Even the thermal conductivity calculations could be wrong. In fact, a study contradicting Hirose's measurements ran alongside his in the same scientific journal. "This is a fast-moving field," Nimmo says. "I don't think we have a completely satisfactory answer."

Whatever process turns out to fit the bill could also apply to other worlds. We have already discovered thousands of planets outside the solar system, many of them Earth-sized and, presumably, with similar chemical compositions. And massive temperature-raising impacts could also play a part, as young planetary systems are rife with collisions. If convective mechanisms do power magnetic fields on other planets, then that could facilitate alien life. "Of course," says Buffet, "it depends on the details." ■

Marcus Woo is a writer based in San Francisco



# Blocking cancer

Understanding how tumour cells get their food could help us stop them in their tracks, finds Linda Geddes

In 1924, German biochemist Otto Warburg observed that cancer cells are extraordinarily greedy. Tumours tend to grow rapidly, so it made sense that they had outsized appetites. But Warburg also found that the way they burned, or metabolised, the resources they gobbled so hungrily was different. He was convinced that this change in metabolism defined cancer – and figuring out what drove it would let us beat the disease.

His idea caught on. For much of the 20th century, Warburg's altered metabolism idea guided approaches to understanding and treating cancer. That all changed in the 1970s, with the discovery that certain gene mutations can cause cancer – and with it a sea change in how we might tackle the disease. Target the genes responsible, the new thinking went, and we could stop cancer in its tracks. Warburg's ideas largely fell by the wayside.

But it turns out that the genetics of cancer is vastly diverse, and quickly comes to resist the carefully targeted drugs we throw at it. What's more, it has become clear that many cancer-causing genes do in fact work by altering how

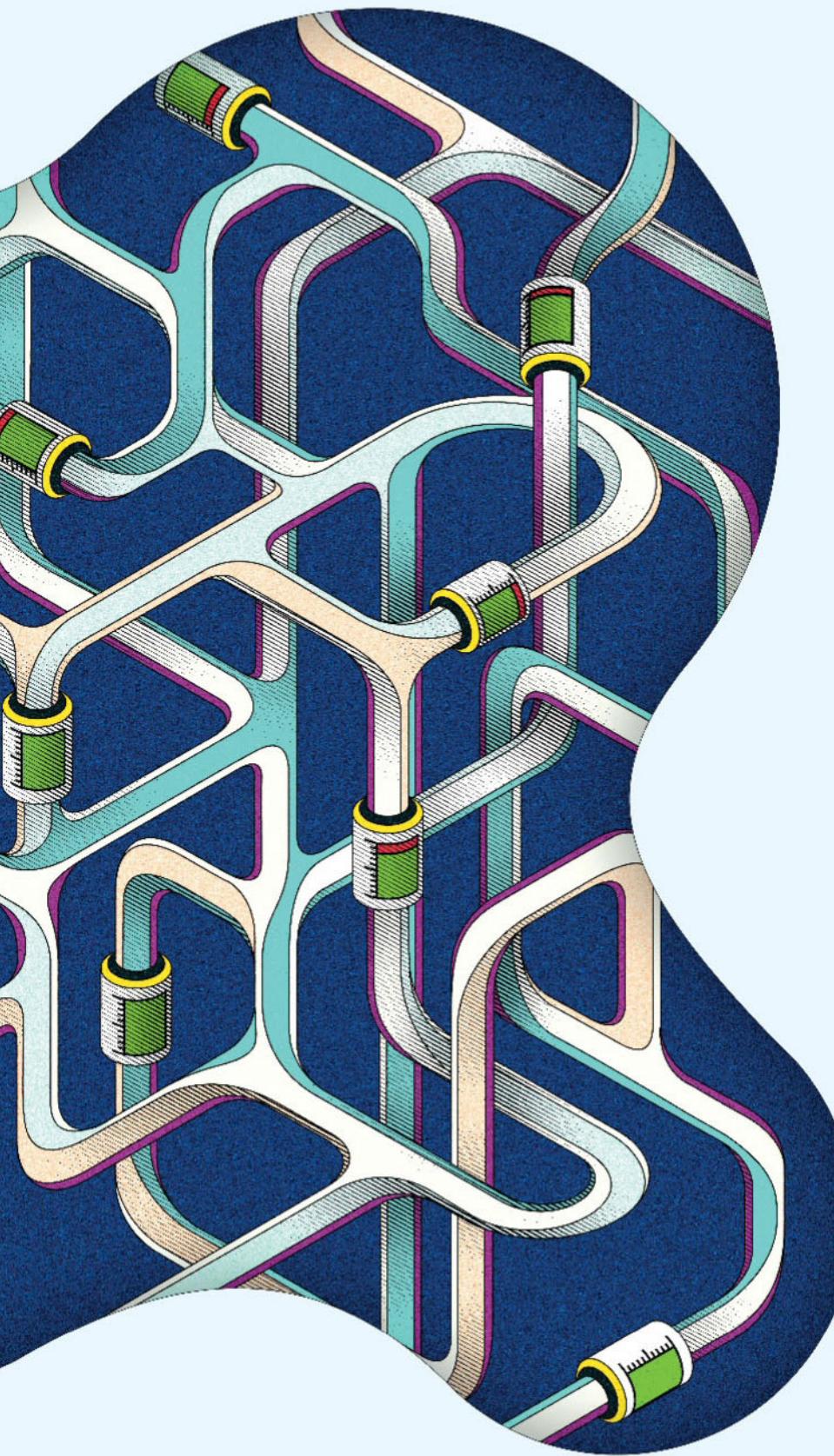
cells burn their fuel. And so Warburg's notions are coming back on board.

There are relatively few ways that tumours metabolise, and they are often the same across many cancers. By targeting these common pathways, we may get treatments that work for many different tumour types, and greater numbers of people. Cancer's endless appetite might not just define it; it may be its Achilles' heel.

## Laying waste

Although cancer cells have heartier appetites than ordinary cells, the actual process most use to make energy is more wasteful. Warburg liked to explain it by imagining two engines. One is fuelled by complete combustion of coal, the other by a less efficient version. Even if you know nothing about the engines, the strange smell coming from the second one makes it clear something is different. So it is with cancer.

To make energy, healthy cells break down



glucose, then burn the resulting products in factories contained within the cell called mitochondria. In contrast, cancer cells burn these products elsewhere, using a less efficient process called aerobic glycolysis. Healthy cells do this when oxygen is scarce, such as in muscle during intense exercise, but tumours do this routinely, even when oxygen is plentiful.

This puzzled cancer researchers for many decades, but unravelling the mystery of the metabolic switch proved a major challenge with the available technology. "Each experiment was extremely exhausting and complicated to do," says Lewis Cantley, a cancer biologist at Weill Cornell Medical College in New York.

Then in the late 1970s everything changed: we identified a gene variant that drives unbounded cellular growth. It was some of the earliest evidence that malfunctioning genes could cause cancer, and in the following years more of these "oncogenes" were discovered. Researchers also identified tumour suppressor genes that normally keep

## "The cancer cell is having its cake and eating it"

dangerous growth in check, but can also malfunction to cause cancer. Excitement grew that a cure was within reach: all you needed to do was develop drugs to combat the effect of these mutated genes.

Nearly 40 years later, it hasn't turned out that way. Although many such drugs have been developed, they often only buy a few more months of life because tumours quickly become resistant.

What has thrown metabolism back into the spotlight is the discovery that many common oncogenes actually drive metabolic changes within cancer cells – changes that are fundamental to a tumour's ability to proliferate and spread. "Cancer cells rewire the way they do metabolism so that they are able to continue to build and protect themselves under conditions where normal cells would have stopped," says Karen Vousden, chief scientist at Cancer Research UK. In other words, when Warburg said that deranged metabolism was a defining feature of cancer cells, he was correct. What he didn't realise was the extent to which this metabolic rewiring occurs. ➤



Healthy cells require two things to proliferate: nutrients and a growth signal from a specific protein or hormone. If they are deprived of either, the cells will enter a rest state. However, mutations in an oncogene like *myc*, which plays a part in about 70 per cent of tumours, enable cells to override the brakes. "This change in metabolism really defines what the cancer is, and what the oncogenes do is make that metabolic change happen," says Cantley.

Having no brakes means that, when resources are scarce, tumours aren't able to lie low and wait for better times, the way healthy cells can. "Cancer cells essentially become addicted to a continued nutrient supply," says Chi Van Dang, director of the Abramson Cancer Center at the University of Pennsylvania in Philadelphia. For cancer, it's eat or die.

## STARVE YOUR ENEMY

Cancer genes can alter the metabolic processes within a cell (see main story), but it seems that broader changes to our metabolisms may boost the risk of tumours forming in the first place.

Eating a high-sugar diet over a prolonged period will generally result in an excess of nutrients circulating in the body. This will ramp up metabolism, resulting in the generation of additional reactive forms of oxygen, which can damage DNA, and increase the likelihood of harmful mutations. It may also lead to generally higher levels of insulin, which encourages cells to grow more. Many early cancers possess more insulin receptors than other cells, which further enhances their response.

It makes sense that if you have chronically high levels of insulin, you may predispose yourself to cancer: "You're constantly challenging yourself with this 'go' signal," says Karen Vousden, Cancer Research UK's chief scientist. On top of that, fat cells also release signalling molecules like hormones that could stimulate early cancers to grow.

Starving cancer to death is straightforward in the lab: you just take away the food supply. That's not so simple within a person's body, because healthy cells need fuel too. But if you could eliminate the specific nutrient that a tumour is addicted to, could this kill the cancer?

Removing particular nutrients from the diet has been shown to work against metabolic conditions such as phenylketonuria, in which the body is unable to break down an amino acid called phenylalanine. But for tumours that crave glucose, it's more complicated; cells have other ways to get the substances they break glucose into. Still, the role of diet has come under scrutiny in recent years, as researchers wonder whether our food choices may be driving metabolic changes that favour tumours (see "Starve your enemy", left).

For now, what is clear is that the constant need for nutrients drives tumours to adapt quickly. When cancer cells develop resistance to drugs that target specific oncogenes, they often do so by activating another gene that is able to take over the role. But the metabolic pathway they use frequently stays the same, says Cantley. So rather than targeting individual oncogenes, "one could argue that targeting the metabolic pathway may be a better strategy", says Cantley.

Imagine the cancer cell as a gas-guzzling car you want to bring to a standstill. "If I take the keys away, you might be able to bypass the ignition system, but if I destroy the engine or prevent it from getting any gasoline, the car is not going to drive," says Matt Vander Heiden, a cancer metabolism researcher at the Massachusetts Institute of Technology.

There are several drugs being tested now that aim to do just this. Many cancer cells generate their energy through aerobic glycolysis, as Warburg observed. The final reaction in the sequence requires a particular enzyme, and when that enzyme was inhibited in mice with lung cancer, their tumours began to shrink. Because the treatment blocks the whole pathway, and not a specific oncogene, in theory it should work against any tumours that use that pathway – as up to 80 per cent of cancers do. Clinical trials of drugs designed to inhibit production of the enzyme are expected within the next year or two.

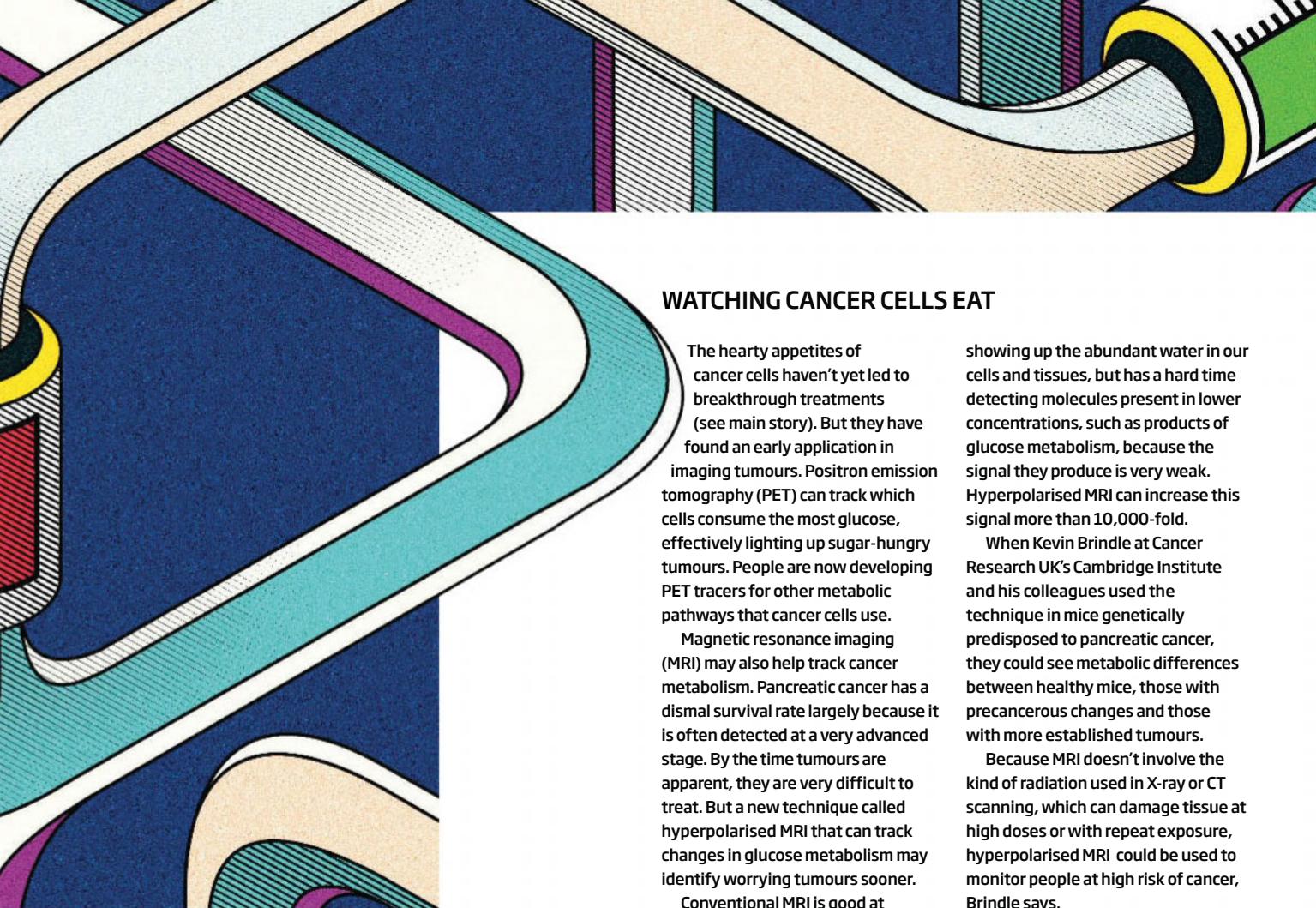
Unfortunately, switching to aerobic glycolysis isn't the only metabolic detour tumours can take. They can use several pathways, and new ones are still being

discovered. That is a challenge, but also an opportunity. "Glucose metabolism is one pathway, but as we dig deeper, we find that more and more pathways are rewired or altered in cancers in a way that we could use," Vousden says.

The connected nature of these routes means we're likely to need more than one roadblock, and possibly a combination working against both the metabolic pathways and the genetic mutations that send cancer cells down them.

To know where to put the roadblocks, we need an accurate map. In the past decade, the technology that enables researchers to plot this out has come on in leaps and bounds. Biochemists identify the products of cellular reactions using instruments called mass spectrometers. "Today's machines have unprecedented sensitivity," says Gary Patti, who studies cancer metabolism at Washington University in St Louis, Missouri.

New ways of imaging cellular metabolism may also provide methods for identifying very early changes as a tumour is forming (see "Watching cancer cells eat", right). And ever more sensitive technologies are enabling discoveries that fill in gaps we didn't even



## WATCHING CANCER CELLS EAT

The hearty appetites of cancer cells haven't yet led to breakthrough treatments (see main story). But they have found an early application in imaging tumours. Positron emission tomography (PET) can track which cells consume the most glucose, effectively lighting up sugar-hungry tumours. People are now developing PET tracers for other metabolic pathways that cancer cells use.

Magnetic resonance imaging (MRI) may also help track cancer metabolism. Pancreatic cancer has a dismal survival rate largely because it is often detected at a very advanced stage. By the time tumours are apparent, they are very difficult to treat. But a new technique called hyperpolarised MRI that can track changes in glucose metabolism may identify worrying tumours sooner.

Conventional MRI is good at

showing up the abundant water in our cells and tissues, but has a hard time detecting molecules present in lower concentrations, such as products of glucose metabolism, because the signal they produce is very weak. Hyperpolarised MRI can increase this signal more than 10,000-fold.

When Kevin Brindle at Cancer Research UK's Cambridge Institute and his colleagues used the technique in mice genetically predisposed to pancreatic cancer, they could see metabolic differences between healthy mice, those with precancerous changes and those with more established tumours.

Because MRI doesn't involve the kind of radiation used in X-ray or CT scanning, which can damage tissue at high doses or with repeat exposure, hyperpolarised MRI could be used to monitor people at high risk of cancer, Brindle says.

realise existed. "It's like looking at Google Maps, then glancing out of the window and seeing a bunch of streets that shouldn't be there," says Patti.

Indeed, his lab has been developing a technique that lets them tag nutrients and follow their passage through cells. As a proof of principle they tagged lactate, the final product of aerobic glycolysis, in cancer cells. They expected just to see this waste product gradually being removed. Not so.

### Sneaking around

"If you look up lactate in a textbook you'll see that it's a metabolic dead end," says Patti. "But we found it was being transformed into energy and all sorts of other molecules. It turns out to be a very important building block that cancer cells utilise."

This discovery, reported last September, helps explain the paradox that puzzled Warburg: why cancer cells burn glucose through aerobic glycolysis, when this process seems so wasteful. Some of the lactate is actually shuttled into the mitochondria, where it is used to produce energy and useful

substances. "The cancer cell is having its cake and eating it," Patti says.

The more we know about cancer, the more dastardly it seems. But probing the way tumours fuel themselves is already leading to possible new treatments. Genetic mutations found in both leukaemia and the aggressive brain cancer glioma cause metabolic enzymes to go haywire. Inhibitors of these enzymes, known as IDH 1 and 2, are being evaluated in leukaemia patients, and the IDH2 inhibitor is being fast-tracked by the US Food and Drug Administration on the basis of promising early results.

We may also be able to turn cancer's gluttony against it. In studies in mice, Cantley was able to exploit the fact that the same genetic change that lets some types of cancer cells import more glucose also leaves them unable to cope with high doses of vitamin C harmless to other cells. "Rather than targeting the oncogene or the tumour suppressor gene directly, you are targeting the consequence of that gene mutation," Cantley says.

Then there's metformin, already widely used to treat diabetes, another disease associated with abnormal glucose

metabolism. Numerous studies have shown that metformin cuts the risk of cancer – particularly pancreatic, colon and liver cancer – in people taking the drug for diabetes. One way in which it might do this is by lowering levels of insulin, which can spur cell growth. There are now nearly 100 trials investigating whether it could be a powerful weapon against established tumours too.

Cancer may seem like an implacable foe, and a closer look at its inner workings will undoubtedly reveal a complexity that Warburg could never have imagined. But it will also identify some weak points. The challenge for the new generation of researchers is to understand which types of metabolism define which cancer cells and why. That's no small feat, because cancer is a moving target that excels at evading our most sophisticated weapons. Achilles was felled with a single arrow to his heel, but cancer is a more formidable enemy. "Targeting metabolism is going to be incredibly useful as one of the arrows in the bow to attack cancer," says Vousden. But it's unlikely to be the only one. ■

Linda Geddes is a consultant for *New Scientist*

# Of presidents and planets

Many scientists are alarmed by the election of Donald Trump as US president. Astrophysicist **Neil deGrasse Tyson** reflects on what the future holds, President Obama's legacy – and the long road to Mars

## What do you think President Barack Obama's science legacy will be?

It's too soon to tell, but he is certainly a scientifically literate person. He understands the value of science in our culture and, more importantly, for our civilisation.

One of my key memories of Obama was a comment he made in 2010 during a speech at Kennedy Space Center. He said the US would go to Mars – and that he wanted to do it by the mid-2030s. I found it curious that he was promising something that would happen under the watch of a later president, under a budget not yet established. That speech cemented for me that, if we are going to go to Mars, or into space in a big way, then we need to elect people who will honour that promise.

## It's now seven years since Obama's pledge to take the US to Mars. Can you see it happening?

We won't go because we consider ourselves explorers or discoverers – if that were the sole inspiration, we would have gone there 10 years after we landed on the moon, simply as a result of the natural trajectory of our curiosity. Sometimes people forget that it was the cold war that fuelled the Apollo programme. My read of history tells me we'll only go to Mars if we think it is in the interest of national security, or because we think we can somehow get rich by doing so. NASA and tax money would lead the way. But if there is no business model, it's just not going to happen.

It could end up a vanity project, though. Maybe Bill Gates, Elon Musk and Richard

Branson will pool their billions to send people to Mars as a one-off.

## Would you go to Mars, if asked?

Sure, but first I'd wait for the person who designed the Mars rocket to send their mother and bring her back safely. Then I'd be good for the trip. And if I'm going to go into space, I'd want a proper destination such as Mars. Right now, all we're doing is driving around the block in low Earth orbit, boldly going where hundreds have gone before.

## You recently created a stir when you tweeted, "When I meet President Trump, I may first grab his crotch – to get his attention – then discuss science with him"...

I actually deleted that Twitter post: it wasn't my intent to create such an online maelstrom. I thought it was funny but, on reflection, I realised it was unnecessary. However, I would invite President-elect Trump to discuss why science literacy is so important. Many people think it is based on a body of knowledge, something you can just spout off on command. And while that is an aspect of it – you should know what a DNA molecule is or how a combustion engine works – what's more important is a capacity for curiosity. This is also a crucial aspect of good leadership because you can consider novel problems, think about them analytically and make decisions accordingly. That mindset works towards the best interests of a country – or the world if that's your priority – particularly if you wield political power.

## PROFILE

**Neil deGrasse Tyson** heads the Hayden Planetarium in New York City, hosts the *StarTalk* radio show and *StarTalk* TV series (National Geographic channel), and is co-author of *Welcome to the Universe: An astrophysical tour* (Princeton University Press)



## Many scientists were alarmed by Donald Trump's election. How do you think it will affect the pursuit of science?

There have not been enough formal statements about science policy to judge whether Trump will be good, bad or neutral for the progress of science. But, curiously, this election was not about science and the issues that our country and planet are facing. It was more about the personalities and characters of the candidates. I would have thought that at least some fraction of media time would have



#### How do you feel about the future?

There are reasons to be optimistic. People have more access to science than ever before, not only via the internet but also increasingly through pop culture: there are so many TV shows that have young scientists applying their knowledge and their moxie to solve crimes and other problems. I'd say this move towards science is largely among people 35 years of age or younger. They're not yet old enough to be the CEOs of corporations or to run the country, but when they are, we will see a huge shift in the nation's priorities towards

### "All we're doing is driving around the block in low Earth orbit"

valuing science, math and engineering as a means to improve our country's well-being.

I see science literacy as a kind of vaccine, an inoculation against the kind of people who would otherwise exploit human ignorance about how nature works.

#### You've said that a "cosmic" perspective is important when considering politics and science. What does that mean?

When you learn how big the universe is, how old the universe is, what the contents of the universe are, you realise how fleeting our presence on Earth really is. It helps you refocus, gives you a new point of view on your problems. If you look at Earth from space, you realise it is small and frail. And while I don't want to make light of the political and cultural unrest that affects so many people day to day, if we could somehow instil the cosmic perspective in our politicians, it could make the world a different place almost overnight. This is why you don't find astrophysicists leading armies into battle. We have a cosmic perspective that says, "The universe is big, we're small. Let's figure this out in a way where we aren't doing damage to the very thing that sustains our lives."

#### One last thing: I promised my mother I'd ask you about Pluto. She's still annoyed it isn't a planet any more. Any words of comfort?

Here's the thing. If Earth was a regular sized car, Pluto would be like a toy car. Even our moon is three times the volume of Pluto. It wasn't so much that Pluto was demoted, it should never have earned its planetary status in the first place. Sorry, mom. ■

been dedicated to issues like climate change or clean energy, especially since policies, including science policies, could affect millions of people. There was so little of that kind of discussion.

**But it doesn't bode well that Trump's nominated cabinet is crowded with climate change deniers, including Scott Pruitt as head of the Environmental Protection Agency.**

Scientists are understandably worried about key appointments. But if controversial

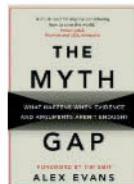
cabinet nominees are approved by the Senate, the issue isn't just with the president – it is also with our fellow citizens who voted for members of Congress who may not be working in the best interests of our country's health, wealth and security. It will be a sign that we are missing some pieces in our educational system. If anyone actually believes that climate change is a hoax perpetuated by the Chinese – something Trump tweeted – then they don't understand what science is or how it works.

Interview by Kayt Sukel

# The quest to save Earth

Creating stirring sagas could spur us to action, finds **Fred Pearce**

*The Myth Gap: What happens when evidence and arguments aren't enough?* by Alex Evans, Penguin



DATA isn't enough. Argument isn't enough. To change the world, scientists need to become storytellers and myth-makers.

This is the message of Alex Evans, who has toiled for years as a researcher-cum-policy wonk for the UN and others on matters like climate change and sustainable development.

Evans has written an important book, *The Myth Gap*, about the need to bring inspiring narratives back to the heart of progressive politics. The good guys, he says, have lost the ability to link the science of the planet and its workings with real and important human values that we all can share.

Fighting climate change and dealing with other planetary environmental challenges is couched in technocratic terms that are "owned by a priesthood of experts", to the exclusion of millions. To reconnect, we must lose the "arid jargon", says Evans, and tell stories of passion and conviction about restoring nature. We need myths we can live by.

If scientists can't do that, they need to let artists and theologians, playwrights and economists, lawyers and revolutionaries tell it their own way. This isn't, in today's political language, post-truth. But it is perhaps post-Enlightenment, or at least a recognition that the Enlightenment was science's own founding myth.

We've lost any ability we had to link planet science to real human values

Evans tells us that his great-grandfather was doctor to Winston Churchill, and was in awe of his "extraordinary power of storytelling". Churchill revived a nation during the Battle of Britain with his famous call to arms, that "if the British Empire... lasts for a thousand years, men will still say, this was their finest hour". Winning the war on climate change needs just such inspiring narratives, says Evans.

The Brexiteers and Donald Trump gained traction by telling stories that resonate with how people feel. If we want to "save the planet" (an emotional truth even if it is a literal nonsense) we need to do the same – but with the right myths. Evans warns of "collapsitarianism" – the view many environmentalists hold that we are doomed by our sheer numbers and profligate ways. That, as the father of Gaia theory, James Lovelock, says, "the bell has started tolling to mark our ending... only a handful of the... billions now alive will survive."

Evans sees this as a self-fulfilling prophecy and also as "the perfect soil in which fascism can germinate" when ecological panic causes nations to scrabble for the last scraps. Instead we need healing and unifying narratives that couch halting climate change and protecting nature in terms of age-old tropes about redemption, atonement and renewal.

This isn't whistling in the apocalyptic wind. There are things to build on. On the human side, there has been a rapid decline in

## "A redemptive tale of maturity has traction because it has truth: our median age is now over 30"

killer childhood diseases; there are fewer wars; life expectancy is rising fast. We are, writes Evans, "living through a golden age for progress on poverty". He might have added some environmental upsides, too. Investment in renewables now exceeds that in fossil fuels; deforestation rates are

in sharp decline; birth rates are half those of a generation ago.

But this is the old world of data. No wonder it fails to resonate. So where is the myth to save us? Evans gets a bit stuck in theology, Jungian psychology and (gulp) "mindfulness". But he does offer this: "humanity is in its teenage years... reckless, rebellious, focused on instant gratification... We need to grow up as a species and begin to assume the responsibilities of adulthood." It's a classic redemptive tale of maturity, in which we stop planet-trashing and start serious home-making. The prodigal species.

I would say this has traction because it has truth, literally as well as metaphorically. As birth rates fall and life expectancy increases, our species is ageing, with our median age slipping over 30, probably for the first time. Maturity looms: it may be our salvation, and Earth's. ■

Fred Pearce is a consultant for *New Scientist*

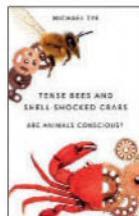


ANDREW BURTON/GETTY

# What else is conscious?

**Matthew Cobb** on hunting mind in other species

*Tense Bees and Shell-Shocked Crabs: Are animals conscious?* by Michael Tye, Oxford University Press



WHEN I was a psychology student in the 1970s, there was a widespread view that the study of consciousness was a passport to irrelevance. Now many scientists grapple with it and anyone who cracks the problem can certainly expect a call from Stockholm.

Philosophers have pondered the issue for millennia and, understandably, are not going to be shoved aside by newcomers armed with electrodes and MRI scanners. Michael Tye, however, is not a neuroscientist, but a physicist turned philosopher, who for the last decade or so has been considering the evidence we use to determine whether other organisms are conscious.

In *Tense Bees and Shell-Shocked Crabs*, Tye confidently applies his method to animals, plants and robots. Because there is no accepted measure of consciousness, Tye resorts to what philosophers do best: rigorous thinking and logical argument. "Animal consciousness," he says, "is just animal experience." For this to be other than tautology, it must mean that consciousness equals experience equals sensation. That would imply that the simplest sensory system, capable of responding to external stimuli and modulating that response (that is, sensing and learning), is conscious.

If provable, this would indeed be a strong solution to the question of consciousness, but it



is not one Tye adopts. Although he peppers his argument with descriptions of various neurons and brain structures, he operates with an obvious rule of thumb (probably shared by many readers) that is linked to apparent degrees of neuronal complexity. Thus he considers all vertebrates conscious, although one of his criteria, the existence of a certain class of pain receptor, does not fully apply to cartilaginous fish. Tye recognises the problem but skips away, leaving it unresolved.

He also thinks that the best explanation of bee behaviour is

**"Strikingly, Tye considers it would be a great leap of faith to assume that worms can genuinely feel pain"**

If dogs and crabs are both conscious, is it in the same way?

that they are conscious, though he is less certain about *Drosophila*. Strikingly, he considers it "a great leap of faith" to think that worms, which do not have many neurons, can "genuinely feel pain". (The phrase "genuinely feel" is oddly vague for a philosopher.)

Tye highlights learning and behavioural plasticity, opening the book with the bold claim that a small dog that whines to be lifted onto an inaccessible bed has self-awareness because it knows it cannot reach its desire unaided.

But it is not clear why this dog is any different from the set of cockroach neurons studied in 1962 by Cambridge University

neurobiologist Adrian Horridge. His experiment showed the cockroach "learns" to keep its leg out of electrified water to avoid a shock. This seems like a similar behaviour to that of the dog: the cells "know" what they want (in this case, to avoid shock). Tye does not discuss this challenging experiment; presumably he would class it as "unconscious learning", a category he applies to a number of counter-examples, excluding them from his central argument without further discussion.

Frustratingly, Tye has not located his exploration of consciousness in an evolutionary framework. Instead, he seems to suggest that if a structure does something in a complex organism, then a similar structure must do the same thing in a simpler organism. But evolution alters function according to selection pressures. A more solid grasp of evolutionary biology would have nuanced Tye's arguments and tempered his judgements, bringing them closer to those of most of the scientists he quotes.

This is an entertaining and stimulating book that may profoundly irritate many scientists; students should be warned that university science generally employs different kinds of evidence and argument than the philosophical approach used here. I hope Tye will collaborate with scientists on experimental tests of his views. That would be far more convincing than any amount of argument. ■

Matthew Cobb is a zoologist, and author of *Life's Greatest Secret: The race to crack the genetic code*

# Make your own meat

Can we grow animal-free meat locally, asks **Sandrine Ceurstemont**

IMAGINE producing meat at home without killing animals. With a few cells and a keg, the process could be no more complicated than brewing your own beer or pickling vegetables. That's the vision of Isha Datar, the CEO of New Harvest, a non-profit organisation aiming to create everything from burgers to silk from cell cultures. "It's like designing a new universe," she told Hello Tomorrow, an event that brought together technology entrepreneurs in Paris last year.

Cultured meat isn't a new idea but it has largely focused on mass-producing beef and pork. In 2013, the first tasting of a lab-grown burger in London grabbed headlines, but the showpiece cost €300,000 and took a year to create. The taste of the burger was described as intense, "close to meat but not as juicy". Growing large quantities of meat from cells in a sustainable way is still far off. As Datar says, "there are so many breakthroughs required".

One of the biggest problems is producing a thick enough piece of meat. The hamburger created for the press event was made by combining several small lab-grown pieces. Since meat is predominantly made of muscle, the process currently involves harvesting muscle stem cells from an animal's body. These are the self-renewing cells that are activated after an injury to repair the damage. They are then coaxed to multiply in the lab by mimicking the job of blood vessels, feeding them with nutrients and oxygen. Although scaffolds are typically used, they struggle to supply every cell as the tissue gets thicker.

Some types of meat may be



EMMANUEL PIERROT/ACE/NURPHOTO/REUTERS

## Muscle matters, but add fat to the mix for a more realistic texture

easier to scale up than others, though. Paul Mozdziak from North Carolina State University and his colleagues, who are working on producing cultured turkey meat, have found that avian muscle cells may not need a scaffold to grow. Instead, they could be cultured in a vessel like a keg or bioreactor, which would allow larger samples to form. Avian cells seem to be able to adjust to different environments more easily than bovine cells, says Datar, so they would be more conducive to home culturing.

Last year, New Harvest started funding Mozdziak's turkey-meat work. Although many enthusiasts

of lab-grown meat are driven by animal welfare, Mozdziak is simply motivated to advance food science. He is excited to get to the stage where he has edible pieces of meat to sample. "I'm curious about what it will taste like and how tender it will be," he says. "It should have almost the same texture as existing meat but we don't know for sure."

Taste is a complicated issue for researchers trying to engineer meat because all different kinds of tissue contribute to flavour. Meat isn't pure muscle: its fat content is responsible for much of its

**"Taste is a complicated issue because all different kinds of tissue contribute to the flavour"**

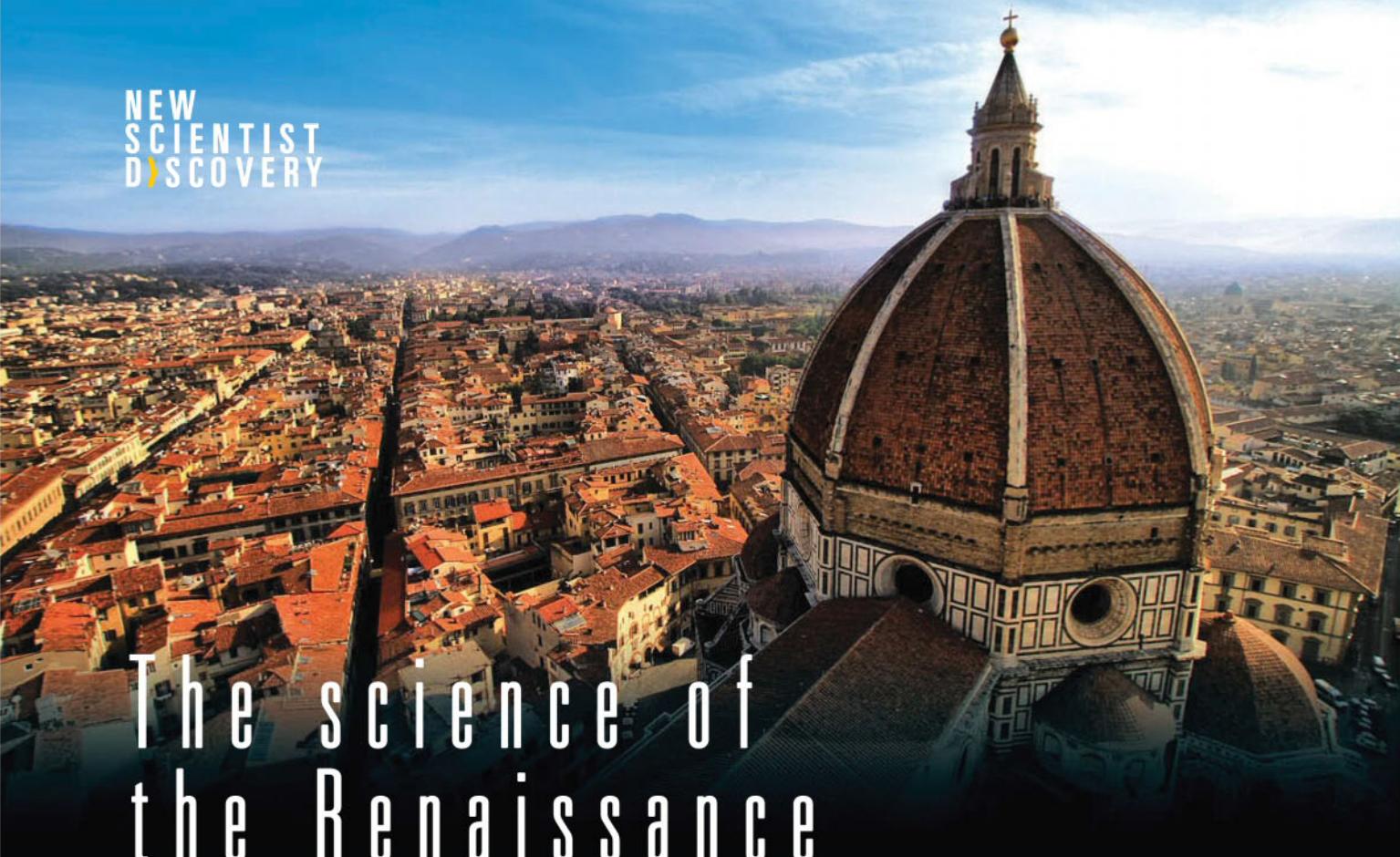
culinary appeal. But Mozdziak and his team found that certain turkey cell cultures could be coaxed to form fat along with muscle when subjected to specific conditions. And the process could be tweaked to combine the muscle and fat into a desired consistency. However, it will probably be easier to replicate the texture of a nugget than to apply the technique to try to replicate a tender prime fillet of beef.

Experimentation will be key. But the first hurdle often faced by enthusiasts is obtaining cells to start the process. At the moment, muscle stem cells are most easily obtained from fresh meat at a slaughterhouse or from live animals – preferably young ones since their stem cells are more plentiful. But harvesting them is hard work.

Datar hopes to change that by making cell lines available for order from lab supply catalogues or by linking up researchers so those with cultures can share them with others, much as people share sourdough starters to make bread. For Datar, "it would be like open-source software. The cells are the code."

Mozdziak thinks that a scaled-up cultured meat prototype could be available in three to five years, but would take longer to appear on supermarket shelves or to join the ranks of DIY food. But once the process is refined, meat as we know it can be reinvented, for example, by creating novel flavours and consistencies. "It's absolutely possible to tweak taste and texture," says Mozdziak. ■

Sandrine Ceurstemont is a writer based in Morocco



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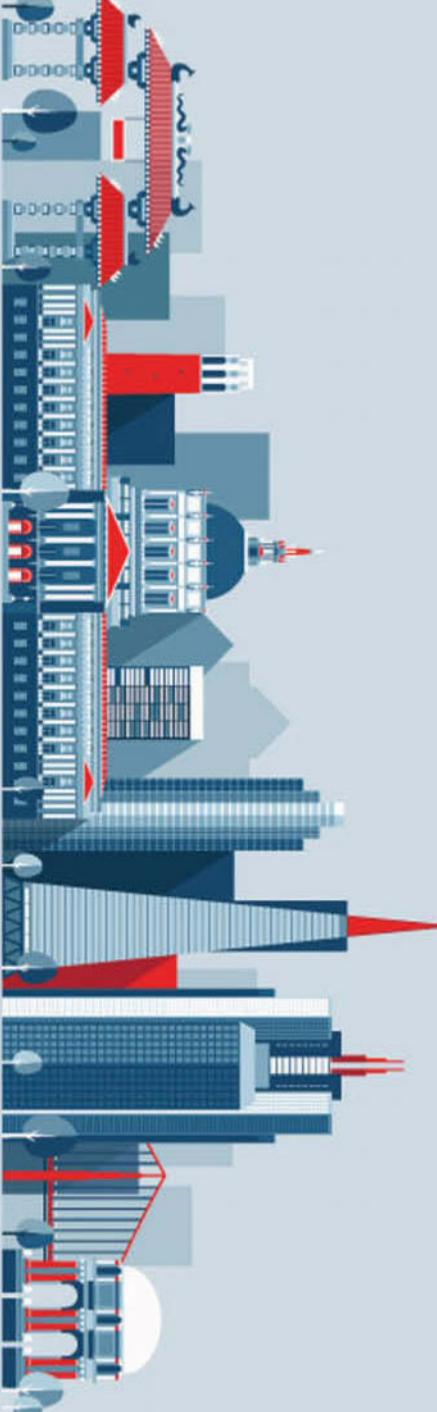
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## EDITOR'S PICK

**The grim loneliness of corporate wellness**

*From Ros Groves,  
Watford, UK*

Employers' attempts to imbue a sense of happiness in their staff lack an utterly vital ingredient: community spirit (10 December 2016, p 40). Employees are becoming increasingly isolated from their coworkers through practices such as working from home,

reliance on email rather than face-to-face communication and a general frowning upon a reasonable amount of chat in the misguided belief that it is symptomatic of non-productivity.

Schemes such as awarding free gym membership merely condemn employees to lonely pounding on a treadmill. A constant focus on monitoring their own happiness simply adds to a depressing sense of introspection.

Regular, simple and affordable work-group outings and activities, enabling all employees and their partners to meet socially, would contribute more to employee contentment and self-worth – and in turn, better productivity – than a working life of pressure and isolation interrupted solely by the stereotypical annual drunken Christmas bash.

**The heat is on and there are other answers**

*From Alex Hromas,  
Hunters Hill, New South Wales,  
Australia*

I am saddened and disappointed by Matthew Watson's call for more research on geoengineering the planet (3 December 2016, p 20). We are putting fossil carbon that took millions of years to sequester into the atmosphere.

It is very unlikely that we will be able to find a short-cut for this process. But we already have some good terrestrial carbon sequestration systems, including the vast subarctic peat forests of Russia and North America, the huge equatorial peat forests of Borneo, the Amazon basin and the smaller forests in New Zealand, Tasmania and South America.

These do not need to be invented: just protected.

*From Rob Ellis,  
Birmingham, UK*

Watson says we need massive geoengineering to curb climate change. His analogy of a boat in a river suggests that when we get to the bank, the problem is solved.

Unfortunately, the river will still run. Rather than planning huge schemes to put particles into the sky or sea to cause possibly uncontrollable feedback, we should be spending time and money on research into better ways to use the sun's near-constant energy output.

*From Neil Dale,  
Bedford, Massachusetts, US*

Agronomist Masoud Hashemi and graduate students at the University of Massachusetts School of Agriculture are among those studying no-till farming, which could sequester major amounts of carbon, offer drought

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## **f "Great, self-driving cars having mental breakdowns on the motorway, just what I need"**

Jesstina Chibinski expresses concern about the side-effects of automata gaining consciences (7 January, p 36)

resistance – and it is scalable. I can't help thinking Watson's call to investigate technological geoengineering is stuck on the wrong side of a paradigm shift. Wake up and smell the flowers!

### **Language use cycles are, like, sick, innit?**

*From Adrian Bowyer,  
Foxham, Wiltshire, UK*  
Sophia Chen describes a 14-year cycle in noun usage over centuries in many languages (3 December 2016, p 9). One possible source for this is that great engine of human lexicographical innovation: teenage slang. As soon as people are linguistically dexterous enough to be able to play with language freely, they coin new words and revive old ones (often with specialised new meanings). They do this for fun and because they need a way to communicate that

is impenetrable to their parents and other adults.

Observing my daughter and remembering my own teens, this creativity peaks around the age of 14, I think.

### **Food from fossil fuel feels farcical**

*From Sam Edge,  
Ringwood, Hampshire, UK*  
The suggestion that our food could soon come from methane is a fine example of the principle that just because something can be done doesn't mean it should be done – or even allowed (19 November 2016, p 10). It is stupid to use irreplaceable fossil fuels to produce food with the by-product of carbon dioxide pollution, when we can do the same using energy from sunlight and actually remove CO<sub>2</sub> from the atmosphere. Conventional

agriculture may have its downsides in terms of land usage and CO<sub>2</sub> generation, but at least it has the possibility of being carbon neutral and of not squandering resources our descendants need.

But in any case, if you are going to go to the lengths of growing micro-organisms for food, why not grow those that can use energy from solar-farm style concentrators? That way you'd avoid the land use issues just as thoroughly as with the methane plan. The only reason I can see for governments allowing this is if politicians are still in the pockets of the fossil fuel industry.

### **These memories are made to entrain you**

*From Howie Firth,  
Elgin, Moray, UK*  
It's interesting to read about the similarities psychologist Janice

Chen found between the brain scans of different people who watched the same episode of the television drama *Sherlock* (10 December 2016, p 6). I do wonder, though, whether this could be showing us more about the homogenising effects of media like TV than a general property of the brain.

After all, detective stories are specifically crafted to draw us into their narratives. It could be interesting to see the outcome of an experiment with a less tightly structured experience – perhaps listening to a sonata.

### **Immoral earnings promise anarchy**

*From John Hockaday  
Canberra, Australia*  
Michael Norton comments on pay inequality but addresses only half the problem (10 December ➤

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2016, p 18). So many rich people do not pay enough taxes. In Australia, and probably all other democracies, the government's solution to reduce a deficit is to stop paying for services to the poor, disabled and unprivileged.

The ideal solution would be to make rich people pay their fair share of taxes. Enforcing an 85 per cent marginal tax rate on incomes over A\$200,000 and on business profits over A\$2,000,000 would provide more than enough money for free national health, support for the underprivileged and infrastructure including renewable energy systems and subsidising electric vehicles to solve climate change.

Anarchy and an international revolution is not the answer because that would give the rich more reasons to suppress the poor. However, that is the likely outcome when inequality becomes unrealistic. The best solution would be to vote for a government that would genuinely address these issues. The problem is that most politicians are part of, or influenced by, the rich and not willing to change the status quo.

TOM GAULD



## Our figures raised some blood pressure

*From Tony Diamond, Stanley, New Brunswick, Canada*  
You report that 594 million people had high blood pressure in 1975, but 1 billion did four decades later (19 November 2016, p 7). But in 1975 there were about 4 billion people on Earth; four decades later, 7.4 billion.

So the proportion of people with high blood pressure is about the same as it was in 1975.

*The editor writes:*

- We should perhaps have made room to point out that huge advances in preventing and treating high blood pressure have led to a decline in the developed nations – but not in poorer ones.

## Whatever became of the Stirling Engine?

*From Barrie Price, East Leake, Leicestershire, UK*  
I read James Randerson's report of an interesting new machine for exploiting waste hot water

just after visiting the East Midlands Parkway rail station (26 November 2016, p 26). This is next to the 2000-megawatt Ratcliffe-on-Soar power station. In the still, cold, evening air, a great cloud of steam from its eight cooling towers was a reminder of the colossal amount of heat our society wastes.

It has always seemed crazy to me that we find it acceptable to waste so much energy when another technology that could exploit this was invented two centuries ago. What happened to the heat engines invented in 1816 by Robert Stirling that could significantly boost the efficiency of these power stations?

## Making things up when the world goes quiet

*From Anita Soley, London, UK*  
Helen Thomson describes some ways in which the brain makes up hallucinations to cover up gaps in perception (5 November 2016, p 29). I can add from experience another example: some now think of tinnitus as

the brain supplying frequencies that are missing as hearing deteriorates. I now have hearing aids, in the hope that my brain will stop supplying its own noise!

## Accepting the historical Jesus into your eyes

*From David Werdegar, Naperville, Illinois, US*  
Nothing illustrates the innate prejudice that Caroline Williams exposes better than the stereotyped picture of Jesus Christ with arms raised in blessing (10 December 2016, p 26). The long, straight hair, the fair skin and blue eyes are typical of northern European men, not of those from the Levant.

Based on mosaic pictures of men from the time of Christ, he would have had olive-hued skin; short, curled hair; and a Roman or semitic nose.

## For the record

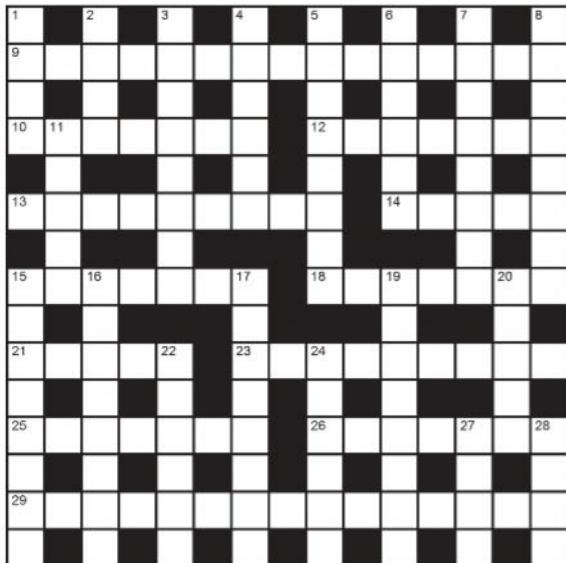
- India's Interlinking of Rivers scheme looks set to submerge an estimated 58 square kilometres of critical habitat in the Panna Tiger Reserve (3 December 2016, p 12).
- But yes, so fast: the speed of an elite endurance runner is 23.4 km/h (10 December 2016, p 26).
- Hic. Women, having a lower water content, reach a high blood alcohol concentration sooner than men and, metabolising alcohol faster, sober up quicker (3 December 2016, p 33).
- Strike a light! It is only in a laser beam, however, that all waves are in phase (19 November 2016, p 9).
- More of the offspring of female red deer with bigger brains reach 1 year old (17/24/31 December 2016, p 15).

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## CROSSWORD

Compiled by Richard Smyth



### Crossword No2

#### ACROSS

- 9 The closest star to Earth, other than the sun (7,8)  
10 In anatomy, the inner part of, say, the kidney or adrenal gland (7)  
12 Bernhard \_\_\_ (1826–66), German mathematician noted for a hypothesis in number theory (7)  
13 Theropod dinosaur of the late Cretaceous (9)  
14 Organic compound derived from ammonia (5)  
15 The diffusion of water or any other solvent through a semipermeable membrane (7)
- 18 Claude \_\_\_ (1916–2001), "the father of information theory" (7)  
21 Synthetic dye colour created by William Henry Perkin in 1856 (5)  
23 Combining with oxygen; rusting (9)  
25 Sent via Yahoo or Outlook, for example (7)  
26 Term for a transparent and accessible internet (4,3)  
29 "A dynamical theory of the \_\_\_ field", 1865 paper by James Clerk Maxwell (15)

#### DOWN

- 1 Unsolicited, unwanted email (4)  
2 That which might be covalent, ionic or metallic? (4)  
3 Sir Edward Leader \_\_\_ (1828–1910), first chief engineer of the Manchester ship canal (8)  
4 Hedy \_\_\_ (d.2000), Hollywood star inducted into the National Inventors' Hall of Fame in 2014 (6)  
5 In medicine, the death of tissue or cells (8)  
6 MIT/IBM educational computing project (6)  
7 A change in an organism's genetic make-up (8)  
8 Name given to the system of binomial nomenclature (8)  
11 Paul \_\_\_ (1913–96), Hungarian mathematician, subject of the 1998 book *The Man Who Loved Only Numbers* (5)  
15 Anodyne, 18 Assayer, 21 Dirac, 23 Numerator, 25 Circuit, 26 Rhombic, 29 Operating System. DOWN: 1 Bohr, 2 Agar, 3 Industry, 4 Apollo, 5 North Sea, 6 Applet, 7 Taxonomy, 8 Feldspar, 11 Orion, 15 Adductor, 16 Orreries, 17 Einstein, 19 Sardonyx, 20 E coli, 22 Causal, 24 Mirage, 27 Beta, 28 Coma.

Answers to Crossword No1

ACROSS: 9 ORGANOPHOSPHATE, 10 RORQUAL, 12 TELFORD, 13 CITATIONS, 14 TROOP, 15 ANODYNE, 18 ASSAYER, 21 DIRAC, 23 NUMERATOR, 25 CIRCUIT, 26 RHOMBIC, 29 OPERATING SYSTEM. DOWN: 1 BOHR, 2 AGAR, 3 INDUSTRY, 4 APOLLO, 5 NORTH SEA, 6 APPLET, 7 TAXONOMY, 8 FELDSPAR, 11 ORION, 15 ADDUCTOR, 16 ORRERIES, 17 EINSTEIN, 19 SARDONYX, 20 E COLI, 22 CAUSAL, 24 MIRAGE, 27 BETA, 28 COMA.

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**WE'RE** sure many readers will be atoning for their sins over the festive season by abstaining from alcohol this January. Barrie Eggleston sends news from Australia of something to do with those idle wine bottles in the interim.

He forwards accounts of an important technological advance, presented by the Brisbane-based *Sunday Mail*. This device promises to improve your tipple, even in unopened bottles.

Placed next to your favourite wine for several hours (or better yet, a wine you don't like), the A\$90 canister will coax water molecules in the wine into novel arrangements of so-called "hexagonal water". This will not only improve the flavour, we are told, but "once opened, your wine will last up to three times longer before it goes off".

A blind taste test by the *Sunday Mail* found that treated bottles were much more fruity - or is that fruitloopy? Feedback wonders if the preservative effect is enough to save our half-finished bottle of port that's been gathering dust since the last of

the Christmas cheese was eaten. Though we suspect there are more reliable ways to improve your wine cellar with A\$90.

**WE DON'T** know who Perry Bebbington got stuck sat next to during the holiday season, but he writes to share his unfortunate discovery of a phenomenon he calls "fractal talking".

"Practitioners will start talking about one subject, then go into greater detail about one small part," he says. "They don't return to the original subject but take one small part of the new subject and go into great detail about that bit. This then repeats indefinitely until the person listening either falls asleep, makes an excuse to leave or dies."

Feedback is reminded of Donald Trump, a man who speaks in so many nested clauses that reading transcripts feels like unpacking a bewildering series of Matryoshka dolls.

A president-elect who doesn't

**George Neil** received a news digest whose subject line announces: "Tips for Raising Happy Kids | Marijuana Use Rising In Pregnant Women". Some connection, perhaps?

PAUL MCDEVITT

waste time finishing one sentence that could be better spent starting another? That may well popularise this phenomenon.

Might we expect a US veto on full stops, to be replaced forever with semi-colons? You heard it here first;

**CAUGHT** in a whirl: Adrian Simper has been struggling to parse the name of his favoured brand of dishwasher tablet: "Finish powerball super charged quantum max", which reads less like a product name and more like a cryptic crossword clue.

Adrian has written to the head of science at Finish in an effort to get to the bottom of the mystery. Feedback wonders, can something be both quantum and max? And what kind of spooky action is it promising will happen to your cutlery?

**FEEDBACK** has previously devoted rather too much time to the mystery of missing socks. And now we discover that we may have misjudged how common a phenomenon it is.

Margaret Pitcher reports that she never loses any socks at all. She wonders if it's something to do with XX chromosomes, which, Feedback belatedly realises, is another set of pairs that men managed to lose one of.

Enterprising Mark Redman suggests individual socks could be connected to Wi-Fi, to broadcast their location no matter where they are. Perhaps by washing them with the aforementioned detergent, you might entangle the pairs?

**VOICE-ACTIVATED** assistants are finding their place in our homes, like small electronic oracles. In the US, Jane Tatchell says she asked Amazon's Alexa for the latest headlines one morning, and after the first few categories were rattled off, she was told that "Science is not available".

"That's what I fear for the next four years," she sighs.

**PREVIOUSLY** Feedback examined the problems arising in scientific

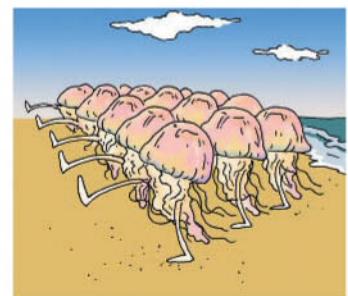
literature from the plethora of words for dung (10 December 2016). Mike Walsh writes to assist.

"Linda Losito could easily have found many more words for poo by scanning that most scholarly publication from Viz – Roger's *Profanisaurus*," he says.

"My sexual and scatological vocabulary has increased immeasurably since being given a copy of this erudite work." Truly an indispensable resource for doctors of all things dirty.

**ON THE** subject of spraint, our colleagues previously announced the news that dogs habitually orientate north-south when relieving themselves (17/24/31 December 2016, p 44). Steve Martin sees a useful application: "If you are exploring, take your dog with you and you will never get lost." Just remember to give it a big feed first.

Vivien Harrison, meanwhile, cautions that the correct breed is necessary. "My brother informs me that his dog doesn't orientate itself north-south when it defecates," she says, "as it is not a shih tzu pointer."



**FINALLY**, "Scientists warn of irukandjis' southward march," reports the *Brisbane Times*. "These jellyfish have evolved quickly," says a worried Sean Williams. Feedback promises step-by-step updates as the story progresses.

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.

## No stone unthrown

Personal experience suggests that if you put human males beside a body of water with a supply of stones to hand, they will soon start throwing them into the water. What drives them to do this, and is the same true of females? Is this unique to humans, or has it been observed in other primates? What purpose can it possibly serve?

■ I have just listened to a radio programme by David Attenborough about the aquatic ape theory, and it strikes me that this question fits well with this hypothesis.

Thinking of our environment, we struggle to picture the land or sea in pre-industrial times when both were teeming with animals. Our distant shore-living ancestors would have been constantly scanning the water for fish or other marine food animals, and lobbing stones would surely have been a simple way of killing a few.

Maybe the skill was translated to throwing slings, boomerangs, spears and so on when humans later made hunting excursions further inland.

Since young men would naturally compete against one another with their hunting skills, males skimming stones seems another argument for the aquatic ape theory.

Stella Perrett  
Bristol, UK

■ Many primates throw rocks, faeces and sticks, and some chimps have been known to

throw rocks at zoo visitors. Some bonobos throw rocks at their preferred male to indicate they're ready to mate.

However, heaving stones into water with no obvious hunting intent seems to be the preserve of *Homo sapiens*. Some theorise that this is a fish-hunting activity but, if so, the results are abysmal.

Given some rocks, water and nothing else to do, humans quickly become competitive, battling to see who can make the largest splash, skip a flat rock the furthest or hit a floating target. This clearly

### "Many primates throw rocks, faeces and sticks and some chimps throw them at visitors to zoos"

provides hunting practice, but is also classic play behaviour, think cats and their prey.

The "nothing else to do" factor is important, and also suggests play behaviour.

Ron Dippold  
San Diego, California, US

## Round and about

People of my generation (I am 75) can remember when hens' eggs used to have a rounded end and a pointy end. Now the ends seem much more alike. Have eggs changed over the years, and if so, why?

■ Most eggs still have a round end and a pointy end – indeed, a quick survey of eggs from battery hens in my local

supermarket revealed 100 per cent normal eggs, although just what is egg-shaped is open to debate. Any spherical or near-spherical eggs are most likely a result of severe inbreeding.

The majority of commercial egg-laying chickens are ISA Brown hens – ISA standing for Institut de Sélection Animale – which have been specifically bred for maximum egg production. These birds are now found across the world and frequently exhibit genetic faults previously found only in obscure textbooks.

My purebred Wyandotte chickens lay "normal-shaped" eggs, with each hen laying a shape that is distinctly her own. The eggs get bigger during the laying period (between three and five days is normal) as the thickness of the shell decreases and its radius of curvature increases. This affects shell strength and means that eggs laid later are fatter, though never spherical.

After the laying period, the hen will take a break of up to two days and begin again. Battery fowl kept in heated environments with controlled lighting will have a laying period of up to three weeks before taking a short break.

Eggs pass along the oviduct "pointy" end first. If the hen is not frightened or interrupted, it will rotate the egg horizontally in the cloaca just before laying so that the egg is expelled round end first. If the bird is disturbed, the egg will

be forced through pointy end first. The egg is laid with a soft shell that hardens rapidly in contact with the air.

Nina Dougal  
Malmsbury, Victoria, Australia

## This week's questions

### STONED AGAIN

Your question about throwing stones (above) leads me on to another. I am left-handed, but like many of us in this back-to-front world I can do most things fairly well right-handed. Yet when it comes to throwing overarm or skimming stones, I can only do it right-handed and not with my dominant hand at all. Does anyone know why this might be?

Bryan Simmons  
Westbury, Wiltshire, UK

### VACUUM PACKED

The OSIRIS-REx mission to the asteroid Bennu will gather samples using a robotic arm equipped with a vacuum cleaner. How does a vacuum cleaner work in the vacuum of space?

Douglas Lee  
Glasgow, UK, and  
Tony Lamont  
Townsville, Queensland, Australia

### SLEEPING SICKNESS

Being sedentary is one of the causes of deep vein thrombosis. So why don't we get DVTs in our sleep?

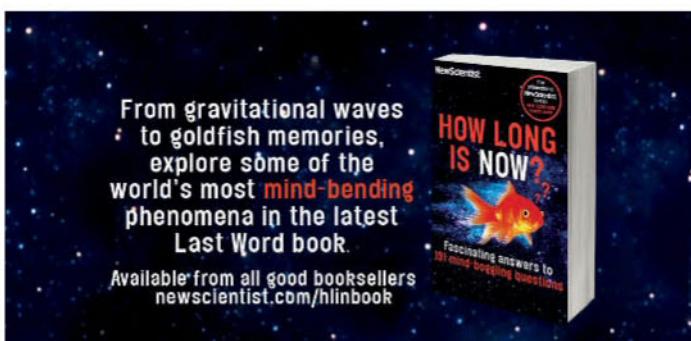
Cormac Byrne  
London, UK

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