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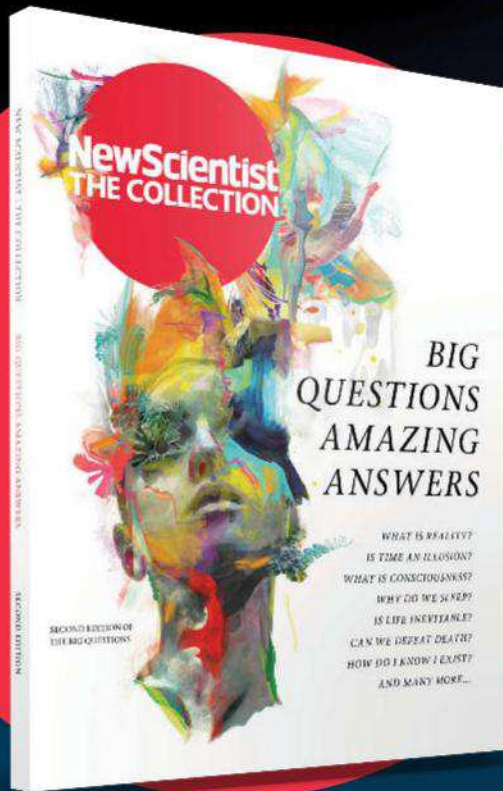
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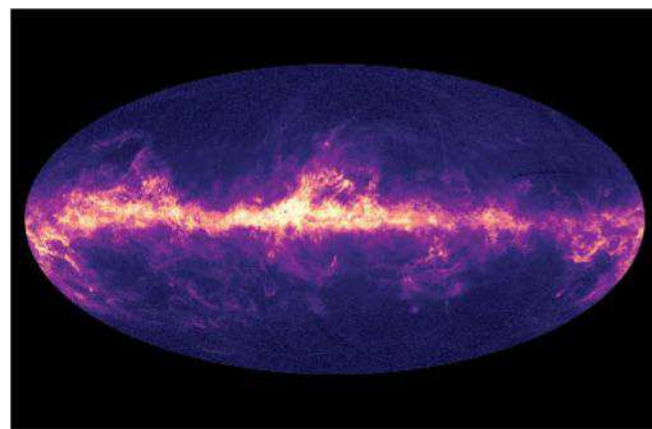
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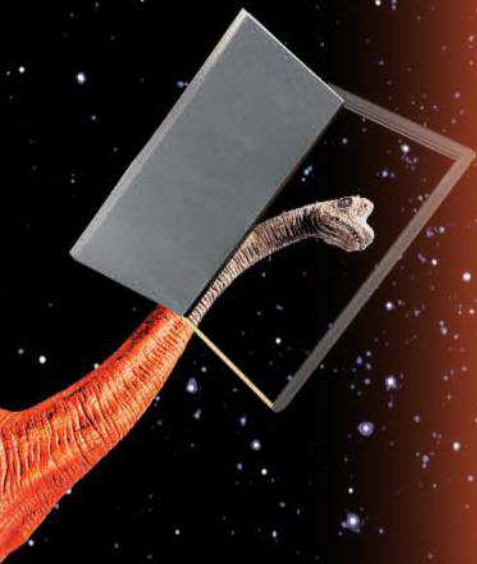
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ERICA CANEPA/BLUMBERG VIA GETTY IMAGES

The high price of meat

Farming's environmental toll means we must give alternatives a try

ONE of the great obstacles to living a sustainable life is that living unsustainably is often more comfortable, fun and interesting. Sure, flying to a holiday resort dumps a lot of carbon dioxide into the atmosphere, but if you enjoy travelling and can afford to do so, choosing to stay home requires levels of self-sacrifice that many people find difficult. Even offsetting the carbon takes effort and costs money. The same problem applies to car ownership, recycling, energy efficiency and consumerism in general.

One area of life where luxury is particularly damaging to the environment is eating meat. Despite the growing trend towards vegetarianism and veganism, most people on Earth eat meat.

According to a recent report by the Economic and Social Research Institute in Dublin, Ireland, only about 20 per cent of the world's population – 1.5 billion people – never eat meat. Most of these are vegetarians out of necessity. "They will start to eat meat as soon as they can afford it," the report says.

Increasingly, they can afford it. In China, for example, per capita

meat consumption increased 400 per cent between 1970 and 2007. Even this is still less than half of the 120 kilograms a typical American eats each year. Add in a growing world population and demand for meat is likely to go through the roof.

The increase may be slightly offset by the fact that people tend to eat less meat as they become even more prosperous. But this doesn't kick in until per capita earnings rise above \$20,000,

"We should celebrate companies that recognise our desire to eat meat but also to reduce its impact"

way above the global median. There is still a lot of unsatisfied hunger for meat.

Growing prosperity is a great thing, of course, but increasing meat production is disastrous from an environmental point of view. Pasture land for livestock occupies an area the size of Africa. Cropland takes up an area the size of South America, and a third of this is used to grow animal feed. All told, livestock takes up 70 per cent of all farmland. An additional 26,700 square kilometres of land

is cleared each year to graze cattle and grow crops to feed them. Livestock farming produces greenhouse gases and guzzles energy and water.

The obvious solution to this is to eat less meat, but that is easier said than done. So we should celebrate a new generation of food companies that recognise our desire to eat meat but also the need to do something about its impact.

Plant-based meat substitutes aren't quite there yet, but have gone beyond what many thought possible (see page 30). They can only get more realistic, and the prospect of eventually developing affordable lab-grown meat is still alive (see page 34). The latest meat substitutes are worth a try. Even just eating them once in a while can reduce your footprint.

In fact, this philosophy – to satisfy natural human desires for luxury and convenience – may have a better chance of success than asking for sacrifices. It could be applied to other areas of life where doing the right thing is hard: clothing, packaging and consumer electronics spring to mind. Entrepreneurs, start your engines. ■

Bigger brain cells work better

For the first time, IQ has been linked to neuron size and performance

Jessica Hamzelou

WHAT makes some people smarter than others? It could come down to your individual brain cells – the bigger and faster your neurons, the higher your IQ. If confirmed, the finding could lead to new ways to enhance human intelligence.

Most intelligence research to date has identified brain regions involved in certain skills, or pinpointed hundreds of genes that each play a tiny role in determining IQ.

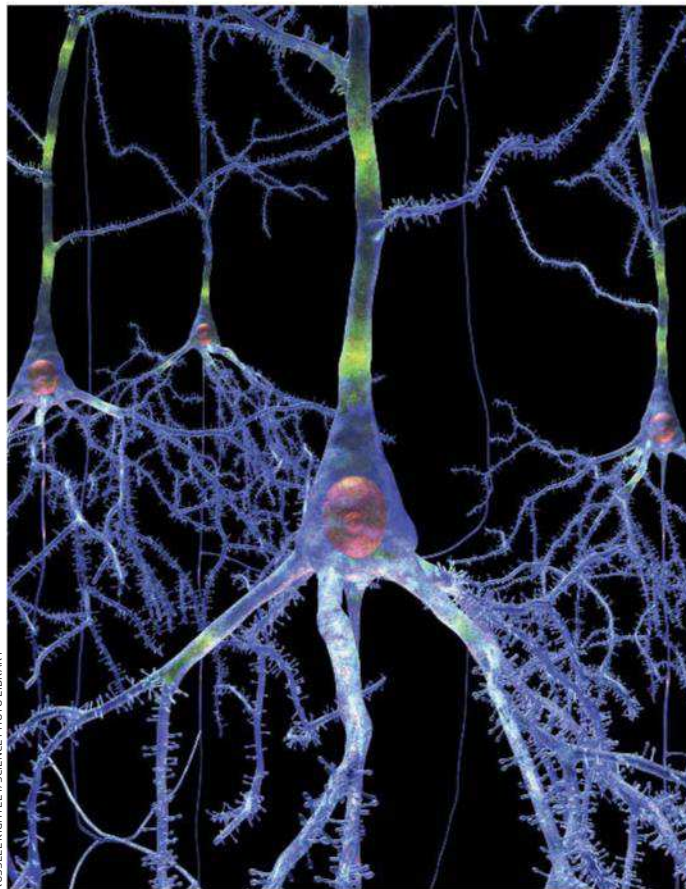
To go a step further, Natalia Goriounova at the Free University Amsterdam in the Netherlands and her colleagues studied 35 people who needed surgery for brain tumours or severe epilepsy. Each took an IQ test just before the operation. Then, while they were under the knife, small samples of healthy brain tissue were removed and kept alive for testing.

The samples all came from the temporal lobe. This brain area helps us make sense of what we see, recognise language and form memories, all of which factor into intelligence.

Examining this tissue revealed that brain cells are significantly bigger in people with high IQ scores than those with lower scores. The bigger cells also have more dendrites – the projections that connect to other neurons – and the dendrites are longer, suggesting that these neurons may be capable of receiving and processing more information.

The connections between neurons are thought to be involved in storing memories, so it is likely that bigger cells have more “space” for memories, the team suggest.

“We’ve known there is some link between brain size and



RUSSELL KIGHTLE/SCIENCE PHOTO LIBRARY

intelligence. The team confirm this and take it down to individual neurons,” says Christof Koch at the Allen Institute for Brain Science in Seattle. “It’s a beautiful study.”

The team also tested neurons’ ability to transmit electrical signals by putting current through them, gradually upping the frequency. Neurons from people with low IQs coped with low frequencies, but became fatigued and slower as the frequency rose. Cells from people with high IQs did not slow down,

“This could lead to neuroscience-based ways to enhance human intelligence dramatically”

Neurons with more connections may store more memories

however (*bioRxiv*, doi.org/cn22).

Using computer models of brain-cell activity, the researchers predict that the neurons of people with low IQs send signals more slowly in general – a suggestion that chimes with observations that people with higher IQs tend to have faster reaction times.

The properties of brain cells explain about a quarter of the differences in IQ, says Koch. Genes, on the other hand, are thought to account for only around 3 to 7 per cent of the difference.

The study provides the first

evidence that human intelligence could be shaped by the properties of individual brain cells – a finding that is likely to be controversial, says Koch. “Some people will say intelligence is so elusive and complex that the idea it can be tied to individual neurons is implausible,” he says.

Extraordinary science

It remains unclear why some people have bigger brain cells than others, and whether this is a cause or a consequence of high IQ.

“We don’t know if the differences are the results of experience, or if they are biologically determined,” says Wendy Johnson at the University of Edinburgh, UK. To establish a clear link between brain-cell properties and intelligence, you would need to study thousands of tissue samples – not just those from 35 people, she says.

But given how difficult it is to study living brain tissue, this is the best one can hope for, says Koch. “If you want human tissue, the only other options are from aborted fetuses or dead brains,” he says.

“What they did here is extraordinary neuroscience,” says Richard Haier at the University of California, Irvine. “It’s the beginning of being able to study intelligence neuron by neuron, and circuit by circuit.” He wonders whether differences between cells in different regions of the brain might explain why some individuals excel in some aspects of intelligence but not others.

“This research could lead to neuroscience-based ways to enhance human intelligence – perhaps dramatically,” says Haier. “We might be able to treat intellectual disabilities or prevent them from occurring.” ■

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Nuclear-free Koreas?

THE world feels slightly safer - but that may be short-lived. Last week the leaders of North and South Korea agreed to the goal of "complete denuclearisation, a nuclear-free Korean Peninsula".

North Korean leader Kim Jong-un had already pledged to suspend all nuclear and missile tests. Now he has invited "foreign experts" to witness the closure of his test site ahead of a summit with US President Donald Trump.

But Korea watchers are warning that "denuclearisation" means different things to Kim and Trump, as the US seems to have no plans to give up its nuclear capabilities on the peninsula.

As that becomes clear, diplomacy could collapse with the risk of sparking a war, with hawks in the

US arguing for military solutions after talks fail, says James Acton of the Carnegie Endowment for International Peace in Washington DC.

"When Kim says 'denuclearisation', he means exactly what Barack Obama meant when he said he would seek a world without nuclear weapons," says Jeffrey Lewis at the Middlebury Institute of International Studies in Monterey, California. That means a process in which everyone disarms, not just one country.

The US has pledged to defend South Korea and has nuclear weapons stationed in nearby Guam. US National Security Adviser John Bolton has said denuclearisation does not imply the US would commit to keeping its nukes out of Korea. He wants "total disclosure" of North Korea's nuclear weapons programme.

Massive cybercrime market busted

LAST WEEK, the world's biggest cybercrime-for-hire website was shut down and its administrators arrested. The Dutch-led operation involved more than a dozen law enforcement agencies, including Europol and the UK National Crime Agency.

The site, webstresser.org, was an online marketplace that hired out sophisticated distributed-denial-of-service tools for as little as \$18.99 a month. A DDoS attack is a popular technique used to target websites by swamping them with traffic - often sent from huge botnets of hacked devices - and forcing them offline.

[Webstresser.org](http://webstresser.org) had 136,000 registered users, many based in the US. More than 4 million attacks have been launched using the site, including those against seven of the UK's largest banks in November 2017.

"They were one of the most significant players in the crime-as-a-service market," says Alan Woodward at the University of Surrey, UK.

Neonic ban to help save Europe's bees

CAMPAIGNERS have hailed a decision by European countries to ban three neonicotinoid pesticides as a "major victory". These chemicals pose a threat to bees, according to an assessment by the European Food Safety Authority in February.

The European Union already restricts neonicotinoid use because of reports of their "sub-lethal" effects, such as impairing bees' ability to forage and form colonies.

The EU will now completely ban their outdoor use, meaning they can only be used in greenhouses.

However, what farmers do in response will be crucial, says Dave Goulson at the University of Sussex, UK. "If these neonicotinoids are simply replaced by other similar compounds... then we will simply be going round in circles," he says.

"What is needed is a move towards truly sustainable farming methods that minimise pesticide use, encourage natural enemies of crop pests, and support biodiversity and healthy soils," says Goulson.



EMMANUEL DUNAND/AP/GETTY

Ancestry site used to hunt serial killer

A CALIFORNIAN serial killer may have been identified by genetic profiles that his distant relatives uploaded to a free genealogy website.

According to reports, investigators used the site, GEDmatch, to help identify the suspect they believe is the so-called Golden State Killer, who is accused of more than 50 rapes and 12 murders across California in the 1970s and 80s. Last week, investigators arrested Joseph James DeAngelo, a 72-year-old former police officer, and charged him with eight counts of murder.

They tracked him down by comparing samples of DNA taken decades ago from a crime scene with genetic profiles of individuals held on the GEDmatch database. Before arresting him, they took a new DNA sample from an item DeAngelo had discarded, to confirm the DNA match.

Once the investigators had found a partial match on the database, they identified related individuals and narrowed the search.

NEWS & TECHNOLOGY

Face recognition spots missing Indian children

THOUSANDS of children vanish every year in India, many the victims of human trafficking. Facial recognition software is now helping to reunite them with their families.

In a recent test in Delhi, police used the technology to scour photos from a government database called TrackChild, which combines reports of missing children filed with police and records of children being looked after in childcare institutions.

Over the course of four days, the software compared photos of around 65,000 missing children against roughly 40,000 living in care homes. It managed to match 2930. Efforts are now under way to return the children to their parents, according to police.

It is possible to search the TrackChild records using things like name, physical characteristics and the date when the child went missing. But the size of the database and the patchiness of the records make this a daunting task, says police special commissioner R. P. Upadhyaya, who oversaw the initiative.

"Trying to connect them using parameters like height or age takes a lot of time," he says. "With facial recognition it's instant."

Official figures from India's Ministry of Women and Child Development (MWCD) show that more than 240,000 children were reported missing between 2012 and 2017. While some run away, the majority are taken by human traffickers, says Swati Jha from child rights organisation Bachpan Bachao Andolan, which suggested the software to the police.

Victims are either kidnapped

or lured away from their parents with promises of jobs and education. "These children are trafficked to Delhi and other metropolitan cities, where they are placed as domestic help or child labour or even prostitution," says Jha.

But it can still be hard to get these children back to their families even after they are rescued, she adds. Years may have passed since they were kidnapped, so they often don't

Almost 3000 missing children were matched using the software

remember details that could help reunite them, such as their address. The sheer number of records also makes it near impossible to search the database manually.

Bachpan Bachao Andolan realised that applying facial recognition software to the photographs of the children could be a workaround, says Jha. So it went to the High Court of Delhi to push the MWCD, which controls the national TrackChild database, to share photos with Delhi Police, which is responsible for finding missing children.

The police force procured commercial facial recognition software especially for the task. Upadhyaya says the force now plans to create web and mobile applications that will allow officers to quickly upload photos of rescued children to see if they have been reported as missing.

MWCD secretary Rakesh Srivastava says that following the successful trial in Delhi, the ministry will make TrackChild data available to any state police force that wants to carry out a similar analysis.

If it is technically feasible, the ministry may seek to integrate facial recognition software directly into the TrackChild portal to allow records to be automatically matched, he says, but there are no formal plans yet to do this. **Edd Gent** ■



AMIT DAVE/REUTERS

Lightning strike switches off brain implant

DOCTORS are warning some people to change how they recharge their brain implants, after a nearby lightning strike made a woman's brain stimulation device shut down.

Brain stimulators are often used to treat people with Parkinson's disease, tremors or severe muscle spasms. They comprise thin electrodes inserted through a hole in the skull

into the part of the brain that controls movement. Wires under the skin link them to a battery implanted near the neck. When turned on, an electric current stimulates the relevant bit of the brain and damps down the movement problems.

Last year, lightning struck the apartment of a Slovenian woman who has a brain stimulator to prevent her having neck muscle spasms and tremors. When the strike hit, her TV and air conditioner - both on at the time - were destroyed.

About an hour later, she noticed her neck tremor returning. At hospital the

next day, Dušan Flisar of University Medical Centre Ljubljana found that the woman's stimulation device had automatically shut down and needed to be reset (*Journal of Neurosurgery*, doi.org/cn3s).

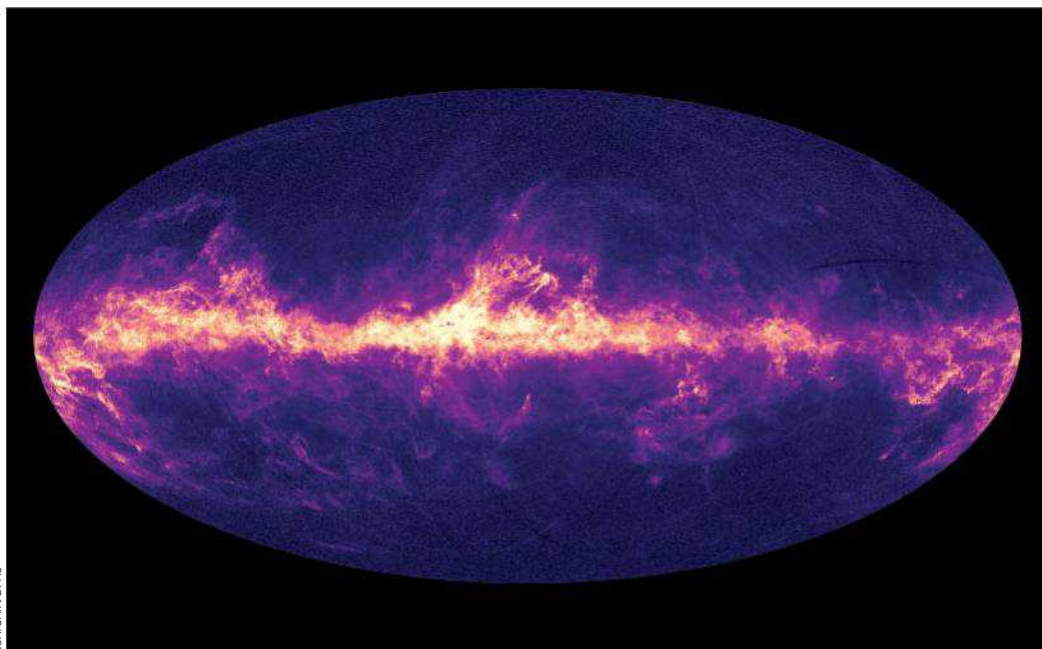
This is the first report of lightning affecting a brain-stimulation device. Flisar says the strike could have killed the woman if she had been recharging her implant in a certain way when it

"A surge of electricity could be conducted into the brain while the system is charging - we don't know"

happened. Devices like this need to have their battery recharged several times a week, by holding the pad of a recharger over the skin.

The charger also needs to be topped up, which is done by plugging it into the mains electricity supply. For some types of device, the implant can be recharged using the charger while it is itself plugged into the mains - but Flisar's team is now warning against doing this.

"If a huge surge of electricity enters the system, it could be conducted into the brain - we don't know," says Flisar. **Clare Wilson** ■



ESA/GAIA/DPAC

Star map adds to cosmic confusion

Leah Crane

THE universe just got even more confusing. Last week, the biggest ever 3D map of our galaxy was released as part of the second batch of data from the European Space Agency's Gaia satellite. The long-awaited measurements revealed the location and brightness of 1.7 billion stars in the Milky Way.

But the first analysis of the data has also crystallised our confusion about the rate of the universe's expansion. We have two ways to determine this rate, expressed in a quantity called the Hubble constant, and they have always come up with different values. Some researchers had hoped that the Gaia data released on 25 April might lessen the divergence, but it has only got worse.

One determination of the Hubble constant comes from the cosmic microwave background (CMB), a relic of the first light in

the cosmos after the big bang. Researchers have used the now defunct Planck space observatory to examine this light and figure out how fast the universe was expanding back then. Those values can then be plugged into models of cosmic evolution to predict how fast the universe should be expanding today.

The other method involves directly measuring the distances to stars called Cepheid variables. This lets us figure out how quickly objects in the local universe are moving away from us. The technique gives a Hubble constant more than 9 per cent larger than with the CMB method.

In the past, we have only been able to measure a few Cepheids at a time, but Gaia pinpointed 50 of them. Adam Riess at the Space Telescope Science Institute in Baltimore, Maryland, and his colleagues analysed Gaia's Cepheid data to see whether the Hubble constant discrepancy

would alter or vanish altogether.

"Not only is it confirmed, but it's actually reinforced," Riess says. Prior to this analysis, he says, there was a 1 in 1000 chance that the apparent discrepancy was just a fluke – now, that has fallen to only 1 in 7000.

If the discrepancy is real, it means that something is wrong with our models of the universe's evolution. And it's looking more and more real.

"Undetected particles could undermine our models, or maybe our guesses about dark energy are wrong"

Undetected particles out there could be undermining our models, or maybe our guesses about the nature of dark matter and dark energy are wrong, says Riess. "When we say the Hubble constant should be lower, that's with models using the most vanilla, least interesting versions of dark matter and dark energy," he says. "But maybe there's a wrinkle. Maybe it's much weirder."

Over 22 months, Gaia classified and measured the brightness of 500,000 standard candles –

Light from 87 million stars shines through dust in our galaxy's disc

variable stars that can be used to measure distances to other astrophysical objects. The satellite also mapped the positions of 14,099 objects within our own solar system – mostly asteroids – as well as half a million distant galaxies and 12 dwarf galaxies that orbit the Milky Way.

Closer to home, the Gaia data revealed a disturbance in our galaxy. The satellite galaxies that revolve around the Milky Way are gravitationally bound to it, so astronomers agree it is likely that some interacted with our galaxy in the past, perhaps smashing through its disc.

Thanks to Gaia, we now have evidence that another galaxy perturbed the Milky Way's disc relatively recently.

Teresa Antoja at the University of Barcelona in Spain and her colleagues analysed the motions of more than 6 million stars from the Gaia data set, and found patterns never seen before. Plots of these stars' velocities have swoops, arches and spirals, indicating patches of stars that are moving together (arxiv.org/abs/1804.10196).

If the Milky Way were in equilibrium and hadn't been recently perturbed, those patterns would not appear. Their presence indicates that something has shaken up the stars recently enough that their orbits have yet to relax back to a stable state.

The researchers found that the Milky Way was probably perturbed between 300 and 900 million years ago, which is also the last time an object called the Sagittarius dwarf galaxy is thought to have made a close pass.

"This is just the beginning for Gaia," says Riess. "Gaia should be delivering data that's five or six times more precise than this in a few years." And for now, analysis of the deluge of data we have just received is nowhere near complete. ■

NEWS & TECHNOLOGY

Hearing aid listens in to your thoughts

Frank Swain

PEOPLE who wear hearing aids can often struggle with the “cocktail party effect” – the inability of the brain to follow a single conversation in a room crowded with voices. Now a device that listens to your brain’s activity can help pinpoint exactly which voice you want to focus on.

Most hearing aids use microphones to identify which voices are coming from in front of the wearer, and then amplifies these. But conversations don’t just happen face to face.

So Florian Denk and his colleagues at the University of Oldenburg in Germany combined a hearing aid with a behind-the-ear device that can sense brainwaves. They were able to show the two could work together to amplify the sounds that a wearer was paying attention to, no matter which direction they were facing.

The brainwave-sensing is carried out by a flexible C-shaped EEG device that wraps behind the ear. It uses 10 small electrodes to pinpoint electrical activity in the brain. The device samples both the wearer’s brainwaves and the audio

signals in the room and can match the two together, indicating what the person is concentrating on.

The device is still just a proof of concept and would have to be much smaller to be useful. At the moment it uses a matchbox-sized amplifier to boost the brain signals, which are then decoded

“A portable device like this could let us study the brain during unpredictable events, such as seizures”

on a desktop computer. But many high-end hearing aids now come with Bluetooth connections that link them to a smartphone, and it is possible that the decoding could be offloaded here, or even to a remote server. “Cloud computing would have a delay of 200 milliseconds, which is unimportant for listener intent,” says Simon Carlile at Starkey Hearing Technologies.

Such a wearable EEG sensor might have further uses. For example, recording an EEG usually requires wearing a cap of electrodes pressed against the head, which can be painful over long periods. This limits



FLORIAN DENK ET AL / UNIVERSITY OF OLDENBURG

This prototype hearing aid can help people zero in on conversations

the amount of data recorded.

If an EEG device could be made small and comfortable enough to wear constantly, it could provide researchers with data about the brain and how it responds to the environment. It would also allow them to study the brain during unpredictable

events, such as seizures.

Other potential uses include a connected headset that allows your smartphone to wake you at the perfect point in your sleep cycle, ensuring you feel alert first thing. Or it could warn drivers if they are fatigued or distracted.

Not so fast, says Carlile. “This technology is not going to arrive in the near term – more like 10 years,” he says. ■

Quolls finally learn to avoid toxic toads

CONSERVATIONISTS have trained endangered quolls to avoid the toxic toads that kill them.

Northern quolls are marsupials from northern Australia. In the 2000s, poisonous cane toads hopped into their territory. The quolls, knowing no better, ate them and died in swathes. They were wiped out in much of their range and are now endangered.

To save the species, some were moved to the toad-free English Company Islands off Australia’s north coast. There, Jonathan Webb at the University of Technology Sydney and his colleagues have tried to prepare the quolls for a return to the mainland.

The team trained the quolls not to eat cane toads by feeding them non-poisonous toads containing a chemical that induced nausea.

The team then reintroduced 29 quolls – 22 trained to avoid cane toads and seven with no training – to Kakadu National Park on the mainland. They tracked them using radio collars.



JONATHAN WEBB

Quolls have some studying to do if they are to survive

Six of the seven untrained quolls were poisoned within days, compared with just four of the 22 trained quolls. At least three survived for 21 weeks (*Austral Ecology*, doi.org/gdbgmt).

However, dingoes ate the last untrained quoll and six of the trained ones. The English Company islands may have been too safe. “It could have been that the quolls lost some of the behaviours that helped them survive,” says Webb.

He suggests teaching dingoes to avoid quolls, using “Trojan” quolls carrying nasty chemicals in special collars. Joshua Rapp Learn ■

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NEWS & TECHNOLOGY



KALMAR COUNTY MUSEUM

Swedish fort's dark secrets revealed

Colin Barras

AN ANCIENT Swedish fort has held a grim secret for 1500 years: its walls bore witness to a massacre. What motivated the brutal attack is unclear, but it was probably linked to the chaos that swept northern Europe after the fall of the Western Roman Empire.

Sandby borg, on the island of Öland, was an impressive ring fort in the late 5th century. Its walls stood 5 metres tall and enclosed a 5000-square-metre area holding about 50 dwellings.

Excavations have revealed extreme violence and disorder. The remains of at least 26 people of all ages, including a baby and a young child, were found in the houses and streets. Many show signs of violent injury. Invaders seemingly slaughtered them and left them where they fell (*Antiquity*, doi.org/cn2x).

There may well be more, says Ludvig Pappmehl-Dufay at Kalmar County Museum, Sweden. "We've estimated that a fully inhabited

fort of this size would have housed some 150 to 250 people."

Pappmehl-Dufay's team also found valuables, including gold and silver artefacts. This suggests the attackers weren't plunderers, but their real motives are unclear.

It may be no coincidence that Sandby borg was hit decades after the Western Roman Empire fell. Scandinavia was always beyond Rome's direct influence, but didn't escape the shift in power

"The remains of 26 people, including a baby and a young child, were found in the houses and streets"

dynamics after the empire's collapse. Ring forts like Sandby borg may have become seats of local power, the team suggests, making them targets for others.

It would be apt if the empire's fall led to chaos in northern Europe. The rise of Rome centuries earlier also did so: mass violence became far more common in the region from about

The skeleton of a teenager found at Sandby borg in Sweden

200 BC, says Mette Løvschal at Aarhus University in Denmark. "One of the reasons we begin to see these scenes is because of the pressure from the expansion of Rome, which led to local conflicts."

In a recent study, Løvschal and Mads Kähler Holst at Moesgaard Museum in Højbjerg, Denmark, argued that northern Europe's mass conflicts took on a religious significance and may have helped maintain the social order (*Journal of Anthropological Archaeology*, doi.org/cnsw).

After battles or massacres, the dead and their weapons were treated in a way that may have intimidated locals, discouraging insurrection. At one site in France, it seems 65 decapitated men and their weapons were strapped to a large wooden structure that may have stood for a century.

But Sandby borg doesn't fit that pattern, says Løvschal. Livestock and other valuables were not sacrificed or ritually treated, but abandoned. This hints at a break with social convention, says Pappmehl-Dufay. Løvschal says it may be evidence that northern Europe's elites lost influence after the Western Roman Empire fell. ■

Weird quantum link seen across clouds of atoms

QUANTUM entanglement between spatially separated clouds of ultracold atoms has been shown for the first time. Three independent experiments achieved the feat, with the total number of entangled atoms ranging from about 590 to 11,000.

In its simplest form, entanglement intrinsically connects the behaviour of one particle with another, typically massless photons. The new studies "really have entanglement between clouds of massive rubidium atoms, and quite a lot of them", says Martin Gärtner at the University of Heidelberg, Germany, a member of one of the three teams. This opens the door to exploring whether quantum effects disappear past some upper mass limit.

The teams induced entanglement in a Bose-Einstein condensate (BEC), a cloud of atoms confined using lasers and cooled to near absolute zero.

In earlier work, the entanglement was always within the same cloud, and was considered a global property of the condensate. "Can we also get entanglement between two different spatially localised parts of the BEC?" says Gärtner. "This was not entirely clear."

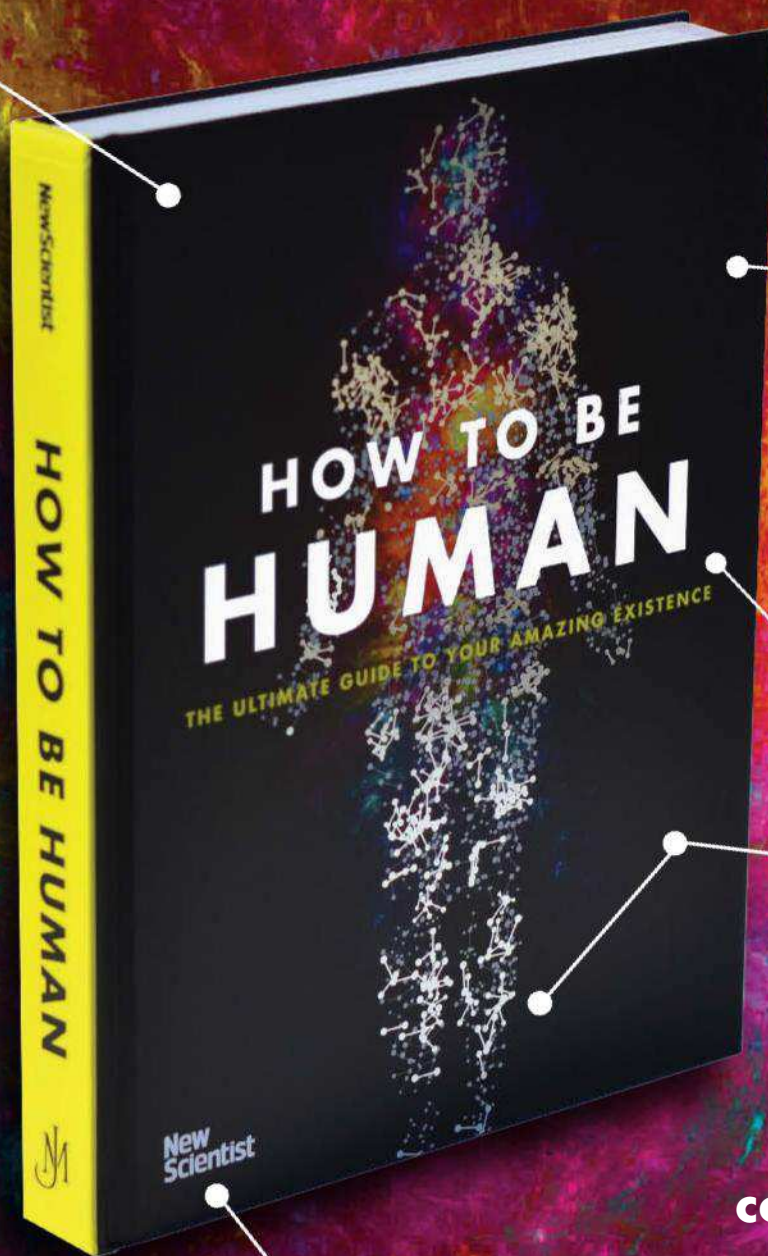
The three experiments probing this question are conceptually similar but differ in detail. They start with a BEC of rubidium atoms, then induce interactions between the atoms to entangle their spin states, for example. Then the laser trap confining the atoms is relaxed, so that the cloud expands and forms sub-clouds.

The teams manipulated the atoms with, say, radio-frequency waves, so that they could observe certain spin states in a sub-cloud. When they looked at one cloud, they found that the spin states in the other were fixed in precisely the same way (*Science*, doi.org/cnzt, doi.org/cnzw, doi.org/cnzw). That is, they were still entangled and measuring one affected the other.

Anil Ananthaswamy ■

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NEWS & TECHNOLOGY

Horses remember the face you made

Sam Wong

WHY the long face? Horses can remember the expressions they see on human faces, and respond differently if you smiled or frowned when they last saw you.

Leanne Proops, now at the University of Portsmouth, UK, and her colleagues at the University of Sussex showed in a 2016 study that horses' response to photographs of happy or angry human faces differed. Now they have looked at whether horses can form lasting memories of people based on their facial expressions.

First, they showed horses a photo of one of two human volunteers, displaying either a happy or an angry face. Several hours later, the human visited each horse in person, this time with a neutral expression. As a control, some horses were visited by a different person to the one they saw in the photograph.

Crucially, the volunteers didn't know which photo the horse had

seen earlier. This was to prevent any involuntary cues influencing the horses, a problem first exposed in the early 20th century, when a horse called Clever Hans amazed audiences by seemingly answering simple mathematical

problems by tapping his hoof. It turned out he was responding to involuntary cues from his trainer.

Horses prefer to look at negative and threatening sights with their left eye, and positive social stimuli with their right eye. When the horses in the study saw someone they had seen frowning in the photograph, they spent more time looking with their left

One of these animals has a very expressive face, the other is human



PAL TERAVAGIMOV PHOTOGRAPHY/GETTY

eye. They also exhibited more stress-related behaviours, like scratching and floor sniffing. In contrast, when they saw someone they had seen smiling earlier, they spent more time looking with their right eye. In other words, the team found that the horses remembered the models' previous facial expressions (*Current Biology*, doi.org/cn2w).

Many other animals have shown an ability to remember human faces, including sheep and fish. Wild crows will hold a grudge for years against people who have treated them badly, and even teach other, unaffected crows to mob them.

However, only horses have been seen forming an opinion about people based on their expression in a photograph. "That's something we haven't really seen in animals before," says Proops.

"The horse family has the most expressive faces after primates, so logically they pay attention to faces and expressions," says Frans de Waal at Emory University in Atlanta. "Horses surrounded by people have ample opportunity to learn what our expressions mean." He says the finding is "yet another study that shows emotional intelligence in other species". ■

'G-spotplasty' aims to increase sexual pleasure

THREE women have received surgery intended to improve G-spot sensitivity. The procedure tightens tissue in the vaginal wall around the so-called G spot, an area reputed to produce intense orgasms when stimulated, although experts still argue over whether it really exists.

The surgery - dubbed a G-spotplasty - was performed on women who said they had lost the ability to orgasm through vaginal stimulation alone following childbirth. It was carried out by Adam Ostrzenski, a gynaecological surgeon in

Florida, who in 2012 claimed to have identified the G spot as a well-defined sac within the front vaginal wall of a cadaver of a woman, a few centimetres from the opening of the vagina.

For each woman, Ostrzenski removed a small piece of vaginal wall from the supposed location of the G spot. He then stitched the wall back together again, causing it to tighten. The procedures were carried out in 2013, using a local anaesthetic and a sedative, and the women's experiences were then recorded.

All three women went on to say that they had regained the ability to reach vaginal orgasm - without stimulation of the clitoris - and now had intercourse more frequently (*Aesthetic Plastic Surgery*, doi.org/

cn2z). However, there was no placebo in the study, and it is unclear if these women would have seen the same improvements without surgery.

There is still considerable debate concerning the G spot, says Devan Stahl at Michigan State University. "There are researchers who think it absolutely does not exist, others who think that it may exist but not every woman has it, and still others who think that it is not a single 'spot' or anatomical structure, but rather a complex of varied anatomical structures." Since Ostrzenski's study in 2012, several other studies have

failed to produce conclusive evidence.

The procedure isn't the only G-spot amplification therapy available. Others include a collagen injection into the vagina, intended to improve sensation in the area. "G-spot therapies have become a multimillion-dollar business, promising to increase sexual pleasure for women, with virtually no evidence that these therapies work outside of a placebo effect," says Stahl.

She says that for women who are sexually frustrated, the G-spotplasty reinforces the message that they have a problem. "What is actually statistically normal - difficulty achieving orgasms through penetrative vaginal intercourse - is now considered pathological," she says. Helen Thomson ■

"G-spot therapies have become a multimillion-dollar business but may just be a placebo effect"



OMAR DAKHANE/GETTY

The sun's rays are all wrong

Leah Crane

THERE is something amiss in the sunshine. A nine-year survey of the sun's gamma rays turned up two surprises: an unexpected dip in lower-energy forms of this electromagnetic radiation, and far more of the higher-energy forms than theory predicts. And we're not sure what is going on.

"The higher the energy of the gamma ray, the harder it is to make it," says John Beacom at Ohio State University in Columbus. "But the process of converting cosmic rays into gamma rays seems to be more efficient at higher energies, not less. It makes no sense."

Some gamma rays are constantly made in the sun as high-energy protons from cosmic rays hit gas particles in the solar atmosphere. The sun's magnetic field draws the protons in, and some of the gamma rays are flung towards Earth where we can detect them. Beacom and his team examined data from 2008 to 2017

collected by the Fermi Gamma-ray Space Telescope.

Overall, they saw gamma rays with energies of about 1 to 200 gigaelectronvolts (GeV). But there was a dip between 32 and 56 GeV, with only about half as many gamma rays in that range than the average over all energies (arxiv.org/abs/1804.06846).

"It seems inexplicable, random and strange," says team member

"Converting cosmic rays to gamma rays seems to be more efficient at higher energy. It makes no sense"

Kenny Ng at the Weizmann Institute of Science in Israel.

"In terms of energy scale, there is nothing special about 30 to 50 GeV."

If the dip were at the end of the spectrum, it would be less odd: lots of astronomical phenomena have maximum energies above which they drop off. But it is followed by even more gamma rays at higher energies than at lower ones.

The researchers came up with several potential explanations, but none seem quite right, they say. The sun's magnetic field may be collecting cosmic rays from every direction and only re-emitting gamma rays in the direction the sun rotates. But no other observations indicate that the solar magnetic field has the sort of geometry that would lead to a spike in higher-energy gamma rays.

As for the lower-energy form, the authors say that gas in the sun may absorb some, but they admit that the gamma rays would interact with the gas so rarely that this is unlikely.

Or it might be a problem with the telescope itself. The detector is shielded from charged particles to avoid contaminating the data, but neutrons that the sun also emits – which are chargeless just like gamma rays – could sneak in and mess with the analysis.

Segev BenZvi at the University of Rochester in New York says others are now using experiments in an effort to see if these strange features persist. "The study of this gamma-ray excess will lead us to new understandings of the structures of the magnetic field of the sun, and I have no idea what those are going to be," he says. ■

How some bacteria snack on antibiotics

SOME types of bacteria don't just resist antibiotics, they eat them too - and now we have worked out their trick.

Gautam Dantas at Washington University in St Louis, Missouri, and his colleagues discovered this by accident 10 years ago. They were growing soil bacteria in the presence of penicillin, expecting that it would stop them from growing.

"But we saw exceptional growth on antibiotics," says Dantas. His team found that some strains were around 50 times above the threshold at which bacteria are normally classed as antibiotic-resistant, and that they were feeding on the penicillin.

Now, Dantas and his colleagues have figured out how these bacteria do it, by focusing on the genes that became active in four strains. Deleting these genes and observing the effects revealed that the bacteria are able to thrive on penicillin using a cocktail of enzymes: proteins that catalyse chemical reactions.

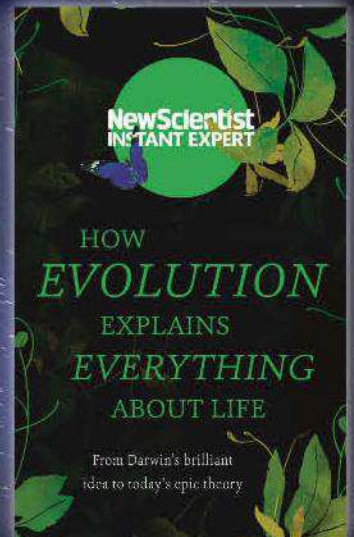
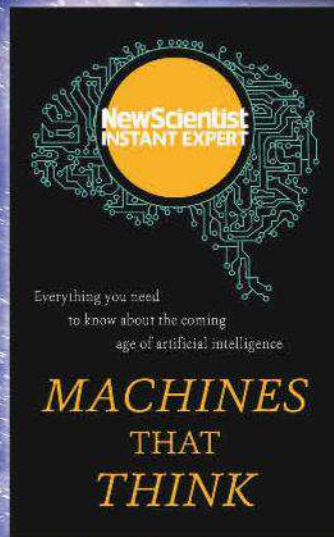
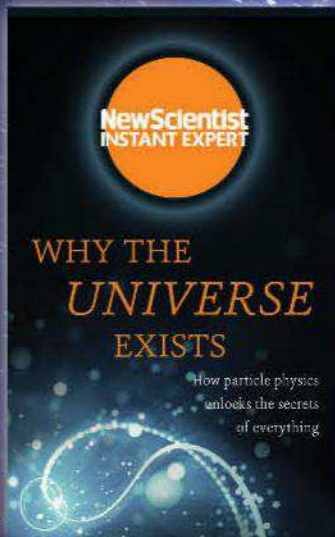
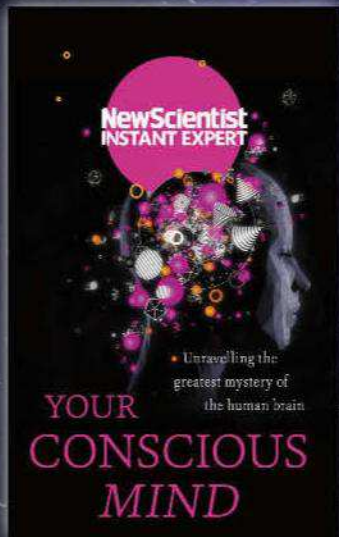
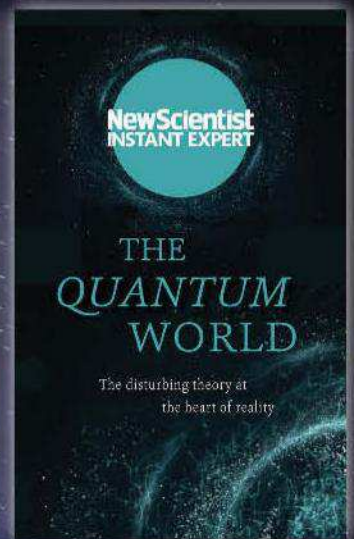
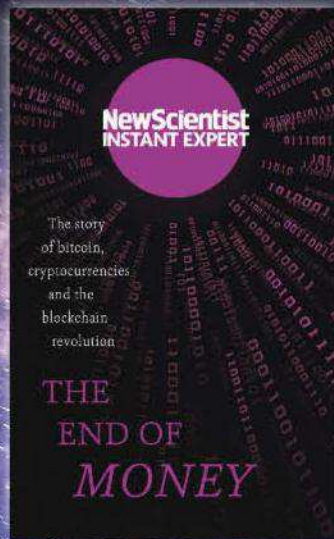
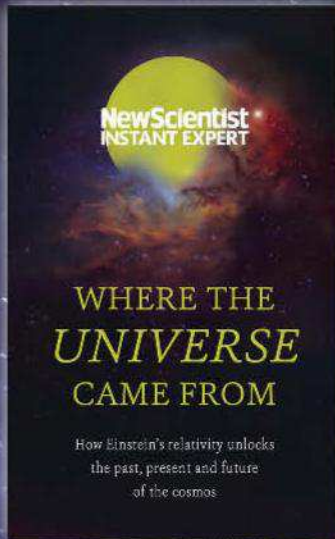
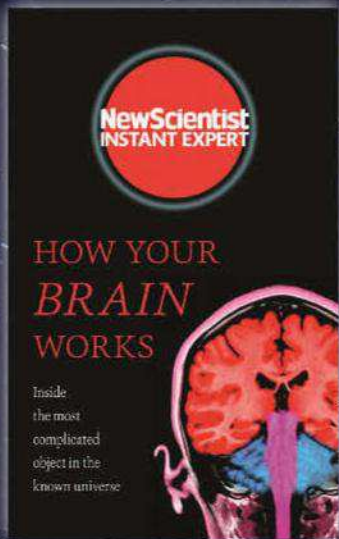
First, the bacteria use an enzyme to resist the antibiotic, so it doesn't stop them growing. Then they use a couple of enzymes to start breaking the penicillin apart, before deploying 10 or more enzymes that enable them to use the carbon in the degraded antibiotic as a food source. Giving genes for these enzymes to harmless *E. coli* bacteria enabled them to eat antibiotics the same way (*Nature Chemical Biology*, doi.org/cn23).

Antibiotics have been around for millions of years, so it is unsurprising that bacteria have evolved to use them as a food source, says Matthew Avison at the University of Bristol, UK.

Dantas hopes the findings will enable the creation of antibiotics that can't be broken down this way. The team's modified *E. coli* may also be useful as it could help deal with the antibiotics in sewage that later find their way into our tap water, says Jonathan Cox at Aston University, UK. Jessica Hamzelou ■

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IN BRIEF

TOMASZ SKOCZEN/GETTY



Dragonfly wings inspire light-as-air materials

AEROGELS are some of the lightest materials in the world, and they make excellent insulation for homes, or heat shielding for spacecraft. But they are extremely difficult to make. Now, researchers have developed a new method that mimics how baby dragonflies ready their jelly-like wings for flight.

When an entomologist called in at Lidija Šiller's lab in Newcastle University, UK, to use her electron microscope, she thought they would just be looking at dragonfly wings to identify their species. But when she had a peek, she was taken aback. The wings were full of tiny

pores, just like the aerogels her team studies.

When dragonflies shed their larval skin, it reveals soft wings. The insects then produce sodium bicarbonate in their hindgut and rectum. When they excrete it, this chemical reacts with the water in their wings to create carbon dioxide, creating pores and drying them out.

To mimic this process, Šiller's team started with a jelly-like cube, a matrix of silica molecules full of water pockets. Then they added sodium bicarbonate, which interacts with the water and another chemical solvent to create carbon dioxide. That gas props up the pores so they don't collapse (*Advanced Materials*, doi.org/cnxm). The material is then rinsed and left to dry for a day.

It costs about \$4 to produce a kilogram of aerogel this way, which Šiller says is cheaper than other methods.

Blood-bacteria hybrid carries drugs

A CURIOUS hybrid of a red blood cell and an *E. coli* bacterium could carry drugs inside the body.

Drugs can have side effects when they cause changes in parts of the body they are not intended to treat, so researchers hunt for clever ways to package drugs and target them more precisely.

Cells of *E. coli* bacteria are strong swimmers, with a spinning tail that acts like a propeller.

However, these cells are small and have little room for cargo. Red blood cells, meanwhile, are big and spacious, but can't propel themselves.

Metin Sitti and colleagues at the Max Planck Institute for Intelligent Systems in Stuttgart, Germany, decided to combine the two. They loaded mouse red blood cells with a cancer drug and magnetic nanoparticles, then

chemically stuck them onto *E. coli* bacteria that had been engineered not to cause disease.

The hybrid swimmers achieved speeds of around 10 micrometres per second and were easily steered using magnetic fields. When the cells reached their target, the team used a flash of infrared radiation to rupture them, releasing their drug cargo (*Science Robotics*, doi.org/cnzd). The team plans to test its swimmers in rodents next.

Drilling set off a major earthquake

SOUTH KOREA'S most damaging earthquake in a century may have been caused by humans. Two teams argue the quake was the result of pumping water underground.

Several dozen people were hurt in Pohang by the magnitude-5.5 quake in November last year. Now it seems the quake was no more than 2 kilometres from where water was pumped underground to extract geothermal energy, implying this caused it (*Science*, doi.org/cnzn, doi.org/cnzp).

Since 2014, seismologists have used a formula to estimate the maximum earthquake size such action could cause. It is applied to geothermal energy schemes and to fracking to extract oil and gas. But it missed the risk to Pohang.

It seems the formula may be flawed, says team member Rob Westaway at the University of Glasgow, UK. "That's potentially alarming," he says.

Stoner app tracks how high you are

ARE you stoned? An app that tests memory, attention and reaction times – traits often impaired by cannabis use – aims to answer that question.

The app, called Am I Stoned, was tested on 24 cannabis users who took either a placebo or tetrahydrocannabinol, the ingredient in cannabis that intoxicates users. The volunteers completed a range of smartphone and computer tests designed to detect signs of impairment in behaviour and motor skills.

Cannabis is now legal in a small but growing number of countries and US states, and the team at the University of Chicago thinks its app will contribute to our understanding of how cannabis can alter people's mental state.

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Dogs can give owners a UTI

YOUR pooch is a possible source of urinary tract infections.

UTIs occur when bacteria infect the bladder, urethra or kidneys. Most of the time, they are caused by bacteria from a person's own faeces, usually *E. coli*.

Peter Damborg and colleagues at the University of Copenhagen, Denmark, investigated whether pets could also be a source of UTIs. They screened 119 people who were treated for UTIs at Hvidovre Hospital, Copenhagen. Of those patients, 19 lived with pets.

The team asked the pet owners to sample their pet's faeces with a cotton swab. Genetic analysis of these revealed that two dogs had *E. coli* bacteria that matched those that caused their owner's infections.

To find out if the owners had caught the bacteria from their dogs, or if the dogs might have caught them from their humans, the team asked the owners to send human and dog faecal samples 10 months later.

One person didn't have any sign of their UTI-causing strain, but their dog did (*bioRxiv*, doi.org/cnzk). This suggests their dog persistently carries this strain, and was probably the source of its owner's infection.

It is not clear yet how bacteria from dogs may cause UTIs, says Damborg. However, he suggests people should avoid being licked.



Disney's smart walls make rooms interactive

NO MORE fumbling for light switches in the dark. A team at the Disney Research lab in Pittsburgh, Pennsylvania, and Carnegie Mellon University has developed a way to convert walls into surfaces that can sense taps and swiped gestures. Wall++ can even detect what devices are being used in a room.

First, a conducting paint layer is applied to the wall in a grid. It costs just \$20 per square metre – roughly the same as low-cost wallpaper. This sensor array is then covered with standard paint.

Wall++ removes the need for light switches, volume controls and thermostats, says Chris Harrison from Carnegie Mellon University. Instead, you would simply swipe in predefined areas. And if a movie or video game is projected onto the wall, it could be controlled via touch buttons assigned to parts of the makeshift screen.

The smart walls can also act like antennas, picking up electromagnetic signals emitted by nearby gadgets and appliances. This lets the walls identify and

locate devices in a room, such as hairdryers or food blenders. The team suggests this information could be fed to a home assistant like Amazon Alexa, letting it know what else you were interacting with. This would give the home assistant more context to understand what you said to it.

"This low-cost sensing approach opens up exciting new design possibilities," says Aaron Quigley at the University of St Andrews in the UK. "The fabric of the environment has the sensing in place."

44 genes linked with depression

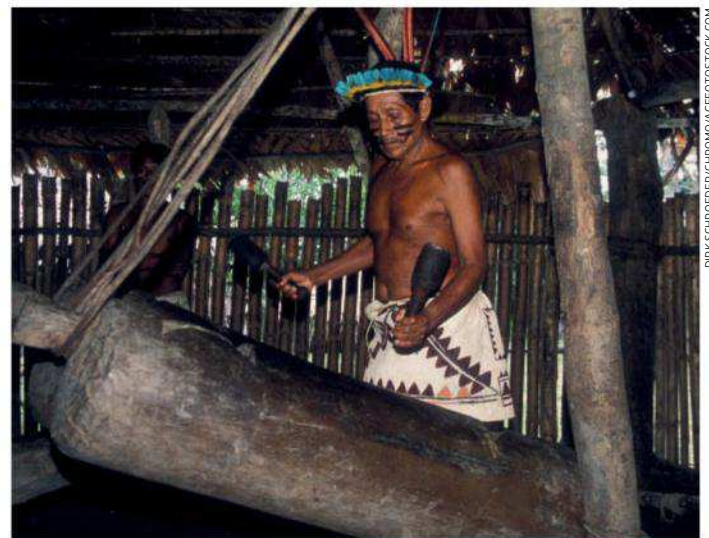
AN ANALYSIS of more than 135,000 people with depression has pinpointed 44 genetic variants that are linked to the condition, 30 of which have never been identified before.

Depression affects around 14 per cent of people worldwide. To better understand how genes may play a role, the Psychiatric Genomics Consortium – a team involving more than 200 researchers – compared data from people with depression with nearly 345,000 people who don't have the condition.

Of the 44 variants the consortium identified, some are also linked to psychiatric conditions like schizophrenia (*Nature Genetics*, doi.org/cnzh).

"The new genetic variants discovered have the potential to revitalise depression treatment by opening up avenues for the discovery of new and improved therapies," says Gerome Breen at King's College London, who worked on the analysis.

However, it is unclear exactly how all these genes affect or cause depression. Because there are so many of them, it is unlikely that a single treatment can be developed that will be able to target them all.



The secret language of drumming

AN INDIGENOUS Amazon tribe swaps messages over 20 kilometres, simply by beating out rhythms on drums. The drumming mimics the entirety of their spoken language.

The Bora people live in Peru and Colombia. They use pairs of drums called *manguaré*, each of which can make two notes, giving four in total.

Julien Meyer at the University of Grenoble Alpes in France and his colleagues studied 169 messages by five expert drummers.

They found that different pitches only play a minor role in translating Bora language into "drum". Instead,

the key element is the rhythm of the drumming, which closely matches that of spoken Bora language (*Royal Society Open Science*, doi.org/cnzj).

"In *manguaré* messages, the number of beats equals the number of syllables," says Meyer. The lengths of the pauses between beats were related to spaces in spoken words.

Most messages are split into four: an introduction, the sender's ID, the main message and a sign-off. "Set pieces" can also be used to announce events like drinking contests. And playing both drums together acts as a "ringtone" to precede a message.

Advertising feature

Investing in zero emissions

It's time to accelerate the transition to pollution-free roads, says Simon Pickett of Octopus Group

THE figures speak for themselves. Every year, 40,000 people in the UK have their lives cut short by air pollution, according to the Royal College of Physicians and the Royal College of Paediatrics and Child Health, both based in London.

A significant amount of that pollution comes from cars, buses and lorries: even the cleanest engines contribute to the build-up of dangerous nitrogen oxides and the fog of tiny particles that cause lung damage. It's small wonder that the capital – where some pollutants are at twice the safe concentration recommended by the World Health Organization – is imposing new restrictions on transport.

As well as the long-established congestion charge, there is now a T-charge operating in London. This requires older, more polluting

“We could end up with 20 million private batteries on people’s driveways”

vehicles to pay £10 per day to enter the city centre. Soon this will be supplemented by a charge to enter an area known as the Ultra Low Emission Zone (ULEZ), applicable to all vehicles except those that meet stringent emissions standards.

Such measures – and similar ones around the world – are not just altering the habits of individual drivers. They are also changing the economics of the entire transport industry. “Transport is at an inflection point,” says Simon Pickett of Octopus.

A major part of the anticipated change lies in the introduction of zero-emission vehicles that could help significantly reduce carbon emissions and air pollution. But implementation is not straightforward. “There are two big obstacles: capital and infrastructure complexity,” Pickett says.

A zero-emission-capable taxi is likely to cost around £60,000, hardly a casual outlay for an individual or even a small company.



octopus

A brighter way

An electric bus can cost two or three times as much as a diesel bus.

However, there is reason for optimism here. According to a study released by Bloomberg New Energy Finance (BNEF) earlier this year, the high upfront cost of an electric bus is offset by lower fuel and maintenance costs. BNEF projects even better savings by 2026, when lower battery prices could make the upfront cost of an

"Air pollution has to go. And whether you care about the planet or your wallet, this makes sense"

Simon Pickett, Octopus

electric bus comparable with that of an equivalent diesel version.

With vans, the story is even more compelling. "By year five you're cost neutral," Pickett says. "And as soon as you start factoring in congestion charges and the Ultra Low Emission Zone, you're talking about material savings versus older combustion technology."

Then there's the issue of infrastructure complexity. Traditional combustion engines benefit from an established, cost-conscious fuelling and maintenance network and from decades of experience. Introducing electric vehicles requires analysis, investment in vehicle charging equipment and upgrades to grid infrastructure. So a bus operator looking to replace half its fleet with electric vehicles has a lot to consider. "Businesses and traditional financiers are used to spending their capital on vehicles, but it's a big ask when it includes extra complexity and costs for non-vehicle assets," Pickett says.

Octopus has a solution for this problem – recasting it as an investment opportunity that delivers electric-powered transport as a full service. The company offers capital for upfront investment in vehicles, together with the charging equipment and any reinforcement required to the grid infrastructure. "The result is a total package, a real turnkey solution," Pickett says. "We're working with operators to finance all the pieces of the puzzle, and we'll wrap that up and charge it to the operator as a pay-as-you-use service that helps businesses optimise operational cash flow."

Hidden benefits

There's a hidden added benefit too, as Pickett explains. "Electric-powered vehicles could become smart resources for the national energy grid – a grid that is moving rapidly in the direction of the 'three Ds' – decarbonised, decentralised, and digitalised." One of the issues with our shift towards this smart clean future is variability: the output from solar and wind farms varies, given the fact that the sun isn't always shining and the wind isn't always blowing where they are. And as Pickett says, "Flexibility will be important in the future energy market, because it allows you to control energy consumption and build a more efficient, clean energy system."

Smart technology can ensure that vehicles are charged at times when renewables are providing cheap, plentiful electricity. And

cutting-edge vehicle-to-grid technology means that fleet owners could be paid to feed some of that stored power back into the grid when shortfalls in solar and wind energy coincide with the vehicles not being in use. Right now, there are thousands of vehicles that aren't always active but could help with energy redistribution. "Flexibility across whole fleets of vehicles is the key to making clean power generation viable," says Pickett.

Commercial vehicle fleets could include those of supermarkets offering home deliveries, logistics firms such as DHL or FedEx, and infrastructure companies such as telecoms and utilities providers. But the

"Octopus has a solution to this problem: recast it as an investment opportunity"

electric vehicle vision is much bigger, as Pickett points out. "One day, every domestically owned vehicle will be part of the solution too. We could end up with 20 million private batteries in people's driveways, providing stability to the grid – and that's hugely exciting."

This won't be an overnight revolution. The government has shown strong leadership, Pickett says, creating taxed emissions zones and legislative pressure to reduce pollution, forcing manufacturers to phase out production of diesel and petrol engines.

Challenges aside, everything is in place for a new era in transport to start right now. Pickett believes that once the big players are signed up, the transition to clean vehicles will only accelerate. When people start seeing buses, delivery vehicles and black cabs going fully electric, that sends a message, Pickett says. "It will have a strong effect on all the other vehicle-buyers, including the private market."

Pickett is excited about the inevitability of this clean-air future. "It's a huge step forward that we can now make the economics work."

Will transport in London be fully electric in 10 years? "I would hope so," Pickett says. "Air pollution has to go. Whether you care about the planet or your wallet, this makes sense." He compares it to the ban on smoking on aeroplanes. "We are 64 times more likely to die of a pollution-related illness in London than in Sweden. One day, we'll wonder how we ever tolerated this."

Find out more at: www.octopusgroup.com

Forget food, it's in your car

Plans to ditch palm oil are missing the real issue, says **Michael Le Page**



BAY ISKOCU/AP/GETTY IMAGES

PALM oil has become a byword for environmental destruction. Found in food and cosmetics, its growing use is destroying rainforests and endangering species like orangutans. In an effort to turn things around, UK supermarket Iceland pledged last month to halt the use of palm oil in its own-brand products. But the real problem isn't in your kitchen cupboard or bathroom cabinet – it is in your car.

Half of all the palm oil imported by Europe is turned into biodiesel and blended into conventional fuel to power cars and trucks. This misguided attempt to “green” fuels is actually tripling carbon emissions, not reducing them. What's more, the practice is subsidised by the European Union. In other words, taxpayers

are paying to destroy rainforests and accelerate climate change.

“People don't know that they have palm oil in their fuel tanks,” says Laura Buffet of Transport & Environment in Brussels, Belgium, which campaigns for cleaner transport in Europe.

And yet, while palm oil has acquired a reputation as a villain,

THE COLOSSAL CARBON CON

If using palm oil as fuel massively increases carbon emissions (see main story), why are we doing it?

It's all part of a much bigger issue with bioenergy. Essentially, loopholes in international carbon accounting rules mean the full emissions from biomass never get counted. “You could cut down the Amazon, ship the trees to Europe to replace coal and that

the plant itself, called oil palm, is something of a hero. It is up to nine times as productive per hectare as other sources of vegetable oils such as rapeseed (canola) and soybeans, meaning it requires less land (see graph, bottom right).

Palm oil is also very versatile. It can be turned into liquid oils or solid butter-like blocks used

Growing oil palm has a huge impact on the Indonesian landscape

in everything from ice cream and biscuits to soap and shampoo. As such, it is found in around half of all supermarket products.

The problem is that we are cutting down some of the most species-rich rainforests in the world to plant ever more oil palms. Growing demand is driving massive deforestation in Malaysia and Indonesia, which produce 90 per cent of palm oil.

To halt this destruction, demand must be curbed. The obvious solution is to ditch palm oil from foods, but this approach is likely to fail.

Unless we stop making a huge variety of products, we will always need vegetable oils. Using

"sustainable" palm oil, as most UK supermarkets have pledged to do, won't stop demand rising (see "Buying 'sustainable' palm oil won't halt deforestation", page 24). Ditch palm oil, and food producers will just use more of other oils instead, which have higher land requirements (see graph, bottom right). For instance, it could lead to further expansion of soya farming in Brazil and drive more deforestation there.

"Any single-ingredient solution risks transferring the problem

"While palm oil has acquired a reputation as a villain, the plant itself is actually something of a hero"

from one supply chain to the other," says Giovanni Colombo, a spokesperson for the Roundtable on Sustainable Palm Oil, an industry body. While some independent researchers agree, others say risks are exaggerated.

"Palm oil has a worse greenhouse-gas footprint than any other vegetable oil and causes habitat loss of endangered species," says Stephanie Searle of the International Council on Clean Transportation in Washington DC. "It's better to expand 5 hectares of rapeseed production onto abandoned cropland in Europe than to destroy 1 hectare of peat swamp forest in Indonesia."

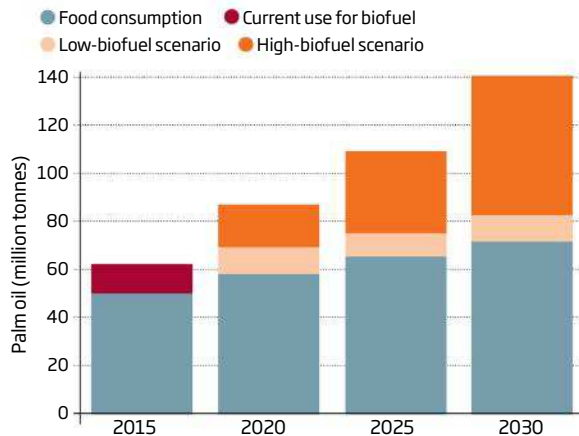
But even if we do reduce palm oil's use in food, it won't be enough. The hidden and growing use of palm oil for biofuel is a much bigger issue. Of the 7 million tonnes of palm oil imported by Europe each year, nearly half is turned into biodiesel. "All the growth has been in energy demand," says Marc-Olivier Herman of Oxfam.

Globally, palm oil production hit 65 million tonnes in 2017, nearly 20 per cent of which was used for biofuel, says Sathia Varqa of data firm Palm Oil Analytics.

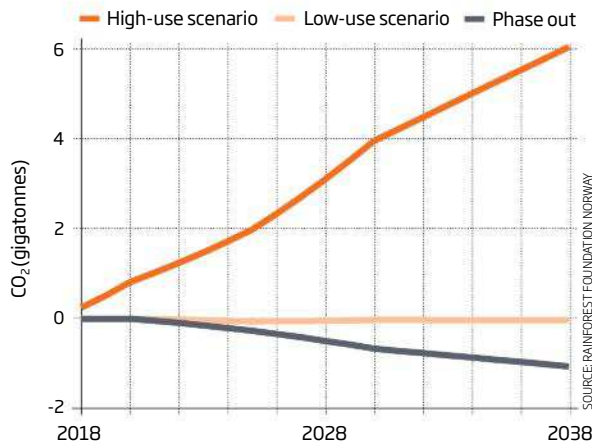
Demand for palm oil could shoot up to 140 million tonnes in

Driving higher

Demand for palm-oil biofuel is set to rise. In a high-use scenario, many countries turn to cheap palm oil to meet current climate targets. In a low-use scenario, the European Union removes support for palm-oil fuel

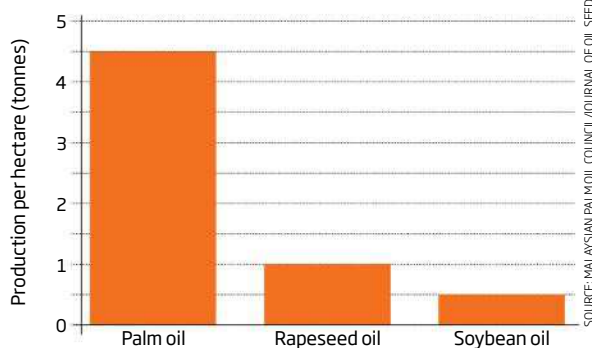


If palm oil use in biofuels continues to rise, we will release billions more tonnes of carbon dioxide into the atmosphere. However, if we phase out its use emissions would fall



Wonder crop

Palm-oil production is a much more efficient use of land than that relating to other vegetable oils



2030, with nearly 50 per cent of that being turned into biofuel, according to a report on palm oil for the Rainforest Foundation Norway published in December 2017 (see graph, top left). "There's an enormous risk," says the author, Chris Malins.

Indonesia, for instance, has adopted targets for aviation use that are essentially plans for palm oil jet fuel, says Malins. "Aviation could be an even bigger driver of deforestation than biofuels used for road transport."

Cutting down rainforests to fuel our cars and planes doesn't seem very green. And yet the growth in palm-oil biofuel is actually being driven by government policies and subsidies intended to reduce carbon emissions.

Under European rules, for instance, 10 per cent of transport energy is supposed to come from renewable sources by 2020. To meet this target, countries are blending biofuels like palm-oil biodiesel with conventional fuels.

Fuelling destruction

Yet in the vast majority of cases, the use of biofuels actually increases overall emissions because their carbon cost is not properly accounted for (see "The colossal carbon con", left). "It's a crazy thing to do," says Searle.

In the rogue gallery of biofuels, palm-oil biodiesel is the worst. Transport & Environment calculates that using palm-oil biodiesel triples emissions versus burning fossil fuels, based on figures compiled for the EU.

This shocking figure isn't only from burning the fuel, but also from the burning of rainforests to grow oil palm, which releases lots of carbon. What's more, there are vast stores of peat under many rainforests, which when drained decompose and can release carbon for decades.

All this might make it sound as if the answer is just to ban the use of palm oil for biofuels. Indeed, the European parliament, which ➤

INSIGHT PALM OIL



DADANG TRI/BELOOMBERG VIA GETTY IMAGES

passes EU laws, thinks so. In January, it voted to end subsidies for palm-oil biodiesel from 2020. The vote has no force, though: the final decision depends on further EU wrangling. "It is not clear what is going to happen," says Buffet.

However, if the EU ends subsidies for palm-oil biodiesel, but keeps its overall biofuel targets, cars will be fuelled with soybean or rapeseed oil instead. This would push up their prices and make food producers switch to palm oil instead.

That's because the markets are all interlinked: any increase in demand for vegetable oil – whether for food, cosmetics or biofuel – contributes to the palm-oil problem. "If you use rapeseed oil, you are basically using palm oil," says Tim Searchinger of Princeton University.

This has happened in the US, which stipulates that conventional fuels must be blended with biofuel, but hasn't approved the use of palm oil because its carbon emissions are

the highest of any other vegetable oil. As more soybean was turned into biodiesel, Searle says, the US started importing large quantities of palm oil for use in food.

All this means that if nations stopped subsidising food-based biofuels, there would be a huge drop in demand for palm oil, which would help halt

"The growth in palm oil is being driven by policies and subsidies intended to reduce carbon emissions"

deforestation and loss of biodiversity. Carbon emissions and food prices would fall, and poor people would benefit – Oxfam campaigns against food-based biofuels because they make food costly. "It's just inherently nuts," says Searchinger. "We just have to stop."

Unfortunately, despite numerous calls for change, things are still moving in the wrong direction – not least because of lobbying from the biofuels

Oil palm nuts are a highly productive source of vegetable oil

industry. The EU has capped support for food-based biofuels, but looks set to keep subsidising them until 2030. Many other countries are introducing or ramping up biofuels targets.

But it's not all doom and gloom. There is a much better way to green road transport: electric cars. These are already cheaper to run than cars powered by fossil fuel, produce hardly any air pollution and can be powered by solar or wind energy.

After all, bioenergy is just an inefficient form of solar energy. Plants capture only a fraction of a per cent of solar energy compared with 16 per cent for current solar panels. "Photosynthesis sucks," says Searchinger.

The challenge now is to persuade governments to change tack. Ending subsidies for all food-based biofuels would be a win for forests, climate action, taxpayers – and orangutans. ■

BUYING 'SUSTAINABLE' PALM OIL WON'T HALT DEFORESTATION

With palm oil becoming a dirty word, many food producers are hoping to hold on to their green credentials by only using "sustainable" supplies. But buying palm oil from producers certified as sustainable doesn't solve the key problem of rising global demand, which is leading to the clearance of rainforests to make space for more plantations.

Certification can help protect workers' rights and reduce local pollution, but does little to slow down deforestation, says Chris Malins, author of a report on palm oil for the Rainforest Foundation Norway.

As you would expect, certification bodies say otherwise. "Although our certification is not perfect, it does make a difference," says Giovanni Colombo, a spokesperson for the biggest certifier, the Roundtable on Sustainable Palm Oil. "[It has] helped to slow down deforestation."

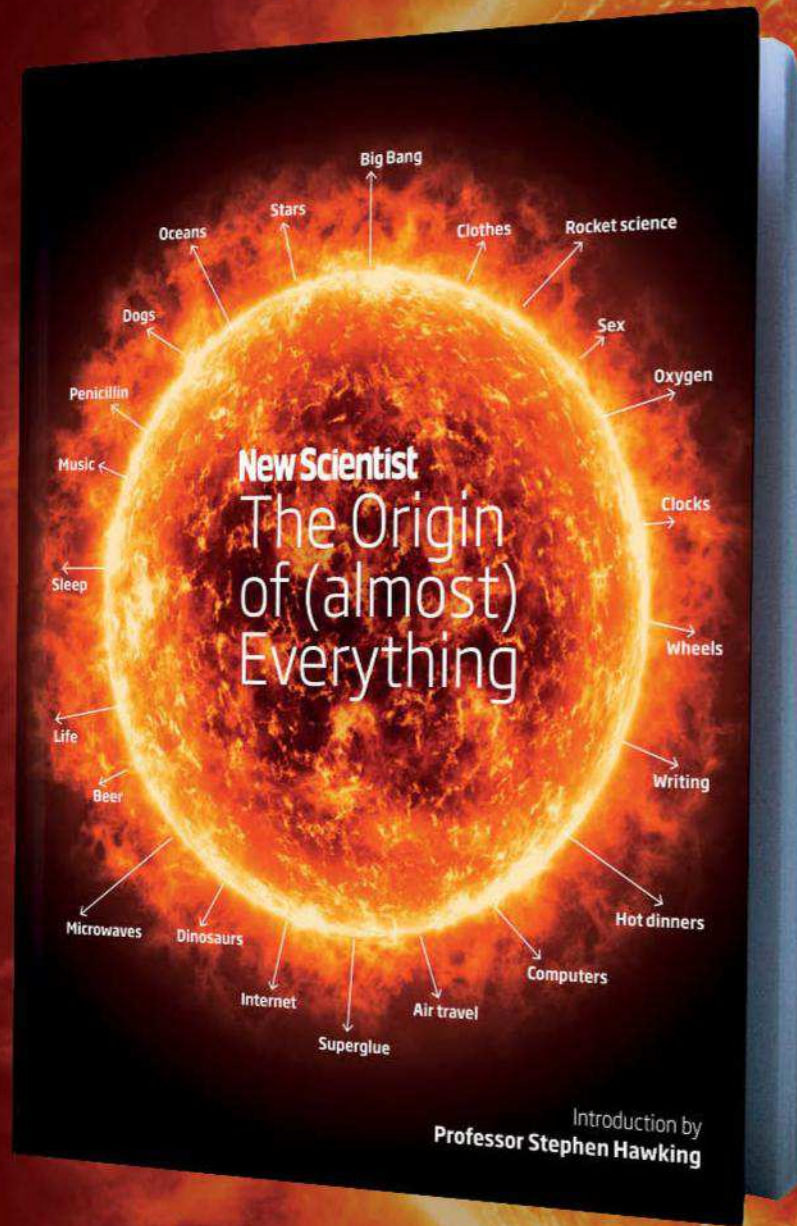
But only around 20 per cent of palm oil produced globally is certified by the RSPO. A study published in December 2017 found that more than 99 per cent of the remaining forest in Indonesia is outside areas controlled by certified growers (*PNAS*, doi.org/gcs45n).

The study also looked at the age of certified plantations, and found that the average date of planting was 1993. That means the growers opting for certification are the ones that have been operating for a long time, and so have already cut down all the forest they intend to, says Malins. This suggests the owners of newer plantations generally aren't signing up to the scheme.

If nearly all growers were certified and the rules were enforced by strict monitoring, it would have greater success in reducing deforestation. "But that's an awfully long way off," says Malins.

Even the RSPO acknowledges there is more work to be done. "Too many palm-oil producers still fall outside the scope of the RSPO certification, and this is one of the main reasons why deforestation is still continuing," says Colombo.

Where did we come from? How did it all begin?



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COMMENT

Thinking ahead

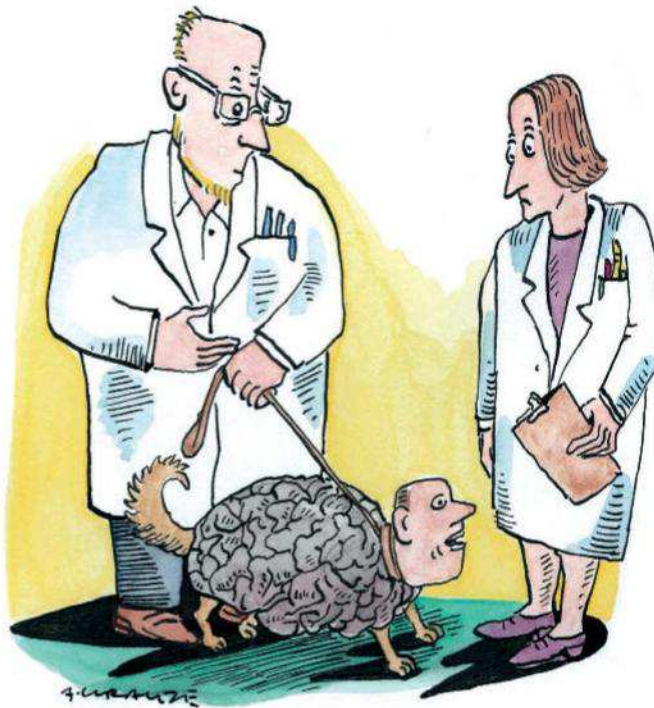
Creating human brain tissue in the lab or in animals is an area of research ripe for ethical debate, says **Alex Pearlman**

THE ability to create, grow and use human brain tissue in the lab is moving fast. So fast that leading neuroscientists, biologists, philosophers and ethicists have recently called for an ethics framework for this research (*Nature*, doi.org/cnwt).

They discuss variants of such brain tissue including organoids, known as 3D "mini-brains" or "brain balls", grown in the lab from stem cells, and chimeras, in which human cells are transplanted into animal brains.

The authors make clear that despite the fact these do not have human capabilities such as self-awareness, the possibility is becoming less remote.

Organoids have proven incredibly valuable to research into diseases like Alzheimer's and Zika. They are also, by all accounts, astonishing: mini-brains can respond to external stimulus,



such as a light. Meanwhile, chimeras are possibly the most controversial human brain surrogate. Deep ethical concerns about them have been growing. In 2017, an investigation found that tiny human brain pieces had been implanted into rats and mice, raising the hackles of bioethicists who worried about the prospect of human-like brain tissue maturing in rodents. There was even talk that such mice performed better at certain tasks involving learning.

Separately, another group of researchers recently announced that their brain organoids had vascularised, growing vessels to connect to a blood supply.

Even if the chance of an organoid or non-human animal being sentient in a human way is slim, we should decide where to draw some lines.

There have been previous efforts to discuss the ethics of

Successful launch

What are NASA's prospects under its unlikely new boss, wonders **Samantha Murphy**

EVERYTHING about how Jim Bridenstine came to be NASA's new administrator was unusual. From the way this climate-change sceptical, non-scientist, Republican politician campaigned for the job – usually the preserve of ex-astronauts or space insiders – to the controversy-laden seven months it took to get him

confirmed in the role.

But don't tune out now. What happens next is worth watching.

NASA has long been torn between two philosophies. The first sees space exploration as a scientific endeavour, with incremental, research-driven steps that bring discoveries along the way. The other is commercial and

goal-driven, sometimes symbolic, favouring benchmarks. Selecting Bridenstine signals a mix of these and has a shot at combining them.

He wrote the American Space Renaissance Act, a road map for military and commercial space and NASA. He also posted "Why the Moon Matters", a blog arguing for a US return to the moon soon, not just on scientific grounds, but for practical, economic reasons.

Bridenstine says lunar water could be used to make fuel to top

"Bridenstine argues for a US return to the moon soon, not just on science grounds but economic ones"

up satellites, fitting into a need for new satellites that would, he envisions, lead to cheaper, better versions of GPS, the internet, military reconnaissance and, yes, even weather pattern data, used to assess climate changes.

The chance to revolutionise satellite operations will please commercialisation fans. To get there, Bridenstine proposes using NASA craft not private ones. That will suit space traditionalists.

But can a politician with a partisan-tinted past bring people and ideas together for a non-partisan goal? In his first speech to NASA staff, Bridenstine did his best. He struck an inclusive tone,

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neurological research, but, more should be done. To create meaningful ethical boundaries that let health technologies advance, we must fully understand why this sometimes unsettling science is valuable. So scientists should make their voices heard. We also need to begin to grasp what a relevant ethical framework looks like.

Bioethicist David DeGrazia's theory of degrees of moral status can be useful here. While it can be controversial to say so, most people believe that compared with a human, a sheep has a lower moral status, towards which we have different moral obligations. Does a sheep with human brain tissue create a different level of moral status, higher than a sheep, but lower than a human? Perhaps it does, and perhaps this can be a way forward for considering how brain surrogate research advances.

There is no doubt the research must advance – but in a way that begins to create an appropriate ethical framework. Open communication between scientists, ethicists and the public is crucial now, before human brain surrogates astonish us in more worrying ways. ■

Alex Pearlman is a bioethicist and journalist

choosing “humankind” over “mankind” and conspicuously avoiding talk of making something “great again”.

Instead, he thanked the US president for ensuring that the US “remains the preeminent space-bearing nation in the world”, making clear that NASA never stopped being great and that he would not be open to politicising the agency. It was a well-received move, and it was nice to have a glimmer of hope on an otherwise gloomy horizon. But that was just day one. Don't look away. ■

Samantha Murphy is a science writer based in Pennsylvania

ANALYSIS Taxing treats



RUTHBLACK/GETTY

Is sugar the real demon in our diet?

Clare Wilson

LAST month, the UK brought in a tax on sugary drinks, following a few other countries, including France, Mexico and Finland. A can of Coke, for instance, now costs 8 pence more, although many brands, such as Ribena and Irn-Bru, avoided the price hike by replacing some sugar with sweeteners, to a chorus of internet outrage.

But the official crusade against the white stuff isn't stopping there. Now, a group of doctors say we need to start taxing sweet foods, like chocolate, confectionery, cakes and biscuits.

They used data on the shopping habits of more than 30,000 British households to study what happens when the prices of sweet snacks and sugary drinks rise. In both cases, a price hike of 10 per cent reduces purchases by around 7 per cent. Because snacks contribute twice as much sugar to our diets as drinks do, a tax on the former should lead to a bigger fall in consumption, argue Richard Smith of the London School of Hygiene and Tropical Medicine and his colleagues (*BMJ Open*, doi.org/cnx7).

Yet it is not clear that taxing sugar

will achieve our true goal: controlling our ever-expanding waistlines.

Almost two-thirds of UK adults are now overweight or obese, with figures being similar in most of the West. But we don't actually know why.

Too much sugar in our diets isn't the only possible cause of this widespread weight gain – others might be overall calorie intake, processed food, eating too much fat or our sedentary lives. We might be focusing on the wrong thing by singling out one particular food group for taxes and bans. Perhaps we

“Almost two-thirds of UK adults are now overweight or obese, but we don't actually know why”

would do better to put more effort into teaching children to cook, encouraging more sport participation or changing our cities to help people get around by cycling and walking. No one knows.

The desire of governments to nudge us into healthy eating has parallels with anti-smoking measures, but our understanding of diet-related problems is not at the same level. While the evidence linking tobacco

with cancer and heart disease is solid, the science of nutrition is shakier.

Most nutrition research consists of “observational” studies, which, rather than randomising people to different diets, just record what they eat, and are notoriously open to bias. It is unsurprising then that dietary advice has morphed over the years.

For decades, the root of all dietary evil was fat, particularly saturated fat from red meat and dairy. We demonised cholesterol, a fatty substance found in animal products; eggs were almost verboten. Now we know that cholesterol in food has little bearing on levels in our blood, though saturated fat does. Come back eggs, all is forgiven.

Similarly, we have long been told to replace butter with vegetable oil. But, for decades, vegetable oil spreads and processed foods like biscuits were based on trans-fats, which we now think are even worse for our arteries than saturated fats. Most such foods have been reformulated to cut their trans-fats, but it makes you wonder if we may have been better sticking to butter all along.

Sugar now seems to have taken over from fat as public health enemy number one. But in light of previous U-turns, perhaps governments should be a little more cautious about trying to remodel our eating habits when the science is still uncertain. At the least, we should wait to assess the results of the first sugar tax before broadening its scope. ■

APERTURE





Art of thought

WHAT resembles the wall of an exotic underground grotto is actually a work of art representing the circuitry of the brain in action. *Engram / Remember* is an incredible moving spectacle, forged from algorithms that convert data about brainwave activity into captivating imagery - this image shows just a single frame. The high-resolution screen starts off showing what seems to be a piece of paper ripping and folding into itself, then morphs into swirling shapes that wriggle and squirm around in an imaginary box.

Artist Refik Anadol creates his "data paintings" and other works at the Neuroscape Laboratory at the University of California in San Francisco. He measures and records volunteers' brainwave activity with electrodes placed on their scalp (pictured below), then uses fractal algorithms and neural nets to turn the data into these shape-shifting displays. *Engram / Remember* uses data taken from his own brain activity while he was recalling positive long-term memories, he says.

The artwork is part of the Melting Memories exhibition, recently displayed at the Pilevneli Gallery in Istanbul, Turkey. Other works from the show include *Engram / Recall*, which resembles a profusion of petals, like flowers coming into bloom, and *Engram / Been There*, which is like viewing an ocean from space and seeing it merge into mountains and canyons. Andy Coghlan



Photographer

Refik Anadol
refikanadol.com

WHERE'S THE BEEF?



If you like meat, but don't want a side order of animal cruelty and environmental destruction, there's something new on the menu. Confirmed carnivore Niall Firth chows down

I LOVE meat. I love the smell of it cooking, the sound of the sizzle. I love the fat dropping onto the coals beneath a barbecue, the deep-pink "give" of a medium-rare steak, the smoke, the blood. I particularly love eating burgers in the US, where the act of griddling meat is an art form that has been perfected into juicy, salty, fatty heaven.

So, let's just say I wasn't straining at the leash when asked to go and try a new vegan burger while in Texas. I was in the home of the barbecue, after all, where steaks are as big as your head. The thought of choosing a veggie burger made me feel weak.

Not for much longer, perhaps. I wasn't off to sample a bog-standard bean burger, but to try an Impossible Burger, one of a new brand of plant-based meat analogues created using the latest in biochemistry and technology. These aren't your standard meat substitutes such as tofu, Quorn and soya mince; nor are they the much-hyped but still experimental meats grown in the lab from stem cells (see "Growth industry", page 34). They are plant products processed to look, smell, taste and feel like meat. And they are aimed squarely at diehard meat-eaters like me.

That could be useful, because I am painfully aware that I should reduce how much meat I consume. According to the UN's Food and Agriculture Organization, livestock graze on a quarter of our planet's ice-free land while another huge swathe is used to grow fodder. The greenhouse gas emissions associated with the industry are vast, around 15 per cent of the

total from human activity. Raising animals for meat also guzzles water and energy.

With a growing global population, this isn't a sustainable way to live. "Quite frankly, if China eats as much meat as America, we're screwed," says Tim Lang at the Centre for Food Policy at City, University of London. "We have to recalibrate our diets." There are also animal welfare issues to consider.

I know all this, of course. The problem is I like meat too much. Could meat-free substitutes really help me reduce my intake while still enjoying my favourite foods?

Impossible Foods, maker of the eponymous burger, is the brightest star in the artificial

"This is the best fake burger I've ever had. The flavour is like liquid smoke"

meat world. Based in San Francisco and founded by former Stanford University biochemist Pat Brown, its products are on sale in more than 1000 restaurants in the US. Bill Gates was one of a number of high-profile early investors. Impossible doesn't just want to create a passable burger for vegetarians and vegans. It wants to give carnivores-with-a-conscience a way to reduce their meat consumption without having to sacrifice the pleasures of the flesh.

"We're not going to be able to just talk people into a plant-based diet," says Impossible's chief scientist David Lipman.

"We need to create foods that are so delicious that people choose them instead of animal-based foods."

That is a big challenge. The first step is getting to the heart of what makes meat so delicious. When meat is cooked, it exudes a complex mixture of volatile compounds that give it that unmistakable aroma. This is what we mean when we talk about the flavour of a steak or burger, because so much of what we experience as flavour is actually aroma tickling the olfactory receptors lining the top of our nasal cavity. For Lipman, recreating this signature aroma of cooked meat is vital.

Impossible is going through the painstaking process of trying to identify all of those compounds, deciding which are the most important, and then finding plant analogues. Lipman's team uses tools such as gas chromatography and mass spectrometry to identify exactly which volatile molecules are released when meat is cooked. "People have never tried to do this before with all the latest technologies," says Lipman.

His team realised early on that the key ingredient in meat's flavour is haem, an iron-containing compound found in blood and muscle tissue. This oxygen-carrying compound is what gives meat its colour and metallic tang. In living tissue, it is bound up with proteins to form haemoglobin in blood and myoglobin in muscle. These give meat its rich umami depth.

But haem isn't only found in animals. Brown realised that some plants also

The Beyond Burger: mostly pea protein plus beets to make it pink and "bloody"

contain an identical molecule bundled up in a different protein, leghaemoglobin, which has the same rich flavour and colour as animal haem. One source is the roots of legumes like soy, but pulling up plants to harvest it would be a costly and difficult process. So Brown genetically engineered yeast to produce leghaemoglobin. The protein can then be extracted, purified and added to the meat.

With haem cracked, Impossible moved on to other elements of the meat experience. Its burger gets its sizzle and char from small flecks of coconut oil scattered throughout the mix. This fat is solid at room temperature, melts in the right way and has a neutral flavour. Wheat and potato protein add texture, while yeast extract and soy protein impart more umami flavours. The whole edifice is held together with plant gums, with spices and seasoning adding the finishing touches. The team is constantly running taste tests and the burger's composition is always changing. Early versions weren't always a huge success. "One of them was described as tasting like rancid polenta," says Lipman.

Proof of the patty

What about their latest incarnation? When it arrived at our table, the burger certainly looked good. The top and bottom were charred and crispy like a well-griddled beef burger. Inside, the colour was pretty much spot on. The texture was pleasingly authentic; only a close inspection of its innards highlighted a hint of stringiness that didn't ring 100 per cent true.

I had hauled along a colleague who recently returned to veganism. She was impressed. "This is the best fake burger I've ever had," she said. "The flavour is kind of like liquid smoke." But while I was pleasantly surprised at the flavour and texture, which were closer to meat than I imagined possible, it still wasn't the real thing. Lipman concedes that there is still room for improvement. "We're just a few percentage points off our target burger," he says.

Another US brand, Beyond Meat, has a similar burger for sale in shops such as Whole Foods. Beyond has also been a darling of the Silicon Valley venture capital scene, slurping up funding from tech luminaries such as Bill Gates (again), Twitter co-founders Biz Stone and Evan Williams and actor Leonardo DiCaprio. The technology to create its texture involves state-of-the-art protein extrusion, which forces mixtures of vegetable proteins through a narrow aperture to create meat-like fibres. But when my colleague cooked one of Beyond Meat's burgers at home she was less



than impressed, complaining of a "pungent" smell and a strange "beaniness" to its flavour. "It looks a lot like meat. But it doesn't taste, smell, feel or sizzle like meat," she told me. "They got one of the four senses right, and it's not the one I would have focused on."

Other brands are trying different approaches. Moving Mountains, based in the UK, launched its B12 burger in February in London. Its main ingredient is mushroom, long a staple in vegetarian meat substitutes, alongside wheat and pea proteins. "We first analysed how beef was structured and spent weeks in a lab dissecting strands of fibres and how the fat and blood is retained," says founder Simeon Van der Molen. Beetroot is

included for juiciness and the pleasing deep red flavour it imparts when cooked (it was marketed as the first "bleeding" vegetable burger). Van der Molen says the goal is to get it as realistic as possible "without the torture and the cholesterol".

I tried it at veggie mecca Mildreds in east London, the only UK restaurant that serves it thus far. While it was tasty on its own terms, there was little chance of me being fooled. The ineffable "meatiness" of a real burger – and indeed, an Impossible one – was missing.

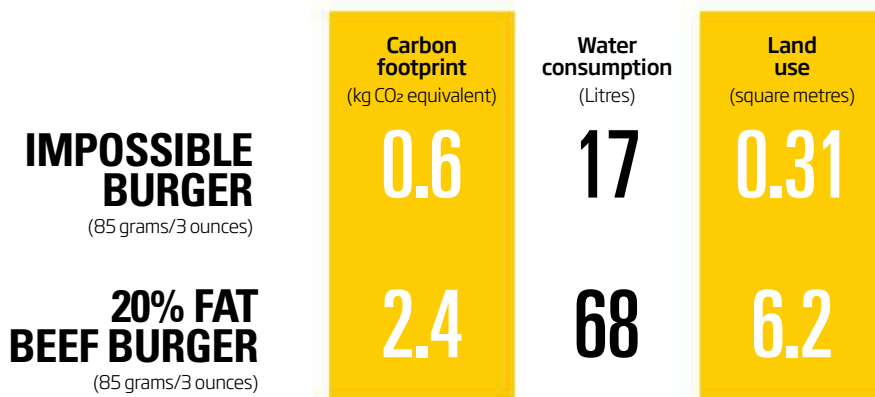
Nonetheless, zero cholesterol is a selling point that I hadn't thought about. But even though vegan diets are known to be healthier than meat-heavy ones, it seems unlikely that the new meat substitutes will advance that cause any further. An 85 gram (3 ounce) Impossible Burger will give you 220 calories, 13 grams of fat and just over a gram of salt. In terms of nutritional sins, that is no better than a typical beef patty (see left). In fact, the Impossible Burger is actually heavier on the salt and saturated fat – as you might expect for something so processed.

Despite the drawbacks, some restaurants are impressed enough to serve the products. As well as the burgers, chefs use Impossible meat in tacos, pizzas and meatless meatballs. US burger chain White Castle has become the first fast-food joint to sell an Impossible Burger. But all of these products are substitutes for ground meat. Recreating the sensory experience of an intact cut, say a prime piece of rib-eye steak, is another story.

That is where texture comes in. Flavour might seem like the most important quality to get right, but if a food feels wrong in your

GOOD FOR THE PLANET...

Plant-based meat substitutes have a much smaller footprint than the real thing



I can't believe its not meat: dishes at The Vegetarian Butcher's restaurant in The Hague

mouth then the eating experience will be ruined. Texture gives us clues as to how we should react to flavours as we eat: studies have shown that we struggle to identify common vegetables once they have been pureed, for example. That is why, for many in the artificial meat industry, getting the texture right is absolutely key to broadening the appeal.

"Texture is more important than we think," says Charles Spence, a psychologist at the University of Oxford. "There's been far less research into this than other aspects of food such as colour and flavour." Another important aspect is mouthfeel, the sensation as fats and other ingredients coat the inside of the mouth as you eat.

Feel the texture

To produce the authentic ground beef texture needed for meat-free burgers, many researchers use extrusion. But there are other ways of adding more complex textures to meat substitutes. Atze Jan van der Goot at Wageningen University in the Netherlands has been trying to crack this for years. His lab is pioneering the use of a technique known as shear cell to create plant-based products that have a texture as close to meat as possible.

"This isn't aimed at vegans," says van der Goot. "Meat analogues are meant for meat-eating people who feel they should do something but don't know how. It's easier if you have a product to help."

Really winning over carnivores will require something that splits and breaks apart like a prime cut of meat. His technique starts with the usual suspects: soy and gluten protein



COURTESY OF THE VEGETARIAN BUTCHER

powders, to which food colouring is added to give them a more appealing hue. This mixture is then pumped with water into a specialised piece of equipment called a Couette cell, consisting of two cylinders, one of which rotates inside the other under slight pressure. This exerts a shear force on the proteins that causes them to elongate into fibres and wrap around one another.

"We can control the fibrousness," says van der Goot. "We hope that our technology will be able to mimic more types of meat than currently meat analogue products do."

His team, in collaboration with engineers at Delft University, is also experimenting with other sources of plant protein in the shear cell

device, including from rapeseed, sunflowers and rice, and constantly tweaking the parameters to produce structures that resemble the muscle fibres in pork and beef. After about 20 or 30 minutes in the machine, a slab of shiny, gelatinous material emerges. It tears in the hand much like a chunk of slow-cooked meat but – it has to be said – isn't the most appetising-looking product.

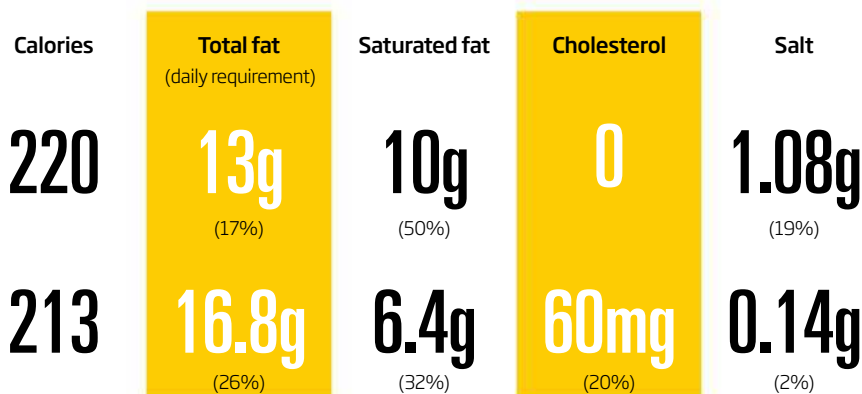
To turn this vaguely stomach-churning substance into something we might want to actually eat, the lab works with one of fake meat's pioneers, The Vegetarian Butcher. The firm has shops in The Hague and Berlin and exports its products across the globe. It sells a spectacular range of "meats" including mince, meatballs, sliced charcuterie and sausages, alongside larger pieces resembling chicken, beef and ham, all made principally from soy and wheat protein. The hardest quality to mimic is mouthfeel, says operational director, Loes Moor-Hulshof. "To get the water released in a really meat-like way is difficult."

George van Hal, a science writer based in The Hague, is a fan. "The likeness to actual meat really is quite remarkable," he says. "With some of their stuff, I'm not sure I could pick it out in a blind taste test." He has also served it at dinner parties without telling guests. "Most were surprised when they found out they didn't eat meat," he says.

The Vegetarian Butcher is also leading the way in replacing another foodstuff that comes with a side of environmental and ethical guilt: fish. Its smoked "eel" salad won a Taste of the Netherlands award, beating some real fish and meat dishes. One of its latest products is ▶

...LESS SO FOR YOU

Cholesterol apart, fake meat is little better than beef



SOURCES: IMPOSSIBLE FOODS; USDA

The Impossible Burger, as close as anyone has got - yet

fishless tuna, which I try mashed up as a salad as per the serving suggestion. It is good enough, with a firm and pleasing texture and distinct fishy tang. I am not fooled, but I know what I am eating and wonder how it would fare in a blind test against real tuna.

For the sheer amount of it that is consumed every year, the market to crack is probably chicken. Worldwide, about 60 billion birds are killed for food every year. I asked leading vegan blogger and author Sean O'Callaghan, who writes under the name Fat Gay Vegan, where I could try London's best fake chicken and he told me to go to The Temple of Seitan.

On a cold Wednesday lunchtime, I find myself back in east London in pursuit of yet more meat-free meat. Sandwiched between an old-fashioned greasy spoon cafe and a halal butchers is the Hackney branch of The Temple, which opened in 2015 and is now a fixture on London's growing vegan fast-food scene.

The Temple serves up fried "chicken" made from seitan, a venerable vegan meat substitute made by washing the starch out of wheat flour to leave gluten. The Temple mixes seitan with spices and soy and then deep-fries it in batter. I order the wings in BBQ sauce and a small bucket of popcorn bites. The flavour and texture of the coating are authentic but what is inside is less so. If the slightly spongy substance mimics chicken at all, it is of the bargain basement nugget variety.

Spence says that my experience with seitan is a risk all meat substitutes face: tipping into the food equivalent of the uncanny valley. This uncomfortable sensation is normally

"These products are catering to omnivores who are looking for more options"

created by humanoid figures that look almost, but not exactly, like real humans. "Improving the similarity between the fake product and the one that you're trying to replicate may dig you into a hole," he says.

Overall, the goal of making foods that are so delicious that carnivores like me would choose them over meat seems a way off. Nonetheless, demand for meat from plants is rising. The market for these products is about to explode, claims Liz Specht, a senior scientist at the non-profit Good Food Institute, which works with entrepreneurs and the food industry to stimulate the market for plant-based meats. She sees them following the trajectory of plant-based dairy products such as soya milk, which are moving out of



GROWTH INDUSTRY

Why go the effort of trying to force plant cells to act like meat when you can get animal cells to do it? That is the rationale behind cultured meat - growing muscle tissue from animal stem cells in a dish.

The concept has come some way from the \$250,000 cultured meat burger cooked up in front of journalists in London in 2013. The Dutch scientist behind that stunt, Mark Post, now works at MosaMeat, a start-up in Maastricht. It has claimed it will have a cultured meat product in supermarkets in 10 to 20 years, although many are sceptical.

Memphis Meats, a Californian start-up, has managed to get the price of its cultured meatballs down to about \$2500 for 500 grams and has created a fully lab-grown chicken product. SuperMeat, based in Israel, has also raised venture-capital money to produce its own version. And Finless Foods in San Francisco wants to make cultured fish meat. However, none of the companies seems close to a commercial launch of a product.

"There may be a lot of attention on lab meat from stem cells, but that won't be the future of food," says Loes Moor-Hulshof of The Vegetarian Butcher, a Dutch company that makes plant-based meat substitutes.

specialist shops and supermarket aisles and into the mainstream. "The vegan market is growing, but that's not what is driving this trend," she says. "These products are now catering to true omnivores, who enjoy the taste of meat and are just looking for more options. That's what's spurring innovation."

The Vegetarian Butcher is finding the same. The company has just opened its first restaurant. Its 50 per cent year-on-year growth is driven by its popularity "among meat eaters and flexitarians", says Moor-Hulshof.

Not everyone is so gung-ho about Silicon Valley's latest attempt to save the world. Meat analogues have a place, but they're not the whole story, says Lang. "I'm wary of technical fixes when we have a fundamental food system that is out of control," he says. "I think there is room for them, but I don't think they are any replacement for the need to tackle the social norms."

That rather throws the ball back into my court - and my culinary experience so far has been mixed. The Impossible Burger was probably closest in terms of texture and moreishness, but it didn't come close to the finest meat experiences out there. But, for the sake of my conscience, that is probably a compromise I would be prepared to make, at least some of the time. I won't quit meat but I will stop eating it so regularly - and enjoy every bloody steak like it might be my last. ■

Niall Firth is *New Scientist's* chief news editor



Earth's most unpredictable eruptions could be signalled in the heavens, finds John Pickrell

Well I'm blown!

THROUGHOUT history, people have suspected the moon of messing around with life on Earth's surface. From inducing madness to affecting the growth of plants, most of these connections are as tenacious as they are ill-substantiated. But one area where the moon's influence cannot be disputed is on the seashore. Long before Isaac Newton's theory of gravity provided a physical explanation, the link between the tides and the phases of the moon was obvious to anyone with an eye for patterns.

And if the moon has such a strong effect on liquid water, well then, why shouldn't the ground be equally affected? Philosophers as

"Volcanoes about to erupt could be most sensitive to the moon's pull"

far back as Pliny the Elder have speculated that the moon's movements across the sky might also be responsible for earthquakes and volcanic eruptions. Statisticians fought over the significance of the connection in the 19th century, and geophysicists of the 1970s and 80s kept the claim alive until lack of evidence finally pushed it out of the mainstream.

The current state of the field can best be summed up by an eye-catching paper published in January by Susan Hough. A seismologist with the United States Geological

BRETT FRYDER

Survey, she had set out to answer an age-old question: does the timing of powerful earthquakes coincide with the phases of the moon? The abstract ran to one word: No.

Most experts would agree that the blame for natural disasters like earthquakes and volcanic blasts lies elsewhere. But even if tidal forces don't have the necessary power to cause eruptions, that doesn't mean their effects should be ignored. In fact, new research suggests that some volcanoes are more sensitive to the moon's pull than we thought. This knowledge could help us predict when they are gearing up for the most catastrophic kinds of eruption, giving us vital early warnings that could save lives. What's more, some researchers are hopeful that such effects could give us some heads up before those even more unpredictable and deadly earthly rumbles: earthquakes.

Most of the volcanic and seismic activity on Earth occurs around the boundaries of tectonic plates, where the immense pressures and temperatures inside the planet make themselves felt at the surface. For volcanoes, the oozing magma below can provide a host of early-warning signals: increased ground deformation, higher concentrations of gases like sulphur dioxide or tiny changes in surface gravity or temperature.

But not all volcanic eruptions involve easily detectable pools of magma. Highly explosive "phreatic" eruptions occur when ➤

pockets of superheated, pressurised steam and gas form beneath a volcano, bursting out with little to no warning. "Phreatic eruptions have proven difficult to predict and can be deadly," says Matthew Pritchard of Cornell University in Ithaca, New York. He points to the 2014 eruption of Mount Ontake in Japan, which was the country's deadliest since 1926, killing 63 hikers. Although phreatic eruptions represent only about 5 per cent of the 18,000-odd events recorded since 1900, they are some of the most lethal.

On 25 September 2007, one such explosion shook Ruapehu, New Zealand's largest and most active volcano. Although it took no lives, the massive eruption of rock, steam and gas sent a plume of debris several kilometres skywards. For 7 minutes, a magnitude-2.9 earthquake shook the ground around the volcano, and two lahars – fast-moving slurries of mud and volcanic rocks – rushed down its slopes, injuring a 22-year-old climber sleeping in a nearby shelter. "It was an eruption that occurred very suddenly. There were no geophysical signals," says Társilo Girona, a geophysicist at NASA's Jet Propulsion Laboratory in California. "Understanding what happened in this eruption in Ruapehu is really important."

So in 2016, when Girona and his colleagues got their hands on 12 years of continuous seismic data from sensors near Ruapehu's crater, they immediately set about looking for patterns. What they found took them by surprise: in the three months running up to the 2007 eruption, the ground vibrations recorded around the volcano appeared to fall into sync with the effects of the lunar cycle. As the tidal pull of the moon and sun increased, in other words, so did the seismicity.

Dark side of the moon

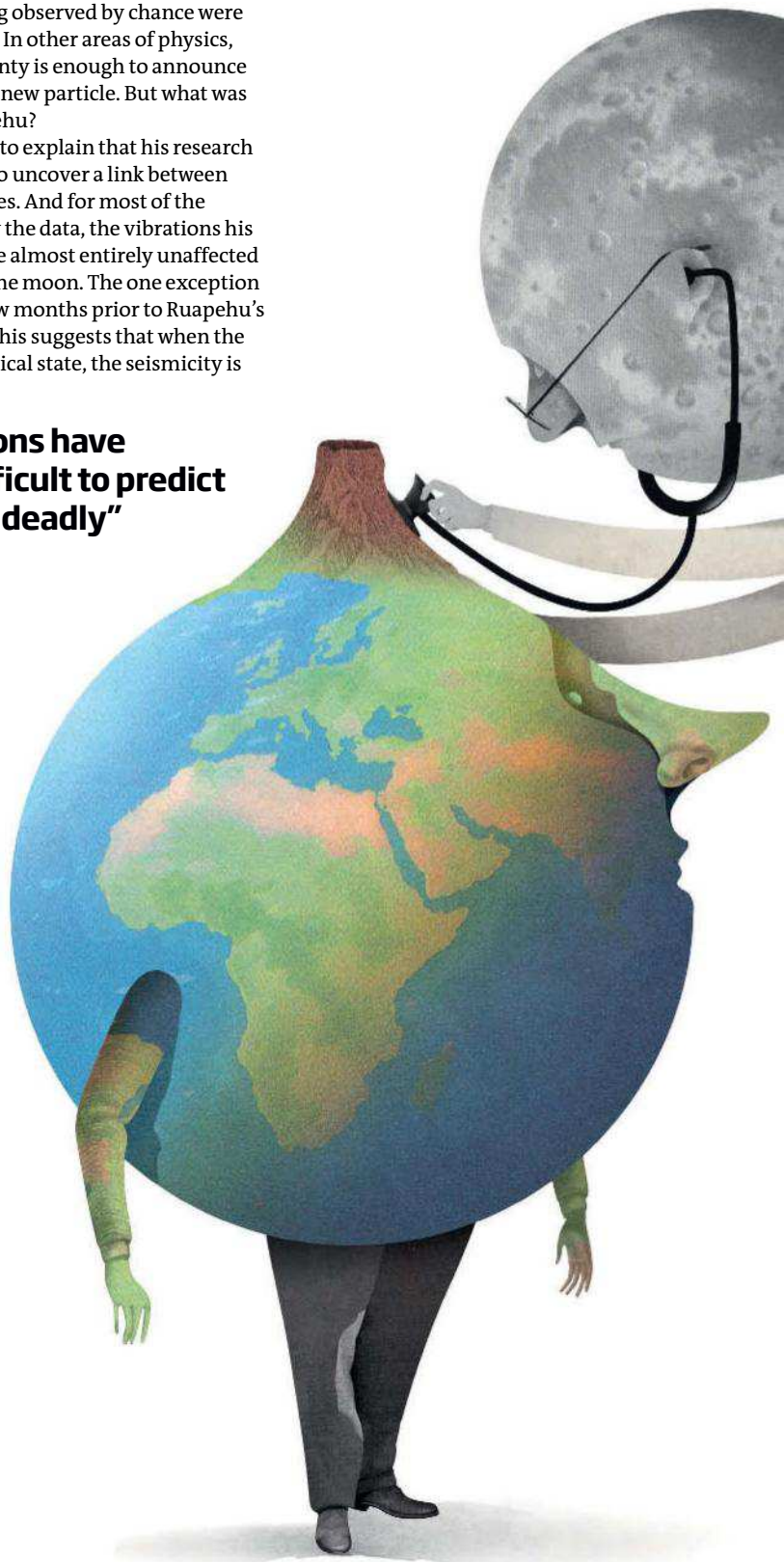
The results were puzzling. Tidal forces cause volcanism elsewhere in our solar system – on Jupiter's moon Io, for example, which has to contend with the gravitational tugging of three large neighbouring moons, besides the gas giant itself. But there are good reasons to think such forces can't cause the same kind of volcanism on Earth. While the combined gravity of the sun and moon is powerful enough to move water on our planet's surface, it is far too small to break solid rock in the way required to generate an eruption from scratch. "The tidal stresses are three orders of magnitude smaller than the pressure needed to trigger an eruption," says Girona.

Nonetheless, the results were clear. From

a statistical perspective, the chances of the same results being observed by chance were one in 3.5 million. In other areas of physics, this level of certainty is enough to announce the discovery of a new particle. But what was going on in Ruapehu?

Girona is quick to explain that his research wasn't intended to uncover a link between eruptions and tides. And for most of the period covered by the data, the vibrations his team studied were almost entirely unaffected by the phases of the moon. The one exception was the crucial few months prior to Ruapehu's 2007 eruption. "This suggests that when the volcano is in a critical state, the seismicity is

"Gas eruptions have proven difficult to predict and can be deadly"



Nobody saw
Ruapehu's 2007
eruption coming



GEONET, 2007; LEFT: BRETT RYDER

responding to the tidal forces – and we can use that, in principle, to detect when a volcano is in a critical state,” he says.

In the immediate build-up to a phreatic eruption, hundreds of thousands of tonnes of steam get trapped in chambers below the volcano itself. And just as lakes are capable of displaying full-blown tides while your bathtub is not, this vast body of gas becomes uniquely sensitive to the moon’s pull.

Michael Manga at the University of California, Berkeley, is intrigued by the finding. “Using increased sensitivity of volcanic earthquakes to small external forcing makes sense as a tool to probe whether a volcano is getting ready to erupt,” he says.

Against the tide

For Hough, however, the benchmark of Girona’s success will be whether or not his results can be replicated before another eruption occurs. “It remains to be seen that the patterns identified at Ruapehu will have any predictive power,” she says.

Girona’s problem, however, may be finding enough volcanoes that have continuous seismic data monitoring. Only 35 per cent of volcanoes that have erupted since 1500 do, and very few make their data freely available online in the same way as at Ruapehu.

What’s more, Girona is concerned that the effects that emerged so cleanly in his data may be more muted elsewhere, given the islands of New Zealand are already known to have some of the world’s biggest ocean tides. “If there’s any place in the world where tides can have an effect on volcanoes, I would expect it’s New Zealand,” he says. That’s why the researchers are already eyeing up suitable volcanoes in Japan and Costa Rica, where they can double-

check their findings in less tidally sensitive parts of the world.

Girona is not ploughing this furrow alone. Gianluca Sottili at the Sapienza University of Rome has studied the volcano on the Italian island of Stromboli that has been in near-continuous eruption for thousands of years. His work showed that over a 17-month period in 2010-11, the hourly number of explosions grew every 14 days or so, in line with the tidal maxima of the full and new moon. Similarly, the perennially active Mount Etna on nearby Sicily appears to show a connection between the deformation of its flank and the position of the moon. When a volcano is already in an eruptive state, says Sottili, its activity may well turn out to be modulated by tidal forces.

For Sottili, Girona’s work on Ruapehu marks the first time a link has been shown between the lunar cycle and the behaviour of a volcano prior to eruption. “It represents an important step forward in our understanding of the interaction between tidal forcing and terrestrial volcanism,” he says.

If his team can replicate the results on other volcanoes, Girona hopes to develop a user-friendly, real-time monitoring tool that volcano observatories across the world can use to identify critical states that precede eruptions. Although the precise moment of an eruption is impossible to know in advance, he hopes that such an early-warning system could at the very least save lives. “Looking for new signals preceding phreatic eruptions is very important work,” says Pritchard.

But Girona is dreaming bigger. For him, the million-dollar question is whether the pull of the moon might have a similarly small but measurable effect on tectonic plates – and could therefore be used to predict earthquakes as well as volcanic blasts.

The way to test this would be to see if highly stressed tectonic plates might exhibit small changes to their overall patterns of seismicity under the pull of tidal forces. Along with team-member Corentin Caudron at Ghent University in Belgium, Girona says he is in the very early stages of looking at data to explore just such a question.

Given how much more difficult earthquakes are to predict than volcanoes, however, their conclusions will need to be watertight if they hope to convince their peers. “If time proves me wrong, I’ll be the first to applaud,” says Hough. “But I don’t expect to be applauding any time soon.” ■

John Pickrell (@john_pickrell) is a science journalist and author based in Sydney, Australia

WHEN IS A DINOSAUR NOT A DINOSAUR?



The rulers of prehistoric Earth are having an identity crisis, says Colin Barras

HARRY SEELEY looked like your typical Victorian gentleman: neatly trimmed beard, sharp side parting, smart suit. But he was a killer. In 1887, he destroyed the dinosaurs. The London intelligentsia were abuzz with excitement over the weird and wonderful ancient giants, but Seeley was having none of it. He looked at the fossil bones and reached a radical conclusion: technically, he said, there was no such thing as a dinosaur.

Seeley was eventually – mostly – overruled. But a study published last year is casting a fresh shadow over the awe-inspiring beasts of prehistoric Earth. It suggests we have completely misunderstood why they ruled the continents for tens of millions of years – and even what creatures qualify to be part of the dino-club in the first place.

The tale began in the early 1840s, a couple of kilometres east of London's British Museum, when a leading scientific celebrity walked into a private collection on Aldersgate Street. Unlike many gentlemen scholars of the time, Richard Owen rose to the pinnacle of British science from the humblest of roots. His circle of friends included the royal family and Charles Dickens. Yet, for the most part, history remembers him in a different light.

"It is astonishing with what an intense feeling of hatred Owen is regarded by the majority of his contemporaries," wrote biologist Thomas Huxley, whose intellectual fights with Owen gripped a nation. Owen is said to have been arrogant, spiteful and ruthlessly vengeful. He gained a reputation for stealing ideas and even specimens from his peers and, according to Julian Hume,

who works at the Natural History Museum in London, was quite prepared to resort to blackmail to get his way.

For all his scoundrel qualities, Owen was instrumental in recognising dinosaurs as unique. In Aldersgate Street, he set eyes on an iguanodon fossil, one of three enormous prehistoric beasts – alongside megalosaurus and hylaeosaurus – that had been dug out of English soil. In a flash of brilliance, Owen recognised that the trio had several unusual features in common, particularly in the structure of a lower back bone called the sacrum. This convinced him that they were unlike anything alive today and closely related to one another. Owen called them dinosaurs.

In the years that followed, interest in dinosaurs exploded. More species were unearthed, showing that they had come in all shapes and sizes, from large, vicious-looking, two-legged predators to extraordinary armoured tank-like herbivores. Some scientists began to sketch out simple family trees showing how the different species might relate to one another.

That was when Seeley arrived on the scene. Dinosaurs evidently fascinated Seeley, and as he studied their anatomy he became increasingly convinced that his peers had missed something significant. Dinosaur hips, he noted, seemed to come in two flavours, with one bone in the pelvis that either pointed backwards, like in birds, or forwards like in lizards. "There is as marked a difference between these two pelvic types as can be found in any part of the animal kingdom," he told the Royal Society in London in 1887.



HEIDIMAYER/PLAINPICTURE



According to Seeley, this meant the two different groups of animals had been mistakenly lumped together under the same label. "Dinosauria has no existence as a natural group of animals," he concluded, some 45 years after Owen had revealed dinosaurs to the world.

Astonishingly, Seeley's dino-slaying became scientific orthodoxy. For much of the 20th century, the consensus was that dinosaurs weren't really a thing. Sure, a number of giant creatures had once roamed the continents, but palaeontologists believed they didn't all fit into one group like insects or mammals do. They continued to use the term "dinosaur" in an informal sense, but it lacked any real biological meaning.

Hips don't lie

Instead, the ancient beasts were split into two groups, depending on the shape of their hips (see "Split at the hip", page 40). They were either saurischians, meaning lizard-hipped – although these were unrelated to lizards – or ornithischians, meaning bird-hipped – but again with no relation to birds.

This split had profound consequences for the way 20th-century researchers thought about the rise of the ancient giants. As more and more fossils came to light, it gradually became clear that they had been incredibly diverse and ecologically successful for tens of millions of years. That sort of success can just boil down to luck, but if dinosaurs emerged from two independent rootstocks, it would imply that both groups got lucky at exactly the same time – which seemed unlikely.

Some researchers argued that this spectacular rise to dominance occurred because, despite being unrelated, saurischians and ornithischians shared a trait or traits that made them inherently superior. They all walked on vertical legs with their belly held off the ground, for instance. Perhaps they converged on this body plan independently, and it was so much better than anything else evolution had come up with that both groups then prospered.

It was only in the mid-1980s – a mere seven years before *Jurassic Park* roared onto the screen – that opinion swung the other way and dinosaurs were reinstated as a scientific fact.

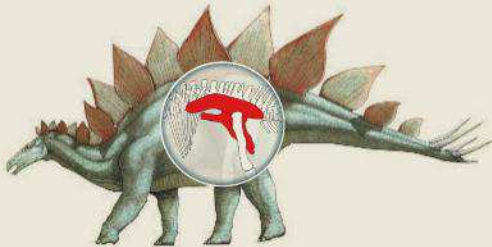
According to palaeontologist Michael Benton at the University of Bristol, UK, the turning point came in 1984 at a conference in Tübingen, Germany. By then, a more



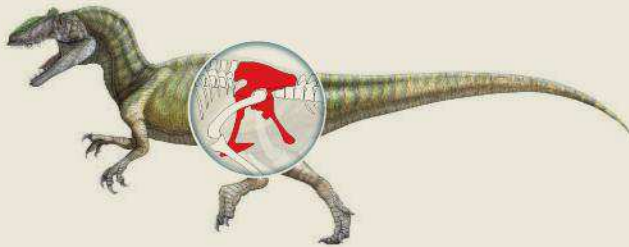
Split at the hip

Dinosaur hips come in two flavours: lizard-like and bird-like (although confusingly, the animals in each group are unrelated to lizards or birds)

Stegosaurus is an ornithischian
("bird-hipped")

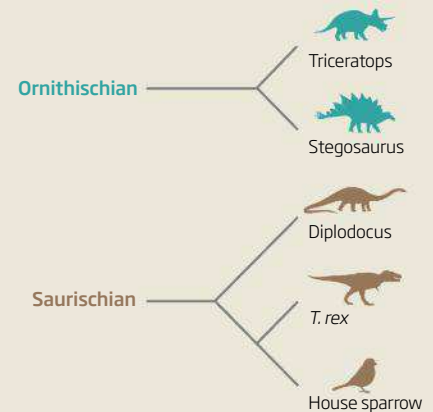


Allosaurus is a saurischian
("lizard-hipped")



SOURCE: UNIVERSAL IMAGES GROUP NORTH AMERICA LLC/ALAMY STOCK PHOTO

The distinction, noted in 1887, was just the beginning of a lengthy existential crisis marked by attempts to draw a dinosaur family tree



1887

The fossils are put in two unrelated groups according to their hips. Dinosaurs don't exist

rigorous method for analysing how different species related to each other had gained momentum. Cladistics took into account the full range of differences and similarities between animals to group them according to their shared evolutionary history. Although there were clearly two types of dinosaur hips, cladistics recognised that there were many other parts of the giant skeletons that looked very similar. For instance, within the hip socket of both "lizard-hipped" and "bird-hipped" animals, there was a distinctive gap where the bones of the pelvis didn't quite meet. Cladistics allowed all of these differences and similarities to be balanced against each other.

In Tübingen, Benton and a few other groups presented the results of their cladistic analyses of dinosaur evolution. Collectively, they convinced the community that the giant beasts of the Jurassic and Cretaceous all descended from a common ancestor. Owen, they said, had been right all along. The results also showed that all modern birds are in fact living dinosaurs. Two years later, the first of those studies was published and dinosaurs were officially reborn as a genuine biological group. With that, researchers could get a new perspective on the question of why they had been so successful. Some said it was partly down

to luck after all: for millions of years they seem to have been relatively minor players, only graduating to the big league in the aftermath of extinction events.

Then again, to flourish in challenging post-extinction times, they must have had some traits working in their favour. That probably didn't include walking on vertical legs with bellies aloft because it was becoming clear that many contemporaries of the dinosaurs did that too. The cladistic studies came to the rescue. Although the consensus was that all

"Dinosaurs were reborn just seven years before Jurassic Park came out"

dinosaurs had evolved from one species, the studies strongly suggested that those first dinosaurs soon divided into saurischians and ornithischians – Seeley's idea. If a feature showed up in both groups, it might well have come from the common ancestor of all dinosaurs.

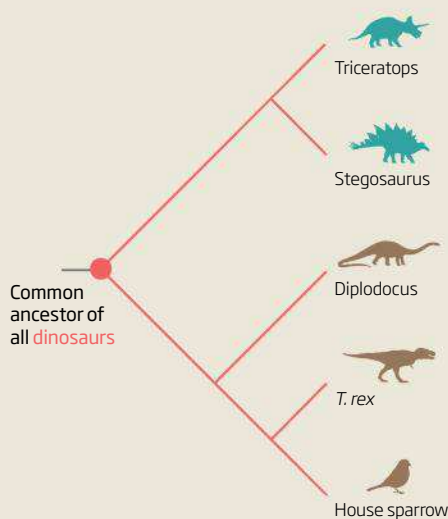
One feature fitting the bill was primitive, feather-like structures. Many researchers think these offered insulation long before they were used for flight. It is possible that the first dinosaurs benefitted from the

warmth that proto-feathers provided, which gave them an evolutionary edge over other animals.

Such insights started to provide tentative answers to the central "where, when and why" questions of dinosaur evolution. Then, in March 2017, a trio of British palaeontologists once more rewrote all of dinosaur history. Armed with data on 450 anatomical features for 74 of the earliest known dinos and dino-like species, Matthew Baron and David Norman at the University of Cambridge, and Paul Barrett at the Natural History Museum, ran a fresh cladistic analysis. What came out was a family tree unlike any seen before. And while it didn't quite slay the dinosaurs, it had equally heartbreaking consequences for one much-loved giant. In the new analysis, the long-necked diplodocus and its sauropodomorph relatives fell off the dinosaur evolutionary tree entirely.

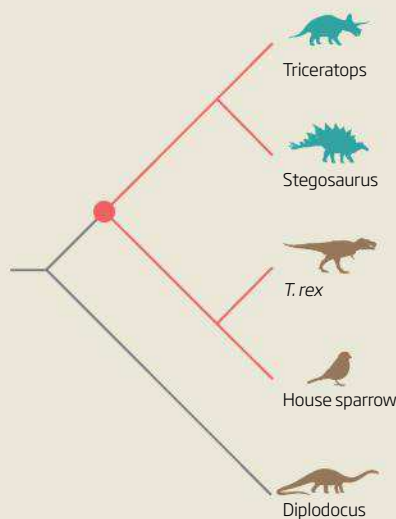
Their ejection was down to how we define what a dinosaur is. To qualify, animals must have evolved from the common ancestor of two dinosaurs: triceratops, and the modern house sparrow. According to Baron's family tree, the sauropodomorphs didn't fit the bill.

Mindful that some might find the eviction of diplodocus too sad to bear, Baron has suggested a solution: redefine dinosaurs as anything that evolved from the common ancestor that gave



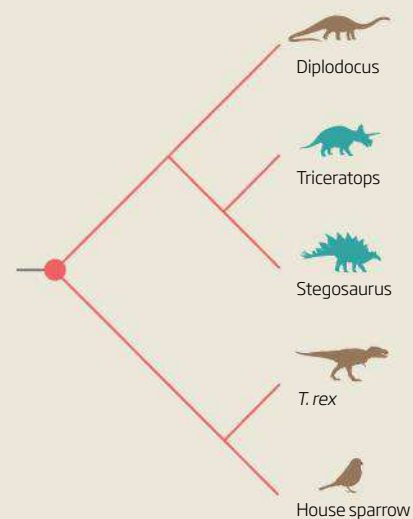
1984

Both groups have a common ancestor. Dinosaurs therefore exist



Early 2017

Diplodocus doesn't descend from the first dinosaur, so is booted out of the club



Late 2017

Re-examining the data suggests diplodocus might have to shift position, but at least it is a dinosaur

rise not just to triceratops and the house sparrow, but also diplodocus. "I didn't think people would thank me for suggesting diplodocus wasn't a dinosaur," he says.

His reshuffle also has implications for what the earliest dinosaurs looked like, and potentially why they were so successful. We haven't yet found a species of sauropodomorph with proto-feathers, meaning they could be a feature not present in the earliest dinosaurs. Instead, the new tree suggests that the earliest dinosaurs were omnivores that stood on two legs with "grasping" hands. If you think that sounds familiar, you're not alone. "We've noticed the parallels with our human ancestors," says Baron. "Obviously, there are huge differences in the way humans and dinosaurs achieved success. But for both, being upright with grasping hands was probably extremely useful."

Being omnivorous may also have offered advantages for both groups. Hominins evolved from forest-dwelling primates, and some believe that being able to find food in the wide-open savannahs may have helped them spread to new environments. Could something similar have happened with dinosaurs? "All of this is basically arm-waving, but in the Triassic, when the environment was really harsh, there were huge inland deserts," says Baron. "Not being too picky about what

you ate was probably quite advantageous."

Another way of seeing it is to say that the special je ne sais quoi that dinosaurs had might just have been a general adaptability rather than crucial specialisations that pigeonholed them to only being able to survive in specific ecosystems.

It is fair to say that the entire dinosaur research community sat up in their seats when Baron and his team published their study. Darren Naish at the University of Southampton, UK, immediately hailed the work as a game changer, destined to leave a lasting mark on the history of dinosaur research – perhaps one as significant as the one Seeley made back in 1887. Others think it is too early to abandon long-standing ideas about dinosaur evolution. Benton was part of a team, led by Max Langer at the University of Sao Paulo in Brazil, that spent a chunk of last year reassessing the results. They went through Baron's data set looking for – and correcting – what they called errors that could explain why the exercise had supported such a drastically different dinosaur family tree.

They published their findings in November 2017. The headline message was broadly that the revised data set supported the family tree of the 1980s after all. Panic over. But a cladistic study on this scale rarely gives you just one

possible answer. Among the options was a tree that was marginally less consistent with the data, but not in a statistically significant way – and it contained Baron's new arrangement, with diplodocus and its kin back in exile. "That's remarkable given they changed a lot of data," says Baron. "I think they were really pushing to recover the old model." He believes that confidence in that model has now been seriously dented.

If anything, the November analysis injected even more uncertainty into dino science. It suggested a third possible tree, one in which a group called the theropods – including the iconic *T. rex* – is isolated from the other dinosaurs. "That was a huge surprise," says Baron. "Any one of the three arrangements between sauropodomorphs, theropods and ornithischians could be correct."

With so much uncertainty, it is even harder to work out what the earliest dinosaurs looked like, what made them so successful – or indeed what species qualify as part of the club. Langer and his collaborators aren't prepared to give up on the model of the 1980s. But even they concede that Baron's research has shaken up the field, making us question assumptions we thought were rock solid. ■

Colin Barras is a freelance writer based in Ann Arbor, Michigan

UNTOLD STORY

High expectations

Branded an "unholy sacrament", cannabis was spurned in the West until **William O'Shaughnessy** saw its potential

ON THE evening of 6 November 1838, William Brooke O'Shaughnessy received an urgent note from the hospital where he worked. Could he come immediately? One of his patients was exhibiting "very peculiar and formidable" symptoms. Alarmed, he rushed to the man's bedside.

O'Shaughnessy, assistant surgeon with the East India Company's Bengal Medical Service, had reason to worry. The patient was one of the first human guinea pigs in his pioneering experiments with cannabis. A few hours earlier, the man had been given a modest dose of cannabis resin dissolved in alcohol. What might have gone wrong?

To a scientifically inclined physician based in India, cannabis – or Indian hemp – was a prime candidate for investigation. It was

popular as a means of intoxication, but local doctors also valued it as a treatment for a range of ailments. In 1813, one of O'Shaughnessy's predecessors reported somewhat sniffily on the intemperate habits of those who indulged in the various preparations. But O'Shaughnessy believed cannabis would make a useful addition to Western medicine and decided to put it to the test.

O'Shaughnessy wasn't just a doctor: he was also a skilled analytical chemist with a modern approach to medical research. He had made a big impression with his meticulous analyses of blood and excreta from people with cholera during an outbreak in England in 1831. He showed that patients were dangerously dehydrated and that bloodletting – then standard treatment – did more harm than good. Two years later, O'Shaughnessy landed a job with the East India Company and set sail for Calcutta.

For millennia, cannabis had been used as a medicine from Egypt to India and China. It had been a traditional remedy in Europe, too, but was hurriedly dropped after Pope Innocent VIII condemned it in 1484 as "an unholy sacrament". By the 19th century, cannabis was largely forgotten in the West.

O'Shaughnessy began by familiarising himself with the plant. As a narcotic, it was "the ready agent of a pleasing intoxication", he reported. Dried leaves – known as bang – were smoked, added to peppery drinks or boiled with milk and sugar to make sweets called majoon. Gunjah, made from the resinous flower buds, was mixed with tobacco and smoked. Most potent and costly was the resin scraped from the plant, known as churrus.

O'Shaughnessy also studied ancient texts and consulted scholars and doctors about the



Medical marijuana got a try-out in Victorian Britain thanks to William O'Shaughnessy (left)

use of cannabis in traditional medicine. But if he was to experiment on humans, he needed to show that it was safe and gauge the right dose. So he began with stray dogs – followed by cats, goats and even fish, vultures and storks. Some animals became helplessly intoxicated, others hardly at all. Crucially, none died and even those on the highest doses recovered with no apparent harm done.

The first three humans he gave the drug to had rheumatism. Early on the afternoon of 6 November, each received their dose of resin. It had no apparent effect on two of them, but the third grew "very talkative, was singing songs, calling loudly for an extra supply of food, and declaring himself in perfect health".



PAUL FEARIN/ALAMY STOCK PHOTO



After two noisy hours, he fell asleep, just as the other two had. All seemed well. Then came the message.

O'Shaughnessy returned to find his patient "quite insensible". Then things got a little weird. He lifted the man's arm, then let go... instead of dropping, it stayed put. Curious, O'Shaughnessy moved his other limbs. "A waxen figure could not be more pliant or more stationary in each position, no matter how contrary to the natural influence of gravity on the part," he later wrote. The drug had induced a rare nervous condition called catalepsy.

The fuss around the "pliant man" woke one of the other men, who began laughing uncontrollably. The third slept on, apparently unaffected: further inquiries revealed that he was a regular cannabis smoker. The next day, all three "were not only uninjured by the narcotic, but much relieved of their

rheumatism", noted O'Shaughnessy. They were discharged "quite cured" three days later.

Pleased with the results, O'Shaughnessy expanded his trials to other diseases – cholera, tetanus, even rabies. He knew there was no saving the patient with rabies, but with frequent doses of cannabis "the awful malady was stripped of its horrors". In cholera patients, cannabis stopped the sickness and diarrhoea that left them dangerously dehydrated, allowing them to recover.

But the most dramatic results were in cases of tetanus, a disease characterised by muscle spasms powerful enough to break bones and trigger heart attacks – and almost invariably fatal. Cannabis relaxed muscles and prevented the spasms. Almost miraculously, many people recovered. The results, O'Shaughnessy wrote, "seem unequivocally to show that when given boldly and in large doses the resin

of hemp is capable of arresting effectually the progress of this formidable disease".

Cannabis was catapulted into mainstream Western medicine in 1842 when O'Shaughnessy's results appeared in the *Provincial Medical Journal*, forerunner of the *British Medical Journal*. He was in London at the time – with a considerable supply of gunjah. His paper caused huge excitement; at meetings and lectures he was mobbed by doctors keen to explore this potential wonder drug. O'Shaughnessy's plan had always been to delve deeper into the plant's potential and, job done, he returned to India in 1844.

Almost immediately, doctors including John Russell Reynolds, personal physician to Queen Victoria, began to experiment and found cannabis effective in treating migraine

"The first test subject grew very talkative and was calling loudly for extra food"

and epilepsy. It eased nerve and muscle pain and was effective in treating spasms and convulsions.

By 1850, cannabis was listed in pharmacopoeias in Britain, the rest of Europe and the US. In 1890, Reynolds was able to write in *The Lancet* that cannabis was "one of the most valuable medicines we possess". It was also a key ingredient in an array of popular patent medicines, from tonics to corn plasters.

Cannabis remained popular as a medicine for half a century. When it eventually fell out of favour, it was for practical rather than moral reasons. Cannabis wasn't soluble in water, so unlike other drugs it couldn't be injected with the newfangled hypodermic syringe. Quality control was an issue: the active compounds had yet to be isolated, and plant extracts were notoriously variable. Synthetic drugs were the future. Medicinal cannabis lingered on into the 20th century until it was eventually finished off by anti-narcotic campaigns and increasingly tough legislation.

But the research started by O'Shaughnessy never stopped entirely. The identification of a key active ingredient, tetrahydrocannabinol, in 1964 was followed in the 1990s by the revelation that the human body makes its own cannabinoids. We are now in a new phase of investigation with a push to develop synthetic cannabis-like drugs. O'Shaughnessy would have approved. ■

Stephanie Pain is a writer based in Brighton, UK

CULTURE

Game for everything

From the Manchester bombing to the Palestine-Israel peace process, games can help explore difficult issues, finds **Douglas Heaven**

FROM loss and grief to politically explosive situations, games are fast emerging as powerful tools for tackling and exploring difficult issues in controlled environments. This was a major theme at Now Play This!, a show staged by Somerset House as part of London's recent Games Festival that combined gallery and games in an attempt to push the limits in all sorts of ways.

Billed alongside a photography exhibition and the Courtauld Gallery's permanent collection of impressionist paintings, Now Play This! dragged games well outside their comfort zone and challenged us to deal with the ensuing confusion. "It's really great to put games in a space like that," says Holly Gramazio, director of the show, which is now in its fourth year. "It shortcuts the fight you have to have about whether games are deserving of cultural attention."

While a few people demanded refunds because they expected experimental technology, that isn't the point. "The idea that if something isn't at the cutting edge then it's not interesting to an adult is superweird," she says.

In fact, the artistic playfulness of placing games in an exhibition space opened up the possibility of examining personal pain and intractable political situations. Take *The Loss Levels*, a game made by Dan Hett in which he explores the experience of losing his brother in last year's Manchester bombing. A series of microgames engage you in driving a car to the police station, pouring wine into a glass, catching falling bunches



BEN PETER CATCHPOLE

of flowers – mundane activities given tragic weight by the narrative that connects them. Taking part in Hett's story, even at a trivial level, connects you to it – and him – in a chilling way.

Games exploring death and grief have found a commercial

"Many were surprisingly effective, giving an emotional kick in ways different to film or books"

audience of late, from Jason Rohrer's *Passage* – a 5-minute game in which you fall in love and live happily ever after until one of you dies – to *That Dragon, Cancer*, in which you play very upsetting scenes depicting the illness and death of the designers' infant son.

But perhaps one of the most audacious games on display

was *Roadmap for Peace*, which presents the Israel-Palestine peace process as two interleaving Scalextric tracks laid out across a large table. The roads run parallel for a stretch then loop and intersect. The aim is for a pair of players to get both cars around without crashing them. It is harder than it looks: as you build up speed down the straight, it can be hard to find the humility to let your partner catch up – or to avoid flying off the track entirely.

This exhibit was the work of artist Yara El-Sherbini. "She's got a strong background in taking familiar games and using them both as a joke and a commentary," says Gramazio.

Last year, El-Sherbini made *Operation Brexit*, a variation of the Hasbro game *Operation*, in which you have 10 seconds

Games can push people outside their comfort zone

to extract the UK from the EU using plastic tweezers – without raising an alarm.

For some, especially those who think games are only for kids, turning grief or political impasse into play may feel facetious or disrespectful. But that is the nature of an experimental medium, and many of the games on show were surprisingly effective, giving an emotional kick in ways that are very different from film or books.

When it comes to what games are and what they can do, there is still everything to play for. Back at *Roadmap for Peace*, I watched as two children derailed their cars – over and over again. ■

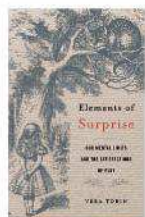
Douglas Heaven is a technology writer

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What happened in the end?

The way our minds work is revealed in a fascinating book probing the stories we tell to entertain ourselves and help us cope with the world. **Simon Ings** explores

Elements of Surprise: Our mental limits and the satisfactions of plot by Vera Tobin, Harvard University Press



HOW do characters and events in fiction differ from those in real life? And what is it about our experience of life that fiction exaggerates, omits or captures to achieve its effects?

Effective fiction is Vera Tobin's subject. And as a cognitive scientist, she knows how pervasive and seductive it can be, even in – or perhaps especially in – the controlled environment of an experimental psychology lab.

Suppose, for instance, you want to know which parts of the brain are active when forming moral judgements, or reasoning about false beliefs. These fields and others rest on fMRI brain scans. Volunteers receive short story prompts with information about outcomes or character intentions and, while their brains are scanned, have to judge what other characters ought to know or do.

"As a consequence," writes Tobin in her new book *Elements of Surprise*, "much research that is putatively about how people think about other humans... tells us just as much, if not more, about how study participants think about characters in constructed narratives."

Tobin is weary of economists banging on about the "flaws" in our cognitive apparatus. "The

science on this phenomenon has tended to focus on cataloguing errors people make in solving problems or making decisions," writes Tobin, "but... its place and status in storytelling, sense-making, and aesthetic pleasure deserve much more attention."

Tobin shows how two major "flaws" in our thinking are in fact the necessary and desirable consequence of our capacity for social interaction. First, we wildly underestimate our differences. We model each other in our heads and have to assume this model is accurate, even while we're revising it, moment to moment. At the same time, we have to assume no one else has any problem performing this task – which is why we're continually

mortified to discover other people have no idea who we really are.

Similarly, we find it hard to model the mental states of people, including our past selves, who know less about something than we do. This is largely because we

"Tobin is weary of economists banging on about the 'flaws' in our cognitive apparatus"

forget how we came to that privileged knowledge.

There are implications for autism, too. It is, Tobin says, unlikely that many people with autism "lack" an understanding that others think differently – known as "theory of mind". It is more likely they have difficulty

inhibiting their knowledge when modelling others' mental states.

And what about Emma, titular heroine of Jane Austen's novel? She "is all too ready to presume that her intentions are unambiguous to others and has great difficulty imagining, once she has arrived at an interpretation of events, that others might believe something different", says Tobin. Austen's brilliance was to fashion a plot in which Emma experiences revelations that confront the consequences of her "cursed thinking" – a cognitive bias making us assume any person with whom we communicate has the background knowledge to understand what is being said.

Just as we assume others know what we're thinking, we assume our past selves thought as we do now. Detective stories exploit this foible. *Mildred Pierce*, Michael Curtiz's 1945 film, begins at the end, as it were, depicting the story's climactic murder. We are fairly certain we know who did it, but we flashback to the past and work forward to the present only to find that we have misinterpreted everything.

I confess I was overwhelmed on finishing this excellent book. But then I remembered Sherlock Holmes's complaint (mentioned by Tobin) that once he reveals the reasoning behind his deductions, people are no longer impressed by his singular skill. Tobin reveals valuable truths about the stories we tell to entertain each other, and those we tell ourselves to get by, and how they are related. Like any good magic trick, it is obvious once it has been explained. ■



AF ARCHIVE/ALAMY STOCK PHOTO

Emma: Jane Austen's heroine fails to see that others think differently

CULTURE

The art of remembering

Powerful reminders of nuclear and military pasts echo in an uncertain present, says **Bob Holmes**

Bombhead, Vancouver Art Gallery, Canada, until 17 June;

Bombs Away: Militarization, conservation, and ecological restoration by David G. Havlick, University of Chicago Press

NUCLEAR apocalypse, a threat that only a few years ago seemed to have passed into history, is back at the forefront of our minds. Suddenly, the Vancouver Art Gallery's latest exhibition, *Bombhead*, is more timely than curator John O'Brian could have imagined when he began planning it two years ago.

O'Brian, a former art historian at the University of British Columbia in Canada, has curated an eclectic mixture of nuclear-themed art, drawn largely from the gallery's permanent stores and his own personal collection, to remind us of our shared nuclear history.

The exhibition space is divided into four areas: The Bomb, Fear, Document and Protest. Not surprisingly, the most wrenching works turn up in Fear. Here Nancy Spero's five paintings, particularly *Bomb and Victims*, stand out for their hallucinatory depictions of mushroom clouds filigreed with human figures vomiting blood and bleeding from wounds. Betty Goodwin's *Rooted Like a Wedge* offers nothing overtly nuclear, but her smudges of grey and tan, abstract at first glance, gradually reveal tortured human figures that build a powerful sense of pain and foreboding.

Other works are more cerebral. Andrea Pinheiro's *Bomb Book* assembles the names of all 2450

nuclear detonations that have taken place since 1945, one per page. The resulting 12-volume set vividly illustrates the scale of nuclear testing. A collection of pamphlets from the 1960s shows bomb shelters and nuclear survival tips, and even, chillingly, includes one called *Fun with the Atom*. Then there is a series of images from Vancouver photographer Robert Keziere that captures the origins of Greenpeace, which started life in Vancouver as a protest against the US nuclear test on Amchitka Island, Alaska, in 1971.

The centrepiece of the show,

however, is Bruce Conner's film *Crossroads*. Wordlessly, it shows a 1946 US nuclear test explosion at Bikini Atoll and its mushroom cloud over and over and over again, in slow motion, from different angles until the viewer feels battered and overwhelmed.

The cloud lingers long after the film ends, an after-image reinforced by the inclusion of Conner's other major work, *Bombhead*, a portrait of a military

"If we forget these sites were once military, we may foster a blithe acceptance of them as wildlife havens"

officer with a mushroom cloud where his head should be. That remembrance is an important counterpoint to the complacency that set in after the end of the cold war. "The people I know have forgotten to be afraid of the arms race," says O'Brian.

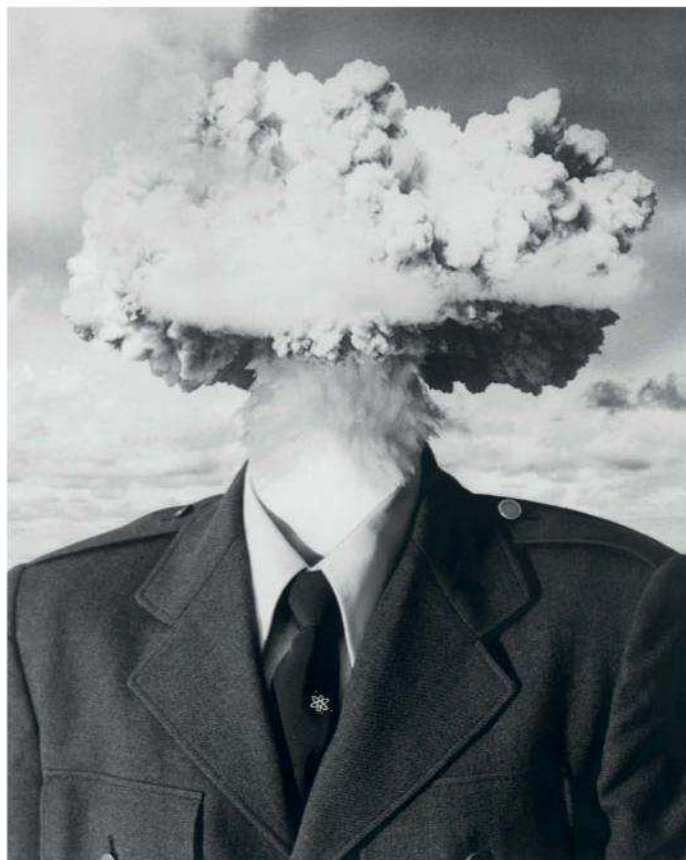
It is vital to remember other kinds of military legacies, too, as David Havlick's book, *Bombs Away*, powerfully demonstrates. Havlick, a geographer at the University of Colorado, explores the conversion of old military sites into wildlife refuges.

He visits decommissioned military bases in the US, the demilitarised zone between North and South Korea, and the "Iron Curtain Trail", a park running the length of the old Iron Curtain that divided eastern and western Europe.

It is easy to see the conversions as ecological success stories – and in many ways they are. But Havlick is adamant that this coat of green paint mustn't obscure the sites' uncomfortable histories and legacies, in many cases of unexploded ammunition, toxic chemicals and human displacement.

If we forget what these sites once were, he says, we may foster a "blithe public acceptance of these places as havens for wildlife without examining or holding accountable the actions and institutions that produced such damaged landscapes". Like O'Brian, Havlick's aim is to nettle us out of an easy complacency about our military history and future. Sadly we may not need that netting now. ■

Bob Holmes is a consultant for *New Scientist*



BRUCE CONNER BOMBHEAD, 1989/2002; PIGMENT ON RC PHOTO PAPER, ACRYLIC PRIVATE COLLECTION © ESTATE OF BRUCE CONNER/SODRAC (2018)

***Bombhead* by Bruce Conner: a visceral reminder of the atom bomb**



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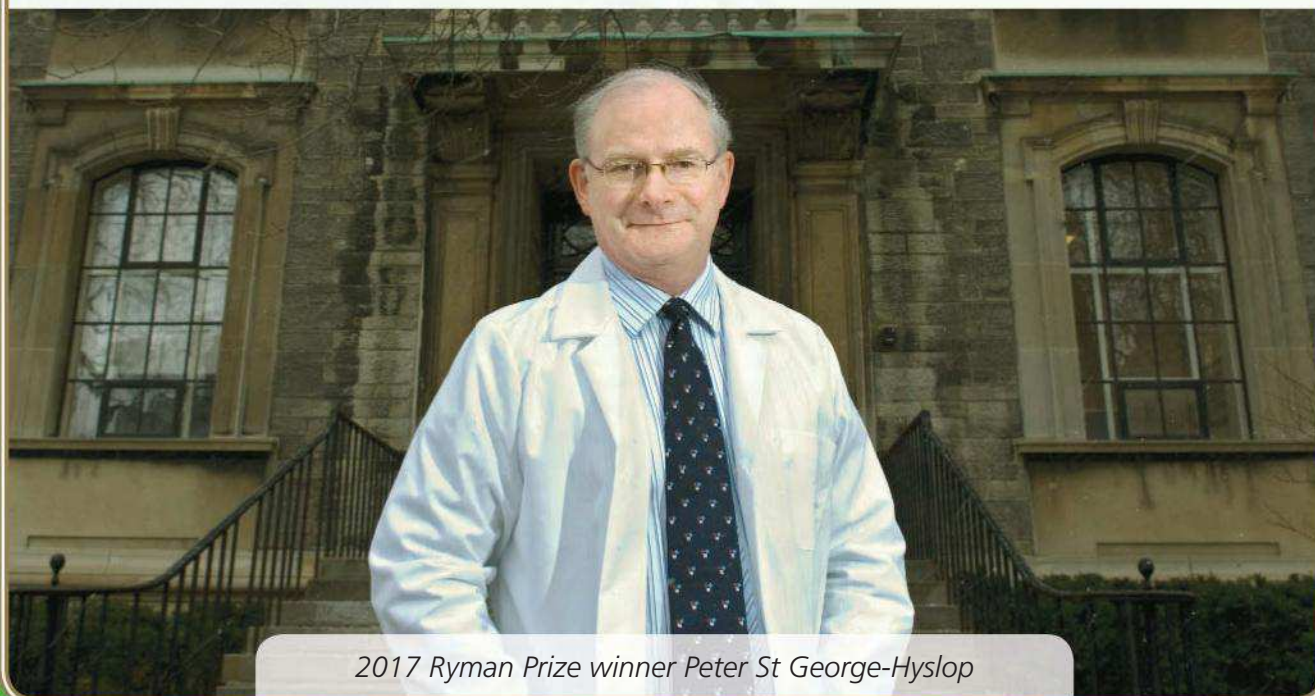
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EDITOR'S PICK

Philosophy can describe science, not define



From Rachael Padman,
Cambridge, UK

Trevor Hussey warns scientists that methods change, which is undeniable (Letters, 14 April). But he suggests we need to discuss with philosophers not only methods, but also our objectives. Isn't this putting the cart before the horse? The philosopher David Hume

understood philosophy as the inductive, experimental science of human nature. This can describe science, but not prescribe its goals.

In my experience, most scientists don't have grand philosophical objectives: we are driven simply to Explain Things. In this respect we are no different from Aristotle, though in 2500 years we have become better at recognising a good explanation.

Moral philosophy, on the other hand, is at heart an inquiry into how we should live (and, by inference, think). Tellingly, its "answers" have varied over time: Thomas Hobbes argued that the sovereign's judgement was absolute.

Philosophy may be helpful in understanding a society's scientific priorities, but I would be amazed if any scientist ever defined their motivation by any philosophical "should".

What work might robots take away from humans?

From Ben Dallimore,
Isle of Luing, Argyll, UK
Sally Adee reports that robots aren't coming for our jobs and indeed they may be creating more work (14 April, p 9). So what is the point in having them?

Ask anyone who did housework in the 1950s about vacuum cleaners and washing machines. They gave people leisure time. They removed drudgery. They improved the quality of life. That's what robots should be doing for us now, not sending us into tedious office jobs. What we need is a new way to distribute wealth.

From Carl Benedikt Frey,
University of Oxford, UK
Adee argues that automation anxiety is overblown, but conflates current automation

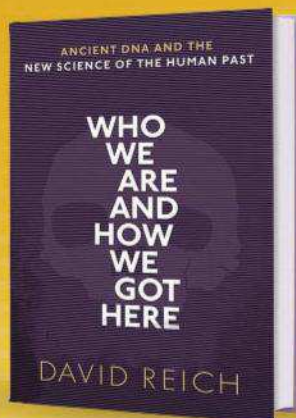
with the future potential for automation. She cites my research with Michael Osborne, which estimates that roughly 47 per cent of US jobs are exposed to automation technologies – but argues that this is overstated because recent surveys of the workplace in Germany suggest that not very many jobs have been automated away so far.

The tractor had virtually no impact on jobs before 1920: should this have been taken as evidence that it was an unimportant technology? It took almost half a century for its full effects to materialise.

How sex differences may lead to extinctions

From Carl Zetie,
Raleigh, North Carolina, US
You report researchers finding that the species of ostracod

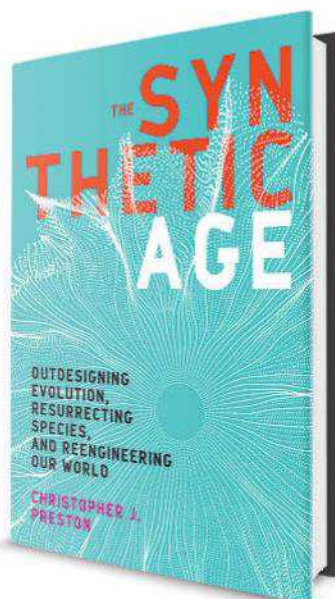
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“... says the builder who accidentally hit the solar panel with a hammer”

Heather Tweed responds to the news that poking tiny dents into solar panels makes them work better (28 April, p 9)

crustaceans with the largest differences between the sexes were also the most vulnerable to extinction (21 April, p 9). They speculate that the cause may be related to devoting resources to sexual display at the cost of other survival functions, much like the peacock's burdensome tail.

This only works to explain extinctions if the burden affects individuals before they are able to reproduce; and that would inevitably select out both the male characteristic and the female preference for it.

A better explanation is that selection for extreme characteristics can easily lead to a genetic bottleneck based on a very narrow definition of “fitness”, with the population rapidly becoming dominated by the descendants of fewer and fewer individuals with the most extreme features. When the

environment changes, species survive and evolve by having a diverse enough genetic pool that some individuals can endure, even if they were not the “fittest” under the previous conditions. Consequently, it seems plausible that selection based on unhelpful secondary characteristics can create a bottleneck and leave an entire species vulnerable to changes in their environment, explaining the extinction patterns seen by the researchers.

More challenges of screening for cancer

From Nick Hardwick, Stafford, UK

H. Gilbert Welch makes a very good point about the danger that screening will find cancers that aren't going to do us any harm (7 April, p 44). However, as a doctor who has investigated

many people for cancer, and who has been investigated for cancer myself, I think the real challenge for medicine is to determine which tumours will progress dangerously, and which will not.

From Bob Falconer, Winchester, Hampshire, UK

I accept that screening for prostate-specific antigen (PSA) doesn't appear to improve prostate cancer survival rates. But I see a paradox. PSA screening followed by checks for symptoms can lead to unnecessary invasive procedures. But when symptoms appear they are generally followed by PSA testing – and the same invasive procedures. Why does it matter what sequence the evidence arrives in?

The editor writes:

■ It's all about the effect of screening large numbers. Testing

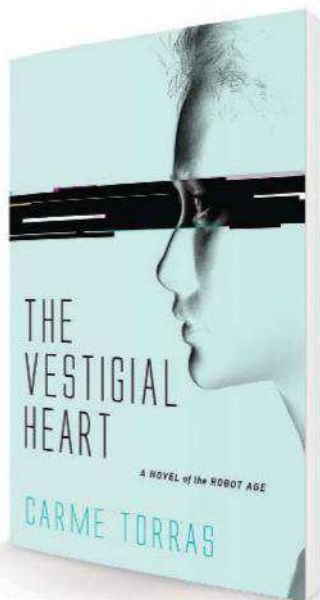
for PSA levels in men who have no symptoms will lead to many more false positives than testing it only in those who do, so it will subject more to unnecessary treatment.

In whom do we put our trust for harm reduction?

From Liz Bell, Great Shefford, Berkshire, UK

I quite agree with the boycott signatories demanding that autonomous weapons lacking meaningful human control shouldn't be developed (14 April, p 24). But the overwhelming issue with guns is leaving them unmonitored in the hands of humans who can't be trusted to behave reasonably and rationally.

History is littered with war and other crimes, not to mention the epidemic of attacks on schools in the US and elsewhere. So I suggest that AI be built into all guns to ▶



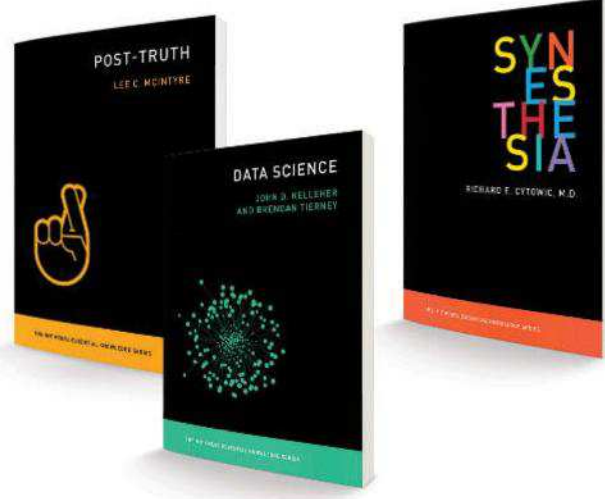
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actively monitor their human users. The weapons should be able to fire only when both the human user and the AI agree that it is the right and proper thing to do so.

Not all casualties in war are soldiers

From Geoff Browne,
Sydney, Australia

You report Aaron Clauset classifying the size of a war by the number of soldiers killed (3 March, p 15). Civilians aren't included. This criterion leads to the bizarre consequence that a war (nuclear or otherwise), fought by artificial intelligence and killing few soldiers but millions of civilians, would be unworthy of recognition as a "large war".

Artificial intelligence for better or for worse-ish

From Alec Cawley,
Penwood, Berkshire, UK

Timothy Revell suggests that watchdogs could go through the code of an artificial intelligence "line by line" to understand the decisions it makes (14 April, p 40).

But it isn't the code that matters: it is the data set on which the code is trained. A classic example is the automatic tap which, trained on white hands, didn't turn on for brown hands.

The idea of testing systems for bias by adjusting inputs and seeing if outputs change works only for factors you choose to test. If you don't realise that short people literally have a different worldview, you will never see a bias against them.

From Adrian Bowyer,
Foxham, Wiltshire, UK

Timothy Revell's discussion of the need for transparency in computer systems that decide whether or not you get a loan, or how long you will spend in jail, was most welcome. But can we stop calling them "algorithms"?

An algorithm, such as the rules for long multiplication, is precise. All the systems that the article discusses are like the nearest-neighbour method for solving the travelling salesman problem.

This is a "heuristic": it almost never gives the best answer; often gives a good answer;

sometimes gives a bad answer; and sometimes completely fails.

The current AI explosion is entirely heuristic.

The editor writes:

■ This distinction is no longer widely made by practitioners of the craft, and we have to follow language as it is used, even when it loses precision.

Batteries can help keep the lights on

From Geoff Russell,
St Morris, South Australia

Garry Trethewey seems to think that renewable energy sources weren't behind South Australia's state-wide blackout in 2016 (Letters, 7 April). As the final report of the Australian Energy Market Operator sets out, there were two issues.

Why did 450 megawatts of generating capacity drop out? This was connected with over-sensitive safety settings on wind farms. And why did it lead to a state-wide blackout?

There were three similarly sized capacity losses before 2016, and

none led to a state-wide blackout. That's because the inertia of large spinning generators kept the electricity supply frequency up for the time it took to "shed load" – to cut off large customers, for example – and keep the system running. In 2016, the low inertia of renewable sources couldn't do this.

The 100-megawatt Hornsdale battery will replace some of this inertia effect. So could the interconnector that Trethewey mentions the new state government promising. Though the interconnector may have more to do with wanting cash from exporting the excess wind power that is currently wasted, a vastly expanded transmission network is a necessary part of any energy system with high levels of wind and solar generation.

An earlier case of making tools from stools

From Paul Whiteley,
Bittaford, Devon, UK

Making tools from stools is neat (14 April, p 15). But it's not new.

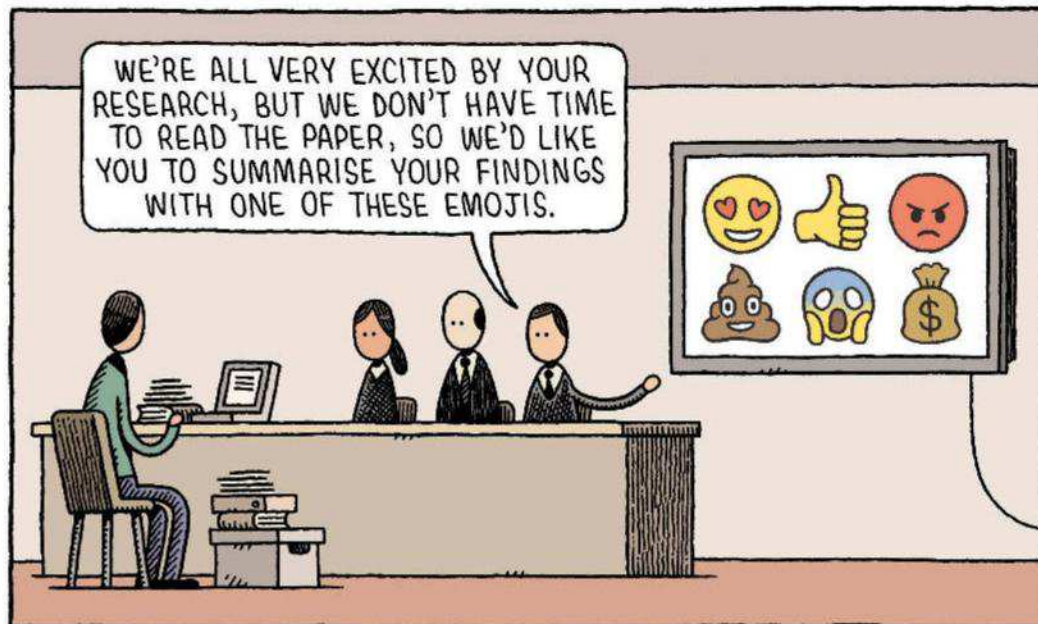
In his autobiography, the Danish explorer Peter Freuchen writes about the time he took shelter from a blizzard under his sledge in Greenland and realised the snow that had drifted over him had frozen, entombing him. He couldn't dig himself out as his gloved hands couldn't get a purchase and taking his gloves off to dig would mean losing his hands to frostbite.

His solution? He passed a stool and while it was still soft shaped it into a chisel, which he allowed to freeze and harden. He then dug away the snow and freed himself.

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TOM GAULD



OLD SCIENTIST

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



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IT SEEMS there was less concern, and obviously a more muted conscience, in science's past views about letting animals meet a sticky end in the name of experimentation. We all know about dogs and monkeys being dispatched into space, usually never to return, but new frontiers were in sight in 1969. In our 15 May edition we reported that three goats – Olive, Pollux

and Charlot – had spent two weeks in a pressure chamber at the University of Marseille, simulating the conditions 2500 feet (about 760 metres) underwater. They adapted well but – in a move that might raise concerns today – Olive was selected for slaughter to check if her organs had been damaged. We did not report the outcome, but Olive's sacrifice seems somewhat unnecessary given that the lead experimenter, Professor J. Chouteau, "warned against relating the results obtained with goats directly to Man".

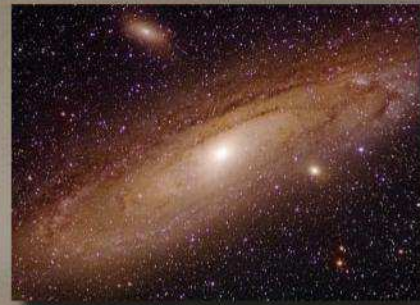
For those who would prefer humans to have no dominion over animals, horse racing can also incite ire. Racehorses tend to be marginally better treated than decompressed goats, but they have still had muscle tissue samples removed. We reported in our 28 May 1994 edition that researchers at Bristol's School of Veterinary Science in the UK had identified which muscle types in which distributions were likely to lead to a champion racehorse, and also whether it would be a sprinter or a distance runner. We chickened out of predicting a potential winner of the imminent Epsom Derby, though.

By 2006, it seemed animals were doing their own experiments. On 29 April, we told how Utah State University biologists fed lambs different substances to cure illnesses. When the lambs recovered, they were able to remember which chemical had made them better and would use it again if illness recurred. We opined that sheep could no longer be described as "stupid". Researcher Juan Villalba told *New Scientist* that if stupid "means an inability to behave based on past experiences... sheep are not stupid at all". **Mick O'Hare** ■

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"Facts do not cease to exist because they are ignored" Aldous Huxley

...to save time, assume I know everything...



FOUR baboons staged a breakout from a secure research facility in San Antonio, Texas, through an ingenious use of their feed barrels. The baboons were kept in an open-air enclosure holding 133 monkeys at the Southwest National Primate Research Center. The centre houses more than 1000 baboons, which are used in research into obesity, heart disease and more.

Several large bright blue drums had been provided to enrich the baboons' open-air pen. By rolling the barrels, they could release food from small holes, mimicking foraging behaviour.

But according to the Texas Biomedical Research Institute, the enterprising baboons rolled the barrel to the enclosure wall and stood it upright. Climbing on top of this gave them enough height to leap over the wall, making their escape.

One baboon - perhaps getting cold feet - returned soon after, but the three other escapees continued on past the perimeter fence into the surrounding countryside. Their taste of freedom was short-lived: within an hour all were apprehended and returned to the facility.

A 5000-year-old cow skull recovered at a Neolithic site in France bears signs of the earliest recorded animal surgery. Found at Champ-Durand, the skull appears to have had a small hole drilled in it, through to where the right frontal lobe would be.

Writing in *Nature*, researchers Fernando Ramirez Rozzi and Alain Froment report that the skull is otherwise intact, indicating that the hole was meticulously carved out rather than being the result of a traumatic injury.

Unfortunately for this patient, there are no signs that the injury healed, implying that this Stone Age surgery may have been fatal. Alternatively, the work could have been performed on a dead animal, perhaps by someone who (understandably) wanted to practise the technique before carrying it out on a human.

Humans skulls with holes drilled in them have been found from as long ago as 10,000 BC. Yet evidence of animal experimentation is rare, because animals were an important food source and

skulls were often cracked open to retrieve the brain and tongue to eat - a practice frowned on in most laboratories these days.

POLICE in Switzerland are on a duck hunt, after a feathered felon was photographed by speed cameras flying down the road at almost twice the legal speed limit. The duck is suspected to be a repeat offender, because a similar-looking duck was caught on camera in Köniz a few days earlier, travelling at 52 kilometres per hour in a 30 zone.

Typically, road users can expect to earn a one-month driving ban for such an offence, plus a fine calculated according to the offender's wealth. It isn't clear if police would be able to collect their bread, however: the Köniz local authority posted the photos of the speeding duck on its Facebook page, asking users for suggestions on where to send the tickets.

SHE has bested aliens, swamp monsters and clandestine spies while investigating *The X-Files*, but Dana Scully's greatest victory may be encouraging more women to follow in her footsteps.

A study from the Geena Davis Institute on Gender in Media suggests that the medical doctor and FBI agent, played by Gillian Anderson, inspired a generation of women to enrol in careers related to science, technology, engineering or medicine (STEM), a pattern they are calling the Scully Effect.

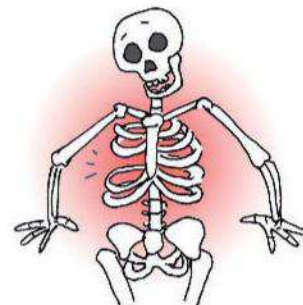
Two thousand women aged 25 and over were asked how frequently they watched *The X-Files* and what influence it had on their career aspirations. Half of those familiar with Anderson's character said she increased their interest in STEM careers. Women who watched the show regularly were more likely to have considered a STEM career, studied these subjects at college and entered these professions.

Of course, those with a budding interest in science may well have been a natural fit for a prime-time

science fiction TV show, and it remains to be seen whether the Scully Effect is one of causation or simple correlation. As Scully herself might say: the truth is out there.

YOUR childhood theories continue to brighten our inbox. Presaging a future in engineering, John Roberts was thinking about mechanics from an early age. "When about 5 years old, I was told that you had a pipe to breathe down in your throat and one for food. But I misheard and thought you had different pipes for different foods." John says he was unsure how many tubes he had and worried what might happen if he encountered a new food - would he have the right pipe to eat it?

AND Jane Cope offers a famous example found in Francis Crick's memoir *What Mad Pursuit*. Here, the author writes how as a child,



the biblical story of Eve being created from Adam's rib led him to the assumption that all men have one less rib than women.

"He lost his religious faith at a young age," says Jane, "but the erroneous belief about human anatomy persisted. It was only in his undergraduate years that he was put straight by a medical student friend who 'almost fell off his chair laughing'."

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Reading Alice Klein's article on sexual dimorphism, Debbie Phelan says she was "momentarily uncertain whether 'Gene Hunt at the Smithsonian' was a person or a research project."

THE LAST WORD

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Whistle down the wind

When the wind howls, what exactly is making the noise?

■ When the wind blows over, through or round an object, it can produce whistles, whistles or howls, depending on the shape of the object and the wind speed. The interaction creates turbulence in the air in the form of eddies, or vortices. As a vortex forms, there is a change in air pressure within it and this propagates a pressure wave. A series of vortices, produced at a certain frequency, will make a sound of the same frequency. As the wind speed

that produce sounds as the wind blows through their strings; they are named for Aeolus, the mythological keeper of winds.

*David Muir
Edinburgh, UK*

■ A neighbour who lived at the top of a hilly and windy estate in Yorkshire always complained about how noisy the wind was in his house. It whistled, howled and moaned around the property. While in his living room one day, I realised that the wind noise was louder when I was standing by his front window. I then noticed that someone at some time had drilled a hole through the bottom of his window frame in order to pass a TV aerial cable through. The cable had since been removed, leaving the open hole. I put my thumb over the hole and the wind noise instantly stopped. It had been acting like the mouth hole in a flute or a piccolo. We plugged the hole and that eliminated all the wind noise.

In summary, wind noise results from some small feature of a building that generates the vibrations of the air which then causes the sound.

*William Poole
By email, no address supplied*

Running battle

Runners have long debated the difference between training on a treadmill and training on solid ground. "Belt turnover" is commonly cited as a factor that helps to move your

foot backwards and thereby makes running on a treadmill easier than running on the road. At constant velocity, is this a real effect? If so, wouldn't it be felt on any "moving" surface you walk on, such as a train or plane – or even Earth?
(Continued)

We realise that this discussion could – if you'll forgive the pun – run and run, so we are declaring the correspondence closed with reference to New Scientist's recent exercise myths special: regardless of whether running on a treadmill is any easier or not, its monotony makes it seem harder (13 January, p 31) – Ed

■ Readers Christopher Kimberley and Eric Kvaalen disagree with my explanation of "belt turnover" (Last Word, 10 February), and I would like to respond.

On a treadmill, the belt is driven at constant speed, while the runner remains stationary. There is no horizontal acceleration of the runner with respect to the belt, hence no work is done by the runner other than that required to move their centre of mass up and down, and move their limbs. It makes no difference which reference frame we select: it is the relative motion between belt and runner that matters.

In contrast, consider the same runner on a flat, level surface, moving with apparently constant velocity, with a tail wind to match, so we can disregard wind resistance.

Our runner must exert a

horizontal force against the ground with each stride. If you doubt this, consider what happens if the runner encounters a low friction surface, such as a patch of ice, loose carpet or perhaps spilled marbles.

Why doesn't this force cause the runner to accelerate? Well, it does. With each stride, the runner repeats a cycle of acceleration and deceleration. Those in the field of biomechanics refer to this as the gait cycle, and the acceleration and deceleration periods are known as absorption and generation, respectively. As with any physical work cycle, energy losses exceed gains, with the deficit here made up by the runner.

On the treadmill, there is altogether less work being done, and the treadmill motor is doing some of it.

*Howard Bobry
Nehalem, Oregon, US*

"Aeolian harps are musical instruments designed to be played by wind as it blows through their strings"

rises, so does the rate of vortex formation and, hence, the pitch of the sound.

As wind blows through trees, it can produce the white noise of a waterfall because of the different frequencies formed at twigs, branches, boughs and trunks, which all have different diameters and textures.

If the wind blows past something like a wire fence, and the frequency of the vortex formation matches the resonant frequency of the wire, the wire will vibrate so that it sings, adding to the wind's harmonies. Aeolian harps rely on this effect. They are musical instruments

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This week's questions

LEGGING IT

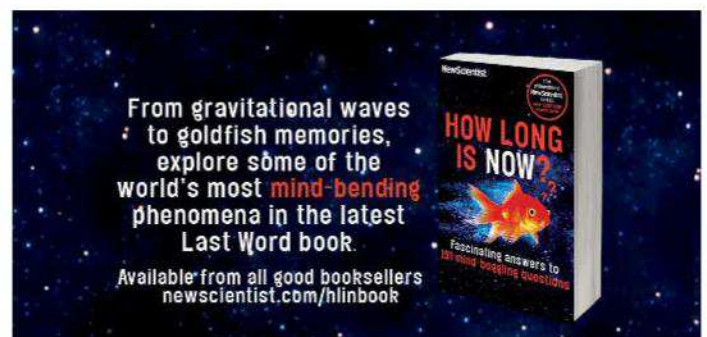
Why aren't there any big animals (not insects) with six legs, or eight legs or more than this?

*Sasha Proudlove (aged 10)
Potters Bar, Hertfordshire, UK*

SUPERSTRING THEORY

Would a very, very, very long piece of string reaching from Earth's surface deep into space remain suspended?

*Geordie Berry (aged 11)
Floreat, Western Australia*



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