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FRANK KURNIAWAN

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THE FUTURE OF HEALTHCARE NEEDS YOU

The location is deep space. Lost astronaut Nozomi floats, alone, running out of hope that she will hear from Earth again. Until one day, a glimmer of hope flickers through the radio. The fictional story of Nozomi was written by Alastair Clayton and turned into the movie *This Is Axiom*, starring Yuriri Naka as the hapless astronaut. Surprisingly, it was not commissioned by Netflix or Hollywood, but by global biopharmaceutical company Celgene, which was looking for a bold, new way to engage people with the issues we face in healthcare.

"Too often people read a headline about drug prices being too high or patients unable to access the latest medical advances," says Kevin Loth, Celgene's vice-president for corporate affairs for Europe and International markets. "They are not getting the full picture of what is a very complex story with no simple answers."

Healthcare is a truly complex issue. Innovations in medicine have led us to living longer, healthier lives and have brought huge benefits to healthcare systems and society. But healthcare systems are under pressure from increasing demand for new and improved treatments. When resources are tight, too often the first thing to go is innovation. In fact, we could reach the day when it is easier to put a person on the moon than it is to bring a new medicine to the people who need it.

No one is against medical innovation. The problem is that despite sharing a common goal, physicians, health economists, policy-makers, academia, patients, carers, other pharmaceutical companies and the media all have very different views on how to achieve it.

Celgene hopes that the movie will foster the collaboration and dialogue needed to make progress. Nozomi's plight is a metaphor for the future of healthcare. Celgene believes that her story will open people up to thinking differently about a topic they thought they understood. "We all need to share our views and find solutions together," says Loth.

Celgene will be screening the movie premiere in the Humans Theatre and discussing why it took this novel approach. You can also listen to a panel of healthcare experts share their thoughts on the complex issues raised through the film.

Throughout New Scientist Live, you can watch the movie and see how it was made at the Celgene stand. Crucially, you can add your views on the future of healthcare. "Celgene is ready to lead the discussion," says Loth, "but we need your voice too."

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Contact us

newscientist.com/contact

General & media enquiries
enquiries@newscientist.com

US
45 Prospect Street,
Cambridge, MA 02139
Tel +1 781 734 8773

UK
110 High Holborn, London WC1V 6EU
Tel +44 (0)20 7611 1200

AUSTRALIA
Level 11, Suite 3, 100 Walker Street,
North Sydney, NSW 2060
Tel +61 (0)2 9422 8559



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KATARZYNA BIALASIEWICZ/GETTY

Fight fire with fire

To stop the trolls, targets of online hate must come forward

IT ISN'T news that the internet is awash with hateful content. But it is still shocking to put yourself in the shoes of somebody who has been on the receiving end. Game designer Zoë Quinn's experiences during the Gamergate affair were extreme, but are a chilling lesson in how internet hate campaigns can ruin lives (see page 42).

The psychological drivers of online abuse are well understood. Anonymity emboldens some people to post things that they would hesitate to say. Trolls can get swept up in a mob mentality, the thrill of transgression, or the twisted belief that it is all a bit of harmless fun.

These are not excuses. Online abuse is a crime, pure and simple.

One long-standing problem is that the law is slow to catch up. Quinn recounts how the police were often powerless to act.

In some places, that is changing. The Crown Prosecution Service (CPS) in England and Wales has stated that online hate crimes are the same as real-world ones. Posting material motivated by "hostility or prejudice" is just as illegal as shouting racist abuse or daubing Islamophobic slogans. For the perpetrators that could mean jail: incitement to religious or racial hatred carries a sentence of up to seven years.

That is an overdue clarification, but it still leaves much to be desired. The new CPS guidelines don't explicitly cover misogynistic abuse; the law is also toothless to tackle brokers who buy and sell personal information and hence enable abusers to discover where their targets live.

But perhaps the biggest change needed is in public perception. Online abuse is shockingly common, but rarely prosecuted. The CPS has invited victims to change that. But unless people come forward, the scale of the problem will remain hidden, and the tyranny of the mob will go unchallenged. ■

Welcome change

SOCIETY takes a keen interest in women's bodies, especially during their fertile years. Yet when the menopause comes around, the conversation goes quiet. Aside from trivial quips about hot flushes and "the change", menopause remains taboo.

This isn't simply men skirting around the issue. A recent survey found that half of UK women go

through the menopause without consulting a doctor. Why? Over a third of them believed it was something they just had to put up with. If women suffer in silence, it's unsurprising that many are blindsided by the severity of their symptoms, especially problems with memory and concentration.

New research into these symptoms provides a wake-up

call that menopause amounts to a lot more than hot flushes. The changes echo some of those seen later in life, in both men and women, as the brain succumbs to Alzheimer's (see page 36).

Rather than being depressing news, the findings should lead to menopause and its attendant health problems being taken more seriously. They may even be a cue for more grown-up conversations about a phase of life that affects us all, one way or another. ■

Harvey's dreadful toll

HURRICANE Harvey made landfall late on Friday night. It is one of the worst hurricanes to hit the southern US since Katrina struck New Orleans in 2005. As *New Scientist* went to press, Harvey's status had been downgraded to "tropical storm" but it was still battering the Houston area with heavy rainfall.

The storm has caused catastrophic floods. Nine people are reported dead as emergency services struggle to evacuate thousands of residents.

Texas is no stranger to such events: in 2008, Hurricane Ike killed 74 people in Texas and caused almost \$40 billion in damages. Yet Texas has since done little to prevent further hurricane damage.

"Houston is sort of playing catch-up," says Philip Bedient at Rice

University in Houston. "We know what needs to be done, but just need to find the political will to make it happen."

One big idea is the "Ike Dike": a coastal barrier across Galveston Bay designed to protect the shore from storm surges. But the project hasn't got off the ground.

What's more, just 10 days before Harvey hit, President Trump rolled back flood risk regulations passed by the Obama administration. The rules required federally funded, public infrastructure to be designed with climate change impacts like sea level rise in mind. Trump argued that they slowed down construction. Bedient calls it "a terrible precedent".

If no steps are taken, the risk is that Texas will be just as unprotected the next time a Harvey-level storm hits.



No defences

Execution cocktail

FLORIDA conducted an execution last week using a lethal injection cocktail that included a chemical never before used for this purpose.

Mark James Asay was convicted of two murders and sentenced to death in 1988. He was executed using a cocktail of rocuronium bromide, to cause paralysis, and potassium acetate, to stop the heart. The latter had been used in an execution just once before, by mistake.

The mixture also included etomidate, an anaesthetic never

Berkeley Law, University of California. "We do not know if it is safe and effective."

US states with the death penalty have recently had to change the drugs they use for lethal injection because pharmaceutical companies have either stopped selling certain drugs or refused to sell them for use in executions.

Asay's lawyers had challenged Florida's planned use of etomidate, but the state Supreme Court ruled that they had "failed to establish sure or very likely risks of sufficiently imminent danger or a proposed alternative that is readily available".

"The state does not have to show that the protocol is safe before they use it," says Moreno. "The burden is on the prisoners, which is highly problematic because states like Florida refuse to provide prisoners with key information about the drugs and the reasons for selecting certain drugs."

Around 1 minute after being given etomidate, Asay's feet reportedly twitched. He was pronounced dead a few minutes later.

"Florida has not provided any information about why it made the switch to etomidate"

before used in this way. It replaced the sedative midazolam, which has been implicated in a number of drawn-out and possibly painful executions in the US.

"Florida has not provided any information about why it made the switch to etomidate or whether it consulted with medical experts," says Jen Moreno of

Making waves

HAVE we detected a new flavour of gravitational wave? Speculation is rife that two neutron stars have collided, producing such a wave.

These waves come from dense objects like black holes or neutron stars crashing into each other. Two experiments – LIGO and VIRGO – detect tiny changes in the path of laser beams caused by passing gravitational waves.

Earlier this month, rumours spread as many optical telescopes turned their attention on

NGC 4993, a galaxy about 130 million light years away. LIGO has deals with observatories to rapidly follow up potential signals before any formal announcement. Since colliding black holes don't produce light, a neutron star collision is the most likely source.

Last Friday, LIGO released a statement saying it had identified a number of promising signals. It said researchers are working to ensure the candidates are valid gravitational-wave events and will announce results as soon as they have them to share.

Ballistic missile over Japan

NORTH KOREA launched a ballistic missile on Tuesday that flew over Japan and landed in the Pacific Ocean.

The missile – thought to be a Hwasong-12 intermediate-range ballistic missile (IRBM) – was fired from North Korea at 5.58 am Japan time. It travelled 2700 kilometres before splashing into the sea about 1000 kilometres east of Japan's Hokkaido island.

This is the first time North Korea has launched a ballistic missile over

Japan. Yoshida Suga, Japan's chief cabinet secretary, said this was an "unprecedented, serious and grave threat to our nation".

North Korea might have been testing whether its IRBM could carry a re-entry vehicle for deploying nuclear warheads. The IRBM didn't cover its maximum 4500 kilometres, which is consistent with it carrying the extra weight of a re-entry vehicle, says Marko Beljac at the University of Melbourne, Australia.

60 SECONDS

Welfare drug tests

THE Australian government is planning a two-year trial of random drug tests for people who get welfare payments.

If approved by Parliament, the trial will kick off next year and

"Inability to change behaviour is a hallmark of addiction, so punitive approaches don't work"

involve 5000 people who apply for government income support because they can't find work or are studying. They will have random saliva, urine or hair tests to detect use of illegal drugs.

A positive result will mean restrictions on how they can spend their welfare money. If they test positive a second time, they must see a medical professional for addiction treatment. The aim is to ensure people "receive the help they need to get on a path towards securing a job", said social services minister Christian Porter last week.

However, medical bodies have raised concerns over the plan. "Substance addiction is a complex, chronic relapsing medical condition," says Hester Wilson of the Royal Australian College of General Practitioners. "One of the hallmarks is an inability to change behaviour despite harm, so punitive approaches don't tend to work."



Japan: "A grave threat to our nation"

SEBASTIAN KENNENKNECHT / MINDEN PICTURES



In danger of reclassification

Cat faces upgrade

THE iconic snow leopard might no longer be classed as an endangered species, if some scientists have their way. That may sound like a conservation win, but others warn the move could backfire.

Since 1986, the International Union for Conservation of Nature has designated snow leopards as "endangered". Now the IUCN is considering reclassifying them as

"The snow leopard is slightly better off than we thought, but it's still facing a high level of extinction"

"vulnerable", meaning the risk of extinction is less urgent.

Estimates now put the Asian cat's population at around 8000, rather than 5300. And although some sub-populations are shrinking, we have no clear evidence of an overall decline (*Oryx*, doi.org/ccjf).

"The word 'endangered' carries this aura about it," says Tom McCarthy of Panthera, a wild cat conservation group. "It's a powerful, evocative word. What is a 'vulnerable' animal?"

McCarthy supports the change, however, saying the new listing would still mean snow leopards are in trouble. "It's slightly better off than we thought, but it's still

facing a high level of extinction."

The worry is that reclassifying the cats might dampen the drive to protect them. "How are we going to get people behind this species and get the dollars we hope for?" asks Beth Schaefer, general curator at the Los Angeles Zoo. "If you say they're not endangered, people go 'ah OK', and they move on."

Steampunk rover

NASA's Jet Propulsion Laboratory has unveiled a clockwork rover designed to survive on Venus – something no previous probe has managed for more than a couple of hours.

Venus is a hellish environment: its atmosphere is 90 times denser than Earth's and gets up to 460°C, hot enough to melt lead and fry the electronics on Martian rovers. To cope, the Automaton Rover for Extreme Environments (AREE) takes inspiration from the mechanical computers of the past.

Wind turbines and sunlight would generate power to push its tank-like treads along the ground and compute its path. AREE would communicate using Morse code, transmitted to relay balloons in the atmosphere.

It is still early days, but the hope is that the rover will wander Venus's surface and maybe even drill into its rocky crust.

Voyager turns 40

On 5 September, Voyager 1 celebrates the 40th anniversary of its launch. With its twin, Voyager 2, it was sent to explore the outer planets of our solar system and what lies beyond, in interstellar space. They each carry a phonograph recording called the Golden Record, containing key details about human life and culture. Voyager 1 is now in interstellar space and Voyager 2 is at the edge of our solar system.

Kenya bans plastic bags

Carrying single-use plastic bags in Kenya now comes with a harsh penalty. The UN Environmental Programme says 100 million plastic bags are handed out in Kenya each year. To stem that tide, a law enacted on 28 August includes penalties of up to four years in jail or a \$40,000 fine for producing or carrying them.

Fighting fake news

Facebook plans to ban adverts from groups caught repeatedly sharing false stories on the platform, saying that they make the world "less informed" in an announcement on Monday. To flag fake news the social media company relies on external fact-checking organisations.

Sink infection risk

Stainless steel sink fixtures may increase the risk of contracting legionnaires' disease at home. After three years, water samples from stainless steel taps showed higher rates of contamination with *Legionella* bacteria than those from brass taps, especially if there was also rust in the water (*International Journal of Hygiene and Environmental Health*, doi.org/ccjd).

Google breaks internet

Half of Japan lost internet access on 25 August because of an error by Google. The search company falsely directed traffic to its own servers rather than Japan's ISPs. The mistake was noticed within minutes, but it led to hours of slow internet.

The gene tweaks that let us speak

Our speech might have arisen from simple fiddles to existing genes



KENNETH HOPE/MILLENIUM IMAGES

Did epigenetics get us talking?

Andy Coghlan

HOW and when did we first become able to speak? A new DNA analysis reveals key evolutionary changes that reshaped our faces and larynxes, and which may have set the stage for complex speech.

The alterations were not major mutations in our genes. Instead, they were tweaks in the activity of existing genes that we shared with our immediate ancestors.

These changes in gene activity seem to have given us flat faces, by retracting the protruding chins of our ape forebears. They also resculpted the larynx and moved it further down in the throat, allowing early humans to make sounds with greater subtleties.

However, some anthropologists say changes in the brain were at least equally important in paving the way for the intricate speech we take for granted. It is also possible that earlier ancestors could speak, but in a more crude way, and that the facial changes simply took things up a notch.

Liran Carmel of the Hebrew

University of Jerusalem and his colleagues examined DNA from two modern people and four humans who lived within the last 50,000 years. They also looked at Neanderthals, a Denisovan, six chimpanzees and data from public gene databases.

They looked for genes that became more or less active over the course of evolution. To identify these epigenetic changes, they examined whether genes

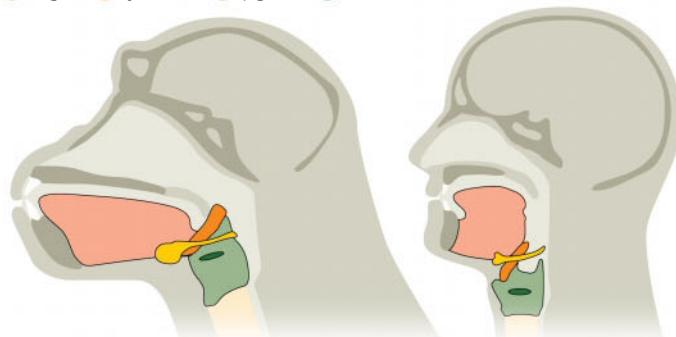
had methyl groups attached to them. In general, methylated genes are switched off and unmethylated genes are switched on. So by looking at methylation patterns, the researchers could track if gene activity was cranking up or down.

Modern humans showed big alterations in the activity of genes associated with face shape and larynx shape, compared with our forebears. In particular, genes

Changing faces

Our faces and vocal tracts changed over the course of evolution, giving us the capacity for complex speech

● Tongue ● Hyoid bone ● Epiglottis ● Vocal cords



SOURCE: doi.org/10.1101/106955

linked with vocal cord and larynx development were significantly altered (*bioRxiv*, doi.org/ccdk).

For example, a gene called *NFIX* was much less active in humans. It is key to jaw protrusion, implying its dwindling influence allowed our faces to flatten. The team argues that this allowed us to develop the ideal architecture for speech, in which the vertical and horizontal parts of the vocal tract are the same length (see diagram, below left).

None of these changes in gene activity was seen in any of the other species studied. "Voice-affecting genes are the most over-represented as differentially methylated genes in the modern human lineage," the researchers write. "Our results support the notion that evolution of the vocalisation apparatus of modern humans is unique."

However, other researchers say that the study does not tell the whole story of speech evolution.

Changes in the brain's ability to process sounds may have been just as important as anatomical changes, if not more so, says Erik Trinkaus at Washington University in St Louis.

"Anatomy doesn't impede primates from producing distinct vocalisations that are homologues to different human vowels," says Adriano Lameira of the University of St Andrews in the UK. He has shown that orangutans can mimic sounds from human speech.

Speech may also have gradually improved over the course of our evolution. "Neanderthals most likely had brains capable of learning and executing the complex manoeuvres involved in talking," says Philip Lieberman at Brown University in Rhode Island. "I think Neanderthals could talk, but more indistinctly than us." ■

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Parkinson's stem cell breakthrough

MONKEYS with a Parkinson's-like disease have been successfully treated with stem cells that improved their movement for up to two years after transplant. A similar trial is now being prepared for people.

Parkinson's destroys dopamine-producing cells in the brain, leading to tremors and difficulty moving. Previous experiments using stem cells from embryos have shown promise in replacing lost cells, but the use of these is controversial.

Jun Takahashi at Kyoto University, Japan, and colleagues wondered whether they could treat monkeys with a disease like Parkinson's using induced pluripotent stem cells, which are made by coaxing blood or skin cells into becoming stem cells.

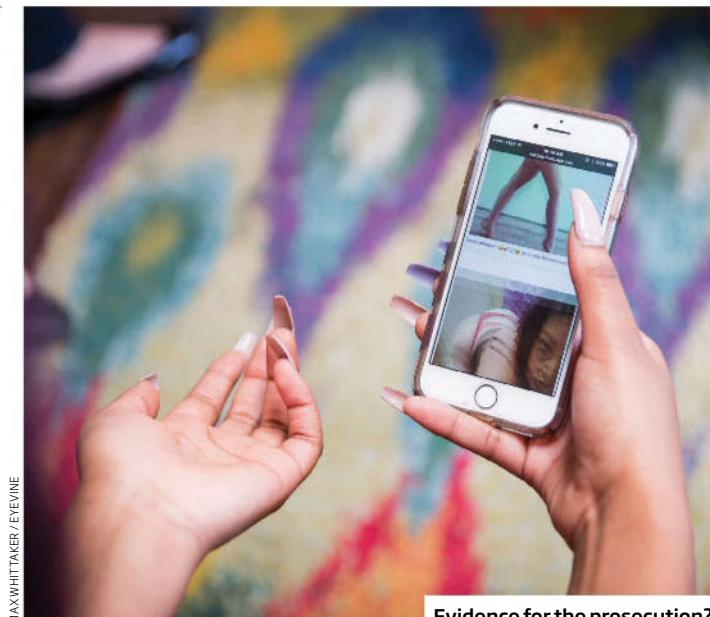
The team generated stem cells from three people with Parkinson's and four without the disease. They then transformed these into dopamine-producing brain cells.

All the monkeys who received injections of these cells showed a 40 to 55 per cent improvement in their movements, matching results from previous experiments with embryonic stem cells. Monkeys who had a control injection minus the cells didn't improve (*Nature*, DOI: 10.1038/nature23664).

Stem cells from people with and without Parkinson's were equally effective. "The monkeys became more active... and showed less tremor," says Takahashi. "Their movements became smoother."

After the transplant, the monkeys were given immunosuppressive drugs to prevent the new cells from being rejected and observed for up to two years. No serious side effects appeared during this time.

This study shows that the stem cells behave as you would like them to and they appear safe, says Roger Barker of the University of Cambridge. "All of which gives one greater confidence in moving to human studies." Helen Thomson ■



Evidence for the prosecution?

How AI and bitcoin can stop sex trafficking

AFTER Kubiiki Pride's 13-year-old daughter disappeared, it took 270 days for her mother to find her. When she did, it was as an escort available to rent on an online classified website. The girl had been drugged and beaten into compliance by a sex trafficker.

To find her daughter, Pride had to trawl through hundreds of advertisements on Backpage.com, a site hosting more than 70 per cent of the US market for online sex ads. It is often no easier for police trying to identify signs of human trafficking in ads. But now, a strange alliance of artificial intelligence and bitcoin is helping to automate the process.

Thousands of sex-related classifieds are posted every week. Some are legal. Others are for people, like Pride's daughter, forced to do it. Working out which is which is a laborious task.

"The internet has facilitated a lot of methods that traffickers can take advantage of without having to reveal themselves," says Rebecca Portnoff at the University of California, Berkeley.

Portnoff and her colleagues have developed a tool to ferret out traffickers. It uses machine learning to spot common patterns in ads, and finds publicly available information from the method used to pay for them – bitcoin – to identify who placed them.

In the US, many victims of sexual exploitation end up advertised on Backpage. A telltale

"Thousands of sex-related classifieds are posted every week. Some are legal. Others are forced"

sign that an advert involves trafficking is that the person behind it is responsible for many other adverts too. However, this is difficult to spot, because adverts name the people being trafficked, not the traffickers.

To identify the authors of online sex ads, Portnoff's tool looks at the style in which ads are written. Artificial intelligence trained on thousands of different ads highlights when similar styles have been used, and clusters

together likely candidates for further investigation.

The second step comes via the payment method. Credit card companies stopped the use of their services on Backpage in 2015, leaving bitcoin as the only way to pay for placing an ad.

Every transaction made using bitcoin is logged on a publicly available ledger called the blockchain. It doesn't store identities, but every user has an associated wallet that is recorded alongside the transaction. The AI tool searches the blockchain to identify the wallet that corresponds to each advert.

It is also easy to see when each ad was posted. "We look at the cost of the ad and the timestamp, then connect the ad to a specific person or group. This means the police then have a pretty good candidate for further investigation," says Portnoff.

Over four weeks, the team tried the tool on 10,000 adverts. It correctly identified about 90 per cent of ads that had the same author, with a false positive rate of only 1 per cent. One of the bitcoin wallets they tracked down was responsible for \$150,000 worth of sex adverts, possible evidence of an exploitation ring. Backpage has not yet responded to *New Scientist's* request for comment.

The tool will help track money in an arena where it moves rapidly across financial instruments and disappears, says Carrie Pemberton Ford of the Cambridge Centre for Applied Research in Human Trafficking, UK.

Portnoff's team is working with several police forces and NGOs in the hope of using the tool in real investigations. The work was presented at the Conference on Knowledge Discovery and Data Mining in Canada this month.

The trafficker of Kubiiki Pride's daughter was caught and sentenced to five years in prison. Successfully prosecutions like that are rare, but with Portnoff's tool that could soon change.

Timothy Revell ■

Thin female models change beauty ideal

Jessica Hamzelou

FOR the first time, researchers have shown in a randomised trial that looking at photos of thin women is enough to shape a person's beauty ideals.

It has long been thought that images of slender women in the media influence what people find attractive, and can make a person feel unhappy with their body. But these pictures are now ubiquitous in many places, making testing this idea difficult.

To find people who haven't been exposed to such images, Jean-Luc Jucker at the University of Neuchâtel, Switzerland, and his team travelled to rural villages along the Mosquito Coast of Nicaragua.

At first, these villages had no electricity beyond the odd solar panel used to power a bulb. The Nicaraguan government is in the process of adding villages like these to the electricity grid – which is likely to bring TV with it. "When they get electricity, people generally say they want two things – a fridge and a television," says Jucker. "They go from having no television to 100 channels."

Before two villages were hooked up to the grid, Jucker's team recruited 80 volunteers from them. These included men and women aged between 16 and 78.

The volunteers were first asked to create their "ideal" body shape for a woman, using computer software that enabled them to generate women of different shapes and sizes.

The team then showed them images from a catalogue for a popular Western clothing store.

Half of the volunteers were shown 72 photos of thin women – with a UK dress size between 4 and 6 – modelling clothes. The images were given in pairs, and each volunteer had to decide which they thought was more attractive.

The other half of the volunteers were shown 72 photos of plus-sized female models, with a UK dress size between 16 and 28. They were given the same task of choosing the most attractive from pairs of images.

After this task, which lasted around 15 minutes, Jucker's team asked the volunteers to again create their ideal women's body size using the software. Those who had seen images of thin women now created ideals that

were thinner than those they had originally generated. In contrast, those who studied images of plus-sized models showed the opposite effect – their ideal body shape increased in size (*bioRxiv*, doi.org/ccdz).

"It is very interesting to see that a brief, 'light-touch' exposure is enough to show a demonstrable change in body ideal," says Helen Sharpe at the University of Edinburgh, UK.

Jucker's team don't yet know how long the effect lasts. But given the fact that most of us are constantly exposed to such images, it wouldn't matter if the effect of each exposure was only temporary, he says – the overall impact is likely to be lasting.

Since the experiment, most of the volunteers have been connected to the electricity grid, while the rest can expect it within months. Jucker has been contacting schools and the local ministries of education and health to inform them about the problem. "We are trying to raise awareness of this thin body ideal, and of eating disorders like anorexia," he says.

"We don't want to demonise television – it's good in that it provides access to political information and storm warnings, and helps people learn languages," says Jucker. "We just say that it is associated with these risks." ■



surveillance devices," says Peter Swire at the Georgia Institute of Technology in Atlanta.

We've known this for a while, but have worried mainly about hackers coaxing internet-connected gadgets to join attacks against websites.

But recent US policy changes to what data ISPs can sell made people wonder if the firms could start profiting from smart-home data. "ISPs are in the most powerful position in terms of having data that they could sell on," says Brent Mittelstadt at the Oxford Internet Institute, UK.

So Noah Apthorpe at Princeton

University and his colleagues set up a mock smart home, complete with seven internet-connected devices, to find out what they might reveal.

Four of the devices could be easily identified by the way they connect to the internet (arxiv.org/abs/1708.05044). Now that everything from insulin pumps to vibrators comes with internet connectivity, just knowing what

'Just knowing what smart devices you are using could be valuable information for ISPs to sell to advertisers'

gadgets someone uses could be valuable for advertisers. And encryption wouldn't hide this information, or stop someone from seeing when the devices are in use.

This type of observation is possible anywhere, but in the US there are few restrictions on what data ISPs are allowed to sell. EU law makes it more difficult, and the upcoming General Data Protection Regulation should protect UK citizens. Ultimately, Mittelstadt says, it's up to consumers to weigh up the privacy risks that come along with using internet-connected devices. Matt Reynolds ■

Your smart home or your (private) life?

HOW much of your privacy would you trade for a smarter home? Internet service providers (ISPs) can peek at the baby monitors, TV set-top boxes and even vibrators that people use in their own homes, as long as the devices are connected to the internet. And it works even when gadgets are set up to protect privacy.

"These home devices are also home

How you file away your memories

WHILE you're daydreaming, your brain is hard at work. For the first time, scans have shown human brains replaying individual memories, filing them away for long-term storage.

Research in rats has found that the hippocampus region of their brain forms new memories by replaying patterns of brain activity linked to specific experiences. When neuroscientists watch the brain activity of a rat running through a maze, for example, they find the same pattern being replayed when the rat sleeps.

Now, Anna Schapiro of Harvard Medical School and her team have seen memories replaying in people. They asked 24 volunteers to learn about 15 made-up satellites. After 45 minutes of memorising their names and what they looked like, participants did a memory test.

The team then used an fMRI scanner to detect the brain activity elicited by images of the satellites. After a break, the volunteers were shown the pictures in the scanner again, to confirm this activity. They then rested while still being scanned, before doing a second memory test.

Analysing the scans, the team found that specific patterns of brain activity associated with the satellites were replayed during rest. "This is the first evidence for item-specific replay in the human hippocampus," the team says.

Satellites that were poorly remembered at first were later replayed more in the hippocampus. Being replayed more times was linked to better recall in the second test (*bioRxiv*, doi.org/ccdw). This suggests that the brain prioritises processing weaker memories, the team says.

Animal research suggests other parts of the brain are involved in replaying memories too, says Loren Frank at the University of California, San Francisco. "If you really want to store a memory for all senses, you have to turn on activity in all brain areas." Jessica Hamzelou ■



Home to problem children

Young stars live too close to our galaxy's black hole

A SWARM of baby stars live just a fraction of a light year from our galaxy's central supermassive black hole. But no one can explain how they ended up so close in their short lifetimes.

Stars form by coalescing out of a cloud of dust and gas. But this can't happen close to the Milky Way's centre as the gravity from the supermassive black hole rips apart nearby clouds before any stars can grow.

"These stars are so close to the black hole that no formation mechanism could work there, so you need some time to bring them in from somewhere else," says Maryam Habibi at the Max Planck Institute for Extraterrestrial Physics in Garching, Germany.

Previous explanations had suggested that the stars might not be young after all, but old ones in disguise, giving them more time to move into position. They could appear younger thanks to mergers with other stars, tidal heating or by having their outer envelopes of gas stripped away.

To investigate further, Habibi

and her colleagues took a closer look at the stars. Since they are almost 25,000 light years away and too dim to examine in visible wavelengths, it is difficult to get any detailed information about them. To get around this, Habibi's team looked at 12 years of data from the infrared portion of the stars' light.

"It's still not clear whether they formed outside the danger zone and wandered in or if they formed there"

The team found that the stars have masses between 8 and 14 times that of the sun, have bulk temperatures ranging from 20,700 to 28,200 °C – more than three times as hot as the sun – and rotate at 60 to 170 kilometres per second at the equator.

The stars are also far younger than the sun. By comparing their observations with models of star evolution, the researchers found that the stars are less than 15 million years old (arxiv.org/abs/1708.06353). This rules out

the possibility that they are older than they look. In comparison, the sun is about 4.5 billion years old.

"There's very little wiggle room now for these to be anything other than garden-variety massive stars," says Don Figer at the Rochester Institute of Technology in New York. "The problem is that they're in a very odd place."

One previous idea for how they got so close to the galaxy's supermassive black hole is that they formed in binary systems much further out in the galaxy. Then, when the pair of stars was disrupted by a black hole or other massive object, one shot away from the centre of the galaxy and one shot towards it and was trapped in orbit.

That process would require the stars to travel for a long time toward the galaxy's centre, however – potentially longer than their current ages. "I was hoping that maybe the ages would be older, so we could solve this by saying that these stars are old and there's more time to bring them in," says Habibi.

Instead, the stars' youth implies that they must have formed in a kind of middle ground closer in, possibly in a disc of stars and dust that orbits just a few light years from the black hole. If they started there, they could have migrated even further inward as drag from the material in the disc slowed down their orbital speed.

Even that process might take too long, though. "It's still not clear whether they formed outside of the danger zone and then wandered in or whether they actually formed in the danger zone," says Figer. While the colossal gravitational pull of the supermassive black hole makes it unlikely that the stars could have formed where they are, Figer says that it might be possible.

"This is presenting a paradox," says Habibi. "We might have to come up with a new theory to answer how these stars at these young ages could get there."

Leah Crane ■

Monkeys see faces in objects too

Helen Thomson

HAVE you ever seen the Virgin Mary in a grilled cheese sandwich? How about a house whose windows and doorway looked eerily like eyes and a mouth? Seeing faces in inanimate objects is a common phenomenon. Now it seems that we're not alone in experiencing it – monkeys do too.

Pareidolia is the scientific term for erroneously perceiving faces where none exist. Other examples include seeing "ghosts" in blurry photos, and the man in the moon.

To investigate whether pareidolia is a uniquely human experience or one other primates might share, Jessica Taubert at the US National Institute of Mental Health in Maryland and her colleagues trained five rhesus macaques to stare at pairs of photos. Each image showed either an inanimate object that prompts pareidolia in humans, an equivalent object that doesn't, or the face of a monkey.

We already knew that both people and monkeys will look longer at images of faces than of other things. So the team

presented each of the photos in every possible pairing – 1980 in all – and measured the time the monkeys spent looking at each.

The monkeys did indeed seem to succumb to pareidolia – they spent more time looking at illusory faces than the non-illusory photos they were presented alongside (*Current Biology*, doi.org/ccdv).

Interestingly, they also spent more time looking at the illusory faces than the monkey faces, perhaps because they needed to study these more unusual "faces" more, or because they tend to dislike holding the gaze of another monkey.

Examining the gaze patterns of the monkeys, the team found that they frequently fixated on the "eye" and "mouth" regions of the false faces, which is also how people behave when viewing real faces.

Vincent Reid, a psychologist at Lancaster University, UK, says he is not surprised by the finding because rhesus monkeys are very social animals. "Just like humans, they rely on facial information for communicative purposes."

But why do we – and monkeys –



PAUL DAVID GALVAN/GETTY

Grate smile

so often perceive faces where there are none?

Our brain is primed to see faces from an early age. Fetuses seem able to recognise a face while in the womb. Scans show that when dots of light are shone through the skin into the uterus, they preferentially turn to look at patterns that resemble faces, but they ignore random shapes.

Being able to quickly spot and interpret a face can give vital

information about whether a social group is friendly or hostile. But sometimes we are too good at spotting faces, seeing a smiling face on the side of a cheese grater.

The fact that monkeys easily perceive false faces too underscores that there is a biological advantage for social animals to preferentially detect faces in the environment. "It shows how deeply ingrained it is in humans," says Reid. ■

Non-native species boost biodiversity

MOOSE and water buffalo do a lot of munching and trampling, so it might seem like a bad thing that these large animals have escaped their native realms and invaded other regions. But there appears to be an upside to their walkabout across the planet.

Beasts like camels and donkeys – known as "megafauna" because of their large size – live far

outside their native ranges, thanks mostly to humans. Often, ecologists give these aliens the cold shoulder, presuming they do harm. For instance, conservationists have called for feral horses in the US – which came over with Europeans within the last 500 years – to be removed from some areas.

But Erick Lundgren of Arizona State University says it is increasingly hard to tell where such animals "belong".

Lundgren and his colleagues have studied the ranges of 76 species of large plant-eating mammals. They found 22 with significant populations outside their native range. Ten of

those are extinct or threatened back home. For instance, there are an estimated 5 million wild donkeys around the world, but only a few hundred of their pre-domesticated ancestors, the African wild ass (*Ecography*, in press).

Lundgren says such newcomers should be seen as nature's comeback. They often perform useful services.

Sometimes those benefits are

"Burros are good at digging to find underground water, a skill that had been lost with native megafauna"

intended. For instance, giant tortoises from Aldabra in the Seychelles have been installed on Mauritius to replace their extinct counterparts and spread the seeds of native trees.

At other times, it has just happened. In his Master's thesis, Lundgren describes the behaviour of wild donkeys or "burros" in the Sonoran desert, US. They dig down to uncover underground water that can then be drunk by dozens of native bird and mammal species. When native megafauna disappeared, nothing remained in the area with the ability to do that. Fred Pearce ■



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May include parasites

Our mummy has a liver complaint

Colin Barras

IT MIGHT have been what the doctor ordered, but it didn't do the patient much good. A 375-year-old mummified man discovered in South Korea had a parasitic liver infection, which he caught by eating raw shellfish – possibly on the basis of incorrect medical advice.

The man, Jing Lee, died in 1642 at the age of 63 and was buried in what is now Cheongdo. His body was remarkably well preserved when archaeologists unearthed it in 2014.

With permission from Jing Lee's descendants, a team led by Min Seo at Dankook University College of Medicine, South Korea, CT-scanned the mummy. This revealed a strange lump on the man's liver.

The researchers removed the lump and found it contained golden-brown eggs, each roughly 85 micrometres long. They identified them as belonging to *Paragonimus westermani*,

a parasitic fluke (*Journal of Parasitology*, doi.org/cb9p).

That means Jing Lee was suffering from hepatic paragonimiasis when he died. He is the oldest known case, say Seo and her colleagues.

P. westermani is carried by freshwater crustaceans. Jing Lee probably picked it up by eating raw crabs or crayfish, both of

"A patient will spit up bloody sputum. That's what brings them into the doctor's office"

which were consumed by the Joseon culture he was a member of. At the time, raw crayfish juice was considered an effective treatment for measles.

Jing Lee might well have experienced unpleasant symptoms such as pain or fever, says Seo. "However, I cannot say that this pathological condition could be the cause of death."

Often paragonimiasis has no symptoms at all and goes

unnoticed, says James Diaz at the Louisiana State University Health Sciences Center, New Orleans.

It is still relatively common today – mainly in South-East Asia and parts of Central and South America, where people often eat raw or undercooked crustaceans.

"The parasite will penetrate through the lining of the intestine and then it's free to move around the peritoneal cavity," says Diaz.

Once the parasite is loose in the body it typically heads for the lungs, hence its common name "lung fluke". But it can sometimes end up in the liver, as in the case of Jing Lee. Either way, it then forms an egg-filled cyst.

At this point the infection may announce itself. When a cyst lodged in a lung bursts, the eggs often find their way into the airways. "A patient will spit up bloody sputum," says Diaz. "That's what brings them into the doctor's office."

Karl Reinhard at the University of Nebraska-Lincoln says the study is the latest in a decade-long series of investigations into the parasites carried by Korea's ancient mummies. It turns out parasitic infections were a common feature of life: all 18 mummies examined so far have carried at least one parasite. ■

Exocomets sighted around distant stars

THE Kepler space telescope has seen thousands of exoplanets, and now we can perhaps add exocomets to the list. Potential evidence of comets has been found around two stars, both about 800 light years away.

Kepler finds planets by measuring the intensity of a star's light over time. When a planet passes in front of its host star, an event called a transit, the light dims slightly. The resulting "light curve" – a graph of brightness over several days – is symmetrical, with the light levels dropping and then rising again at equal rates.

This symmetry arises because both planets and stars are spherical, but the transits found by Andrew Vanderburg at Harvard University and his colleagues were asymmetrical, meaning that whatever made them wasn't a sphere. The team turned to comets as possible culprits, because they release gas and dust from one side, creating long tails that stretch out into space.

Over the four years of the initial Kepler mission, the team saw six transits of the star KIC 3542116, indicating between two and six comet-like bodies in orbit, but only one transit of the star KIC 11084727, making it harder to draw conclusions from that evidence. Each of these lasted for around a day (arxiv.org/abs/1708.06069).

It is possible these light curves are caused by something else, but Vanderburg says the team thinks the evidence is good. "We can't prove yet that these transits are due to comets, but we've put together what we think is a pretty strong circumstantial case."

This isn't the first time exocomets might have been found, but it is some of the best evidence so far.

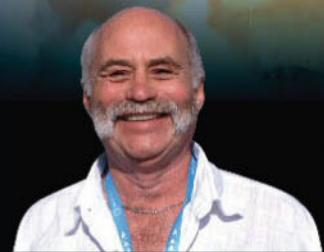
"I think it is good work. A comet explanation is possible, and they have demonstrated to my satisfaction that the signals are real and astrophysical," says Joshua Pepper at Lehigh University in Bethlehem, Pennsylvania. Jesse Emspak ■

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Secret lives of dodos revealed

Andy Coghlan

THE iconic dodo has bounced back from the grave to reveal hitherto-unknown details of its lifestyle. For the first time, researchers have pieced together the complete life cycle of these legendary birds.

Dodos were large flightless pigeons that lived on Mauritius, often in swamps and caves. They were wiped out within 100 years once European sailors reached and colonised the island in the 16th century, probably by introduced species. Its loss drew people's attention to the issue of extinction for the first time.

Now Delphine Angst of the University of Cape Town in South Africa and her colleagues have cracked the dodo's habits. "We know so little about these birds that everything was basically a surprise," says Angst.

The team found that the dodo's life cycle had evolved to suit the seasonal weather cycles on Mauritius. The key challenge was to survive the harsh conditions and food shortages of the southern summer, between November and March.

Once through the tough times, the birds would shed and replace their damaged feathers. "By July, they would have completely new plumage and the next reproduction cycle starts," says Angst.

In August, the females would begin ovulating, laying eggs that hatched in September. That meant there was sufficient time

for the young to grow large enough to survive the summer.

Angst and her colleagues worked out the life cycle by analysing the structure and composition of 22 bones from 22 dodos. With one exception, all the bones were from the hind legs.

Some of the dodos were juveniles: their remains were unusually rich in fibrolamellar bone. This contains many immature cells that can be rapidly deposited, allowing the bird to grow quickly (*Nature Scientific Reports*, doi.org/cddt).

Other bones had large cavities that corresponded with the

moult cycle. "To produce new feathers, the birds need extra calcium, and the cavities show they were extracting it from the bones," says Angst.

Establishing that the birds had a moult cycle also helps to explain why sailors visiting Mauritius gave variable descriptions of dodos – they were seeing the birds at different times of year.

"Some report downy black plumage, probably at the beginning of moulting. Some describe a mix of downy plumage and real feathers. And some report dodos covered with real feathers, probably corresponding to birds that had completed the cycle," says Angst.

The team even identified two bones as belonging to females. These specimens contained an additional tissue called medullary bone, which is a vital source of calcium for eggshells and is unique to females.

"It's very cool that the team was able to identify two individuals in their sample as laying females," says Helen James, curator of birds at the Smithsonian National Museum of Natural History in Washington DC. "The two female bones were similar in size to the other bones in their sample, which tends to refute an earlier idea that male and female dodos were very different in adult size," she says. ■



Summer was a lean time

First step for quantum sea comms

QUANTUM mechanics is going for a swim. For the first time, quantum entangled particles of light have been transmitted through water – a step towards using lasers to send underwater messages that are impossible to intercept.

Entanglement starts with a beam of light shot into a crystal. This splits the light into pairs of photons with

linked behaviour. Manipulate one of a pair and its partner will react. Measure the first one's polarisation, for example, and entanglement could ensure that its twin will have the opposite polarisation when measured.

These entangled photons can theoretically be used to set up a secure communication line between two people, with privacy guaranteed by the laws of physics.

But this fragile quantum state can easily be disturbed by the surrounding environment. So far, entanglement has been maintained between particles separated by long distances

after travelling through air, space and optical fibres, but not water.

Now Xianmin Jin and his colleagues at Shanghai Jiao Tong University in China have been able to transmit entangled photons through a 3-metre-long container of sea water without disturbing their quantum link (*Optics Express*, doi.org/ccdh).

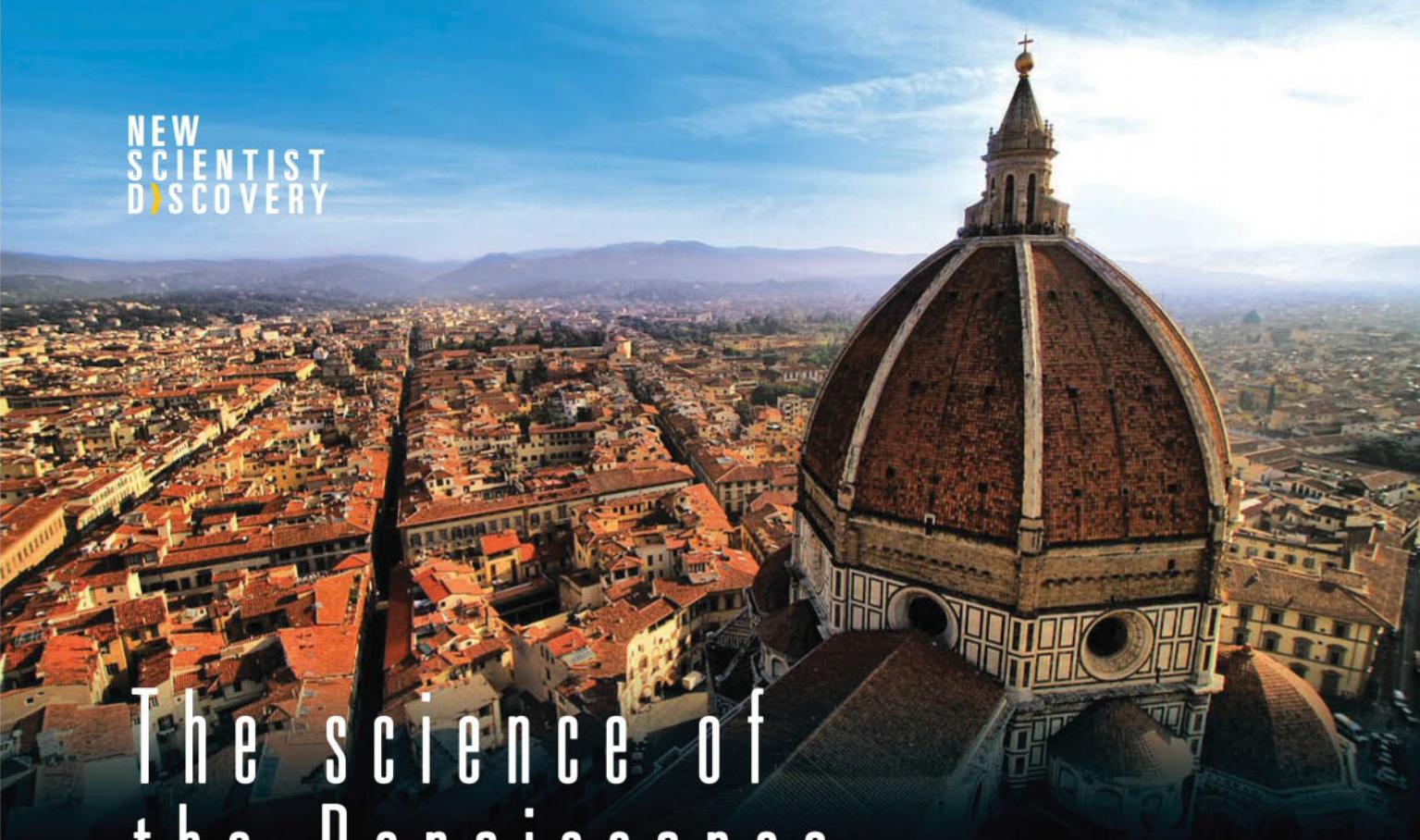
As the first experiment of its kind, it is not clear whether this will be

"An application would be a submarine that wants to remain submerged but communicate securely"

enough to build a communications system. "It's not very surprising to me that if I send light through 10 feet of water it doesn't get depolarised," says Paul Kwiat at the University of Illinois at Urbana-Champaign.

But Jin says this is only the beginning. His calculations suggest that it should be possible to transmit through nearly 900 metres of water.

"An obvious application would be a submarine which wants to remain submerged but communicate in a secure fashion," says Thomas Jennewein at the University of Waterloo in Canada. Devin Powell ■



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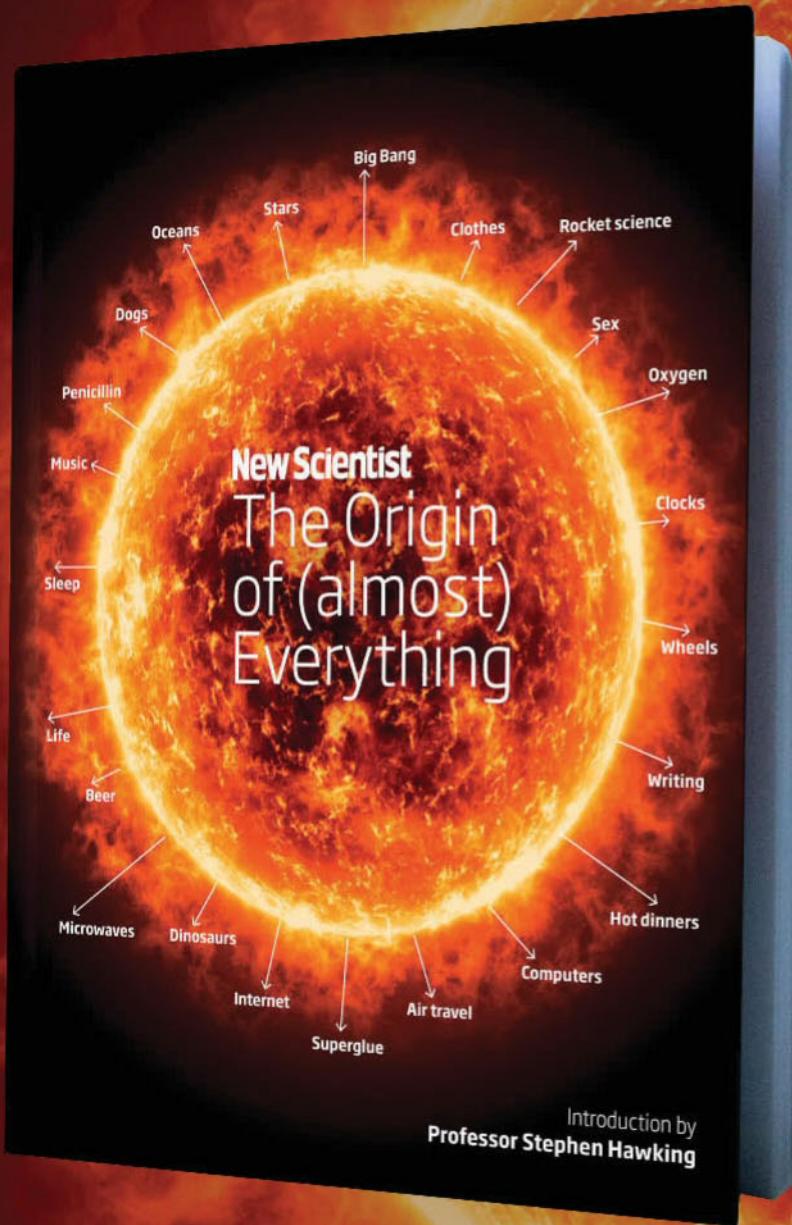


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Insubordinate female monkeys band together

IF YOU'RE trying to overthrow the boss, you need a friend to back you up. The same is true for female macaques.

Rhesus macaques live in strict hierarchies organised around female relationships. Low-ranked females are thought to have little social mobility and must silently bare their teeth to higher-ranked females. This means "I want you to know that I know that you outrank me", says Darcy Hannibal at the University of California, Davis.

But subordinate females can overturn the status quo. To do so, they form alliances with family, friends or both. These alliances help females maintain or

increase their social rank and compete for resources.

To find out what factors affect insubordination rates, Hannibal's team studied 357 captive adult females, who experienced almost 11,000 conflicts.

Insubordination was more likely if the lower-ranked female was older, if she outweighed the dominant female by 7 kilograms and if the dominant animal had no family allies. The more allies the subordinate had, and the more days her mother was present in the group, the more often she would be insubordinate (*American Journal of Physical Anthropology*, doi.org/cb8z).

But Dario Maestripieri at the University of Chicago, Illinois, says the definition of insubordination might be too broad. Events where entire families revolt against their superiors with the intent to kill are rare.

Robot suit helps children walk

ROBOTIC exoskeletons could help children with cerebral palsy keep walking as adults.

A new physical therapy device, developed at the National Institutes of Health in Maryland, could be used at home to improve gait. It is equipped with sensors on the legs to monitor each step. At just the right moment, the exoskeleton gives a muscular boost, improving

posture and easing the strain.

Many children with cerebral palsy can walk, but only 50 per cent are still able to do so when they grow up. The condition often causes crouch gait, or overbending of the knees. As children become heavier, their muscles cannot support this gait, sometimes leading to loss of all mobility.

"If we can change crouch gait at a young age, we can maintain

mobility into adulthood," says Thomas Bulea at the National Institutes of Health.

Seven people with cerebral palsy, aged 5 to 19, used the device. After six training sessions, all but one saw results similar to the corrective surgery that is often required (*Science Translational Medicine*, doi.org/ccd4).

"Using the exoskeleton will only be temporary," says Bulea. "We want them to be able to walk without it."

Meth stroke risk in younger adults

METHAMPHETAMINE makes young people almost five times as likely to have a stroke caused by a bleed in the brain.

As well as tooth decay known as "meth mouth", the drug causes increased heart rate and blood pressure, and can trigger heart attacks. To explore its link to strokes, Julia Lappin and colleagues at the Australian National Drug and Alcohol Research Centre in Sydney sifted through 77 studies that focused on people under the age of 45.

Methamphetamine was to blame for up to 6 per cent of all strokes in under 45s caused by a blockage in the brain's blood flow, and up to 13 per cent of strokes caused by a brain bleed (*Journal of Neurology, Neurosurgery and Psychiatry*, doi.org/cb85).

A third of those who had brain bleed strokes died, while around 40 per cent had lasting symptoms.

Medieval London was basically lethal

YOU thought *Game of Thrones* was rough? Extreme violence was a feature of life for young men in medieval London, far more so than elsewhere in England.

Kathryn Krakowka at the University of Oxford analysed 399 skulls from six London cemeteries dating from 1050 to 1550. She found signs of violence-related trauma on 27 (6.8 per cent) of them, with men aged 26 to 35 worst affected. About 25 per cent of injuries looked "fresh", so occurred near the time of death, hinting blows to the head were the cause (*American Journal of Physical Anthropology*, doi.org/cb5g).

Krakowka speculates that poor people could not access the nascent legal system, so resorted to violence to settle disputes.

Seasonal food shifts microbiome

THE microbes living in our gut could vary with the seasons, according to evidence from a group of hunter-gatherers.

Jeff Leach of the Human Food Project charity and his team spent more than a year collecting stool samples from 350 Hadza people, living in Tanzania. The team discovered that the Hadza microbiome is about 30 per cent more diverse than that of people in Western nations, and it seems to change in a cycle through the year.

Diversity peaks in the dry season, when *Prevotella* species increase. The bacteria that showed the greatest annual fluctuations generally tended to be strains not present in people with Western lifestyles (*Science*, DOI: 10.1126/science.aan4834).

These annual changes in the gut microbiome are probably caused by cyclical shifts in the Hadza diet. During Tanzania's dry season, the Hadza people eat a lot of meat plus tubers and fruit from the baobab tree, but in the wet season they eat more honey and berries.

This is the first detection of an annual cycle of microbiome changes, says Willem de Vos of Wageningen University in the Netherlands. He predicts that microbiomes may also cycle in those of us who manage to eat seasonal produce.



MATTHEW PALEY/NATIONAL GEOGRAPHIC CREATIVE

Twisted carbon nanotubes put wasted energy to work

AN ENERGY-HARVESTING device that uses carbon nanotubes is hitting power levels higher than any others have ever managed.

The quest to capture energy from your surroundings to do something useful has gone on largely unsuccessfully for more than a century. The few times that energy harvesters have worked before, it is because they were accessible and had a lot of vibrations going into them, for example ones mounted on a bridge with plenty of cars or trains rumbling over it.

But not every situation yields vibrations. Ocean waves, for instance, provide too little energy for traditional harvesters. This limits the use of pollution-sensing buoys, as their consequent need for batteries is often a prohibitive hassle.

That is where the new device comes in. The "twistron harvester" is made of nanotubes spun into a yarn around a twentieth of a millimetre thick and twisted into tiny coils. These are then submerged into an electrolyte. When a coil

moves, it generates electricity.

It makes enough to power a sensor from ocean waves (*Science*, DOI: 10.1126/science.aam8771). "We're generating higher amounts of power than any other harvesters, some of which have been around for decades," says Ray Baughman at the University of Texas.

Although they produce sufficient power, the harvesters are too expensive for commercial use at the moment. But Baughman hopes that will change. "It's only a baby," he says. "We've still got a lot to learn."

Lithium in water linked to dementia

HIGH natural levels of lithium in drinking water may protect against Alzheimer's and other forms of dementia, according to a study of more than 800,000 people in Denmark – but only at certain concentrations.

Lars Vedel Kessing of the University of Copenhagen and his team tested water samples from 151 waterworks in Denmark and calculated the levels of lithium exposure for nearly 74,000 people with dementia, and more than 733,000 healthy people.

The team found that people whose drinking water contained between 5.1 and 10 micrograms of lithium per litre were 22 per cent more likely to have dementia than those whose water had 2 to 5 micrograms of lithium per litre.

However, people whose water contained at least 15 micrograms per litre were 17 per cent less likely to have the condition (*JAMA Psychiatry*, DOI: 10.1001/jamapsychiatry.2017.2362).

These results mean we can't use lithium in water to boost brain health, says David Smith at the University of Oxford. "We should not be adding lithium salts to our tap water because we would not know what amount to use," he says.



GOOGLE

Chilled molecules have storage skills

SUPERCOOLED single molecules could soon hold hundreds of times more data than existing hard drives.

By controlling the magnetism of individual molecules, Nick Chilton and his colleagues at the University of Manchester in the UK have shown it could be possible to create a device that stores more than 30.8 terabits per square centimetre. If it were the size of a postage stamp, it would store about 5300 full-length movies.

Normally, single molecules don't retain their magnetic orientation unless kept in a magnetic field. Chilton's team managed to stabilise

the magnetic orientation by chilling molecules to -213°C and adding chains of carbon atoms (*Nature*, doi.org/ccdm). "The molecule needs to be very specifically designed," says Fabian Natterer at the Swiss Federal Institute of Technology in Lausanne.

The team hopes to achieve the same feat at -196°C, the temperature of liquid nitrogen, making it feasible to cool a large-scale device. So while it is unlikely you will ever have cold molecular storage in your smartphone, it could become an option for data centres such as those run by Google and Facebook.



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A gold mine of information

National genome service

People in the UK are being asked to hand over their DNA to the NHS, but privacy concerns must be listened to, says **Matt Reynolds**

YOU are a living data record. Every cell in your body contains genetic information that, if combined with other genomes into a giant database, could form part of one of the most powerful medical diagnostic tools ever created.

England's National Health Service is preparing to do just that. "We need to welcome the genomic era and deliver the genomic dream," the country's chief medical officer, Sally Davies, wrote in a report published

earlier this year calling for the expansion of genomic healthcare.

"By bringing together lots of people's genomes and their health data, and following them long term over a life course we will be able to build up insights that we can't get today," says Mark Caulfield, chief scientist at the 100,000 Genomes Project. Backed by the UK's Department of Health, this organisation aims to pool genetic information from 100,000 people so researchers

can find new diagnostic indicators and ways of targeting therapies.

Medical researchers promise that the benefits of gathering our DNA data will be immense, but your genome is the ultimate personal information – it is literally a description of you. Should we be concerned about

"This is not a database for the sake of a database. This is a database for direct healthcare"

giving it away, not knowing who might see it in the future? Or should the potential lives saved outweigh any privacy worries?

The 100,000 Genomes Project is already benefiting people with certain cancers or rare diseases who share their genome – or their cancer's genome. Although only 32,000 genomes have been sequenced since the initiative started in 2012, it has delivered diagnoses to people who had spent decades without one. Whether that leads to better treatments remains to be seen.

"We use that information to feed back to the NHS and the clinicians looking after that person," says Caulfield. "This is not a database for the sake of a database. This is a database

for direct healthcare."

But soon the government will make the 100,000 Genomes Project a more concrete part of the NHS in England. From March 2018, NHS England will offer whole-genome sequencing to anyone with specific cancers or diseases, with the option to contribute their genomes to the project's database. By the end of 2018, the 100,000 Genomes Project will hand over the responsibility for sequencing genomes to NHS England, moving the database into everyday use.

Donate your genome

The study of many genomes, yours included, may benefit others even if it doesn't help you personally. That makes giving the NHS your genome a bit like blood donation, but unlike blood, sharing DNA might have its downsides.

"The level of interest in that data is going to be far-reaching," says bioethicist Edward Hockings. He is concerned about NHS England granting access to commercial companies, including drug firms. There is a risk your data could end up being used for marketing purposes, for example.

Private companies have an important role to play in unlocking the benefits of genomic medicine by using genomic data to develop new tests and therapies, says Caulfield. In March 2015, the 100,000 Genomes Project set up a consortium of pharmaceutical, biotech and diagnostic companies that could access some genomic data and health information from its database, stripped of identifiers such as a patient's name and NHS number.

Companies who paid to access the data were obliged to commit researchers and other staff to the consortium, which wrapped up recently after operating for two years. The idea is that a successor organisation will work with NHS England to continue this work, says Caulfield.

But who will have access to the database in the future is unclear (see "Your data, your choice", below). "There needs to be much more transparency on the part of the Department of Health and the government," says Hockings.

The NHS in England has a history of mishandling health data deals. Last year, *New Scientist* found that the Royal Free London NHS Trust hadn't disclosed that it had given Google's artificial intelligence branch DeepMind access to detailed information on millions of patients, as part of the development of an app to monitor kidney disease. The Information Commissioner's Office, the UK's data watchdog, later ruled the Trust had "failed to comply with data protection law" and hadn't adequately informed patients as to how their data was being used.

More widely, in July 2016, NHS England finally pulled the plug on its disastrous care.data programme, which aimed to transfer anonymised patient data from doctors' practices into a central database. It was accused of failing to properly inform people about how their records would be handled, leading to a massive public backlash.

But the benefits of a genomic

database strongly outweigh the privacy risks, says Jonathan Montgomery, chair of the Nuffield Council on Bioethics, an independent body that advises policy-makers on medical ethics. "It needs to be part of the infrastructure of the NHS,"

Brits may have a particular social obligation to donate genomic data, since the whole of the UK benefits"

he says. "You can't have personalised medicine without pooling all that information."

For now, the scope of the planned database is limited, but Anneke Lucassen at the University of Southampton, UK, says that unlocking the real benefits of genomic medicine might require much wider national or international genetic databases.

For example, certain genomic mutations have been reclassified through similar large-scale initiatives, she says: families who thought they had a disease-causing mutation in one of the *BRCA* genes, linked to hereditary breast and ovarian cancer, were told that their specific variant wasn't disease-causing after all.

"Such reclassification can have

important clinical consequences," Lucassen says, such as telling individuals they don't need surgery or extra screening.

People contributing to such a database should ideally know how their data will end up being used, says Montgomery. Traditional informed consent – like the kind patients give before an operation – assumes that an individual has understood all the risks and implications of what they are consenting to. Getting informed consent from someone who donates their DNA is much trickier, as it isn't possible to know how an individual's data will be tested or used in the future, says Montgomery.

Although it may be impossible to give people assurances about how their data will be used, Montgomery advocates setting clear boundaries and strong sanctions when it comes to misuse, and the European Union agrees. Its General Data Protection Regulation, which comes into effect in the UK in May next year, forbids anyone from processing genetic data in order to identify an individual. It is likely to remain part of UK law after Brexit.

Getting these rules right and explaining them to the public is crucial. Montgomery says that Brits may have a particular social obligation to donate genomic data as part of the NHS's social contract. Individuals should be willing to contribute since the whole of UK society stands to benefit from discoveries made through NHS England's genomic database, he says, since its healthcare provision is open to all.

But this can only happen if NHS England's genomic mission isn't derailed by a data-sharing fiasco. Although often overhyped, the benefits of genomic medicine are real and can only be uncovered with vast numbers of genomes from different populations. The NHS is uniquely placed to do exactly that, says Montgomery. "If we don't get ahead on this, I think we are wasting science." ■

YOUR DATA, YOUR CHOICE

The safest place to store genomic data might not be a monolithic database. Gill Bejerano at Stanford University in California is working on a system that allows individuals to share their genomes with researchers, while keeping full control of their data.

With his scheme, individuals would hold their genetic data on their smartphone and choose to share it through an app. "Everybody holds their own genome," says Bejerano. "There is no centralised database."

The system works by converting a DNA sequence into numbers and encrypting them, making it impossible to retrieve the original DNA sequence without the decryption key. By comparing encrypted numbers from different people, researchers can

identify particular gene variants as interesting for further investigation. They could then ask the people those variants belong to to share their medical records to see if they have disorders in common.

Researchers can't use the encrypted numbers to access raw genetic information, ensuring privacy is maintained (*Science*, doi.org/cb3g).

The system could one day replace centralised databases like the 100,000 Genomes Project (see main story). But as it stands, Bejerano's method can be used only to share genomic information anonymously, while the most useful genomic research requires fully linking a person's genome with their medical records.

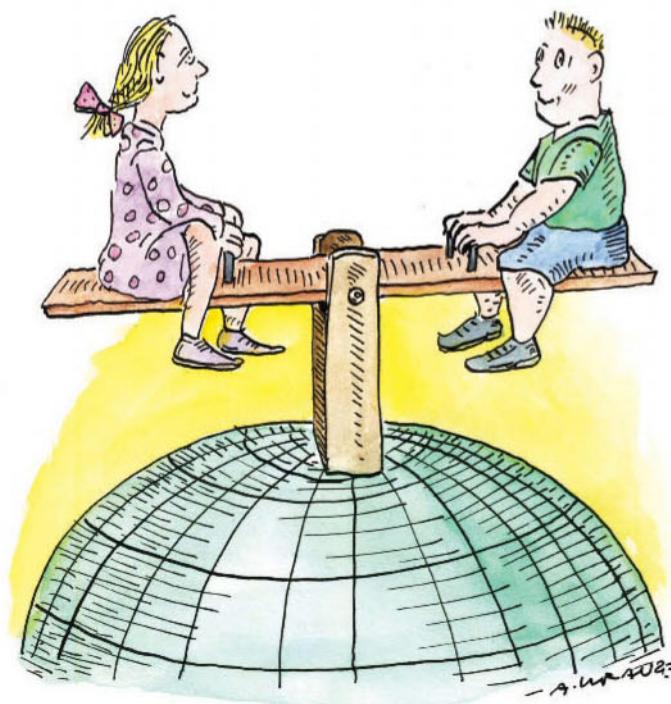
Not so different after all

It is becoming clearer that environment and culture may be behind many traits we ascribe to male or female biology, says **Gina Rippon**

THESE are interesting times for those curious about evolutionary processes and their role in shaping human characteristics, especially differences between the sexes.

It has long been a tenet of traditional evolutionary accounts that differences in behavioural traits between men and women have fixed biological foundations (hence their inter-generational stability) – a “biology is destiny” mantra. Allegedly, these traits “hold fast” in the face of external pressures, shifting only after very long periods of consistent environmental influence. This was supposedly reflected in the consistency of male/female differences down the ages.

But this notion of biology holding fast against prolonged environmental pressure is crumbling. This year, there were reports of “big-headed” geckos on artificial islands in Brazil adapting



within 15 years. And the relevance of social and cultural context was demonstrated by a paper showing that differences in cognitive abilities between men and women in 26 countries varied as a function of attitudes to gender roles.

Now comes a timely paper by researchers in Australia, Israel and the UK suggesting that the roles of biology and environment as sources of stability and variability might be reversed when it comes to the evolutionary processes shaping sex/gender differences.

Its context is an extension of classical Darwinian theory that acknowledges the role of non-genetic inheritance modes, including ecological and cultural inheritance. They focus on developmental trajectories, and how these can be diverted or manipulated by environmental factors. This suggests that social and cultural constructions can

Collision course

We need proper tests to gauge the full risk to airliners from small drones, says **Paul Marks**

IT'S the nightmare scenario, we assume: a consumer drone getting chewed up by a jet engine. But tests that could shed light on the consequences and inform safety have yet to be done.

That's strange, given the growing risk of this happening. We need to know if it could cause an engine to explode in an

“uncontained failure”, one of the most dangerous emergencies for an airliner.

But as far as safety tests go, all we have in the UK so far are recent lab experiments involving drones striking mock cockpits. That is better than nothing, but it only gives part of the picture.

The results appeared in July.

They said drones of three popular sizes (400 grams, 1.2 kilograms and 4 kilograms) can “critically damage” helicopter windscreens and tail rotors, and those of 4 kg and above can damage aircraft windscreens – but, interestingly, not at take-off and landing speeds.

This led the UK Department of Transport (DoT) to announce mandatory registration and safety training for all drone owners. The problem with that is that drones can be built using

“All we have in the UK so far are lab tests to assess what happens when drones strike mock cockpits”

raw components and run open-source software, all beyond legal oversight. A similar scheme in the US has not reduced near misses.

With “limited resources available”, those UK tests fired drones at a piece of an aircraft’s front fuselage, using an airgun. Even that has had its validity questioned. The gun could not take a 4-kg quadcopter, so the main components of one were fixed to a plastic arm and fired. That fudge has upset drone makers and users, who want to see all the test data. That’s unlikely on what the DoT says are security grounds.

Expensive drone-versus-engine

have a core role in determining neural and behavioural outcomes, including those of sex and gender.

The authors propose a model emphasising biology as a source of variability and environment as a source of stability, suggesting that biological variability is in fact being “suppressed” or masked by highly stable cultural forces and socio-environmental conditions.

Why might this matter? The authors, admirably cautious in discussing the balance between biology and environment, do note that the long, intense socialisation of infants is full of emphasis on differences between the sexes, via toys, clothing, names, role models and expectations.

They talk of this influence as creating stability, of holding the phenotype steady. But it could equally be described as repressing the benefits of variability.

This is thought-provoking and timely. It draws attention to the powerful role that sociocultural imperatives can play in the development and maintenance of sex/gender differences. Looked at this way, “limits imposed by biology” becomes “limits imposed by cultural intransigence”. ■

Gina Rippon is a professor of cognitive neuroimaging at Aston University in Birmingham, UK

tests seem unlikely any time soon, but wouldn't just give us a much better picture of the risks. They might also tell us if drones can be designed to minimise these risks, or if the only real answer is the use of robust geofences – GPS-enabled no-go zones – around flight paths.

With the risks of an accident mounting, such tests need to be done soon. If the authorities want to continue to allow drone use, they must ensure our aviation system remains as safe as possible. Tests with “limited resources” are not good enough. ■

Paul Marks is a technology and aviation writer based in London

INSIGHT Online mental health



Screening out dark thoughts

Will Google's online depression test help?

Frank Swain

WHEN you search for a medical condition online, would you also want to take a test for it then and there? Google is planning to offer people in the US searching for “depression” a clinically validated questionnaire so they can find out if they may have the condition. But then what?

“This sounds like a good idea that can help people work out whether they are having low moods or feeling blue, [or if they] may have more serious and enduring problems that could be alleviated by seeking help,” says Marjorie Wallace, of the UK mental health charity SANE. “Our concern [however] is that raising expectations of help can be disappointing.”

Google has partnered with the National Alliance on Mental Illness (NAMI) – a US advocacy group for those affected by mental illness – to provide a link to a questionnaire at the top of the search results for terms related to depression.

NAMI says that the results of the self-assessment can form the first step towards a diagnosis, and help people have a more informed

conversation with their doctor.

One in five people in the US will experience depression in their lifetime, but only half receive treatment – typically around seven years after symptoms appear. The questionnaire provided by NAMI will be “PHQ-9”, which is used routinely by doctors to gauge a person’s mental state.

The test asks people to score how often they are affected by things such as sleeping problems or thoughts of self-harm. NAMI is keen to point out that it isn’t intended to be used as the sole tool for diagnosis of clinical

“Without the resources to provide treatment, better diagnosis doesn’t translate into better care”

depression, but to guide users towards reliable healthcare information.

While PHQ-9 is well-regarded as a diagnostic tool, it needs to be applied repeatedly and regularly to give a meaningful picture, says Simon Gilbody at the University of York in the UK. And widespread testing for depression isn’t necessarily a good idea. “Randomised control trials have

shown that screening for depression doesn’t improve outcomes for patients,” he says.

That’s probably because without the resources to provide treatment, better diagnosis doesn’t translate into better care. For this reason, the UK’s National Screening Committee has repeatedly rejected calls to screen for depression. “[In the UK], we do not have sufficient skilled therapists and there are unforgivably long waiting times in mental health services,” says Wallace.

Tech companies are coming under pressure to help those who may be at risk of suicide. Google searches for suicide methods recently spiked following the debut of *13 Reasons Why*, a Netflix series centred around a teenage girl’s suicide. Facebook has also revealed that it is working on ways to detect users at risk of self-harm and alert their friends or its staff.

At the same time, there has been a mental healthcare tech boom, as firms scramble to offer apps, online therapist appointments and patient support networks. However, a recent study by Gilbody and his colleagues found that online therapy for depression is no more effective than GP treatment.

Nevertheless, Wallace still thinks Google’s plans are worthwhile. “SANE believes that knowledge, however limited, can help people make better decisions about their lives.” ■
Need a listening ear? UK Samaritans: 116123 (samaritans.org). Visit bit.ly/SuicideHelplines for other countries.

APERTURE





Beewolf versus bee

THIS is Graeco-Roman wrestling, insect-style.

In a battle between a wasp and a bee, most would be on the bee's side. But you at least have to admire the wasp on this occasion.

The insect on the left of the main image is called a beewolf – yet it is a wasp. These animals normally eat pollen and nectar, but once a female beewolf has mated, she turns into a hunter of plump honeybees.

The long, spiky legs help the wasp with grasping, and the white bristly sideburns protect its eyes from the scrabbling bee. Once a bee is caught, the wasp curls her abdomen and stings, injecting a substance that paralyses but keeps the bee alive.

The beewolf then carries her victim to an underground lair. The photo below shows the wasp digging its burrow, which can be up to a metre long, with sometimes dozens of side tunnels, each ending in a brood chamber. Although the insects are solitary, they often build brood tunnels in congregations, so a sandy bank might house thousands of burrows.

Each brood chamber is stocked with one or a few living but paralysed honeybees, with an egg laid on the top bee. The larvae enjoy fresh food as they develop, before spinning a cocoon and transforming into adult wasps. Rowan Hooper



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THE ORIGIN OF MATHEMATICS

It's our most effective tool for understanding the universe. But where it comes from and how it developed remain mysterious, finds Anil Ananthaswamy

TO THE Iranian mathematician Maryam Mirzakhani, the first woman to win the Fields medal, mathematics often felt like "being lost in a jungle and trying to use all the knowledge that you can gather to come up with some new tricks".

"With some luck," she added, "you might find a way out."

Mirzakhani, who died on 14 July at the age of 40, ventured deeper into the mathematical jungle than most. Nonetheless, most of us have spent enough time on its periphery to have a sense of what the terrain looks like.

Increasingly, it seems as if humans are the only animals with the cognitive ability to hack their way through the undergrowth. But where does this ability come from? Why did we develop it? And what is it for? Answering these questions involves diving into one of the hottest debates in neuroscience, and reimagining what mathematics really is.

The natural world is a complex and unpredictable place. Habitats change, predators strike, food runs out. An organism's survival depends on its ability to make sense of its surroundings, whether by counting down to nightfall, figuring out the quickest way to escape danger or weighing up the spots most likely to have food. And that, says Karl Friston, a computational neuroscientist and physicist at University College London, means doing mathematics.

"There is a simplicity and parsimony and symmetry to mathematics," says Friston, "which, if you were treating it as a language, wins hands down over all other ways of describing the world." From dolphins to

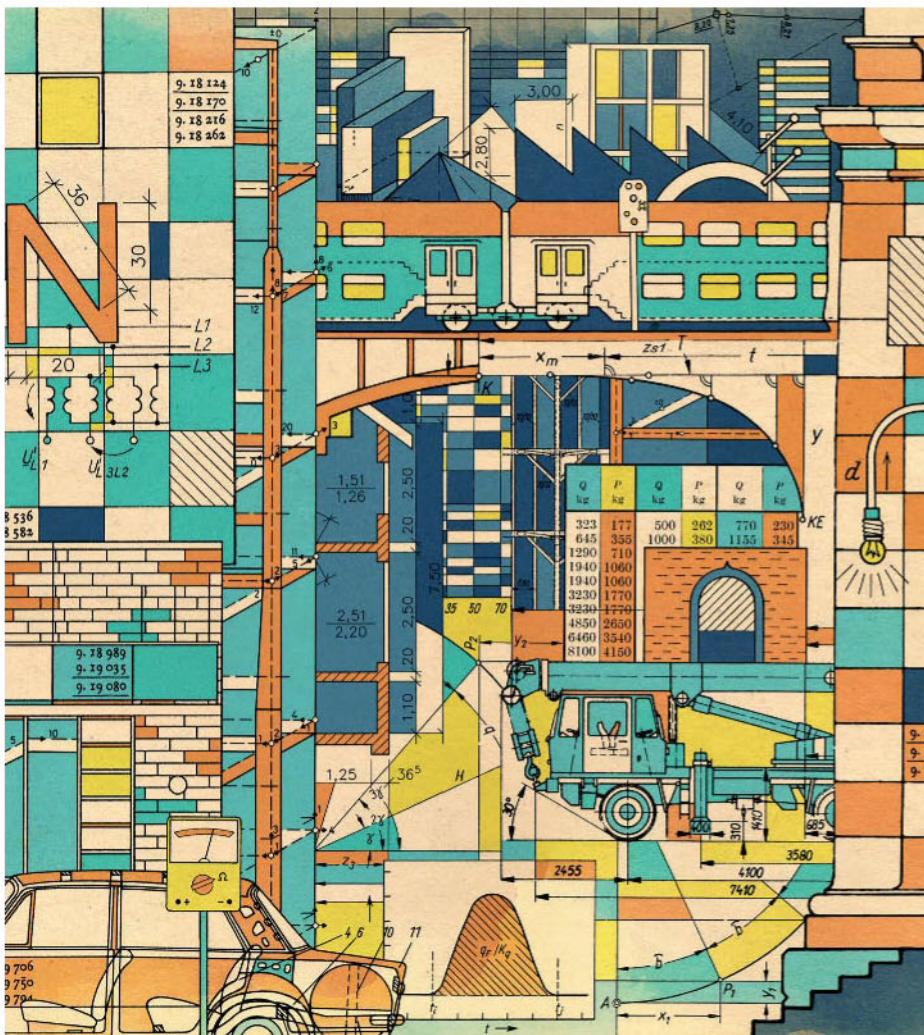
slime moulds, organisms throughout the evolutionary tree seem to make sense of the world mathematically, deciphering its patterns and regularities in order to survive.

Friston argues that any self-organising system – and so any form of life – that interacts with its environment needs an implicit model of that environment to function. The idea goes back to the 1970s and the "good regulator" theorem, co-developed by Ross Ashby, who pioneered the field of cybernetics. To provide effective control, the theorem says, a robot's brain must have an internal model of its mechanical body and its environment. "That insight is becoming increasingly formalised now in machine learning and artificial intelligence," says Friston. The corollary being that an animal's brain, too, must model its body and the world in which it moves.

No thought required

The remarkable thing is that none of these creature modellers are aware of what they're doing. Even we human beings, when we run to catch a ball or dart through heavy traffic, are unconsciously doing some pretty complex mathematics. Each of our brains is constantly using its models to predict what we'll encounter, says the theory, and these models are kept updated by checking the predictions against actual sensations.

Those mathematical functions are undoubtedly being computed by particular bits of the brain, says Andy Clark, a cognitive philosopher at the University of Edinburgh, ➤



UK. But this is not to say that there are specialised modules in the brain similar to buttons on a calculator that we can call up on demand: one to perform multiplication and another to work out cosines. "We don't have access to that," he says.

Although these models try to ensure our survival in a complex world that follows the laws of physics, their insistence on keeping us alive means they sometimes have to compromise on correctness. Take the gambler's fallacy: the mistaken belief that, if the roulette ball keeps landing on red, a bet on black is the best one to make. In reality, of course, both results are equally likely, but the models our brains have built of the world, perhaps to tell our ancestors when to move on from an unsuccessful foraging area, blind us to that simple statistical observation.

Or take the Weber-Fechner effect, which governs our response to external stimuli. Found to hold true across all our senses, it states that our ability to discriminate between sensations of a similar magnitude diminishes as their magnitudes increase

together. So while a 1-kilogram weight can easily be distinguished from a 2-kilogram one, for example, weights of 21 kilograms and 22 kilograms are harder to tell apart. The same applies to the brightness of lights, the volume of sounds and even the number of objects you can see.

Even though human brains share such aberrations with those of other animals, we have developed the ability to identify and overcome some of these flaws. Most obviously, we invented numbers: a system of notation that allows us to instantly deduce that 21 and 22 are as far apart as are 1 and 2. The creation of this complex, symbolic language for mathematics not only allows us to overcome certain such limitations of our subconscious mind, but also to explore abstract concepts in depth and communicate them to others. But how did we develop the

"We could have a sense of number as strong as our sense for colour"

tools to consciously understand what our bodies do instinctively?

One long-standing idea says we are born with a conscious sense of numbers in the same way we are conscious of colours. In his 1997 book *The Number Sense*, Stanislas Dehaene of the INSERM-CEA unit for cognitive neuroimaging in Gif-sur-Yvette, France, hypothesised that evolution endowed humans and other animals with numerosity, an ability to immediately perceive the number of objects in a pile. In other words, three red marbles would produce a sense of the number 3 just as they would produce a sense of the colour red. Dehaene proposed that this numerosity was exact for numbers below 4 and fuzzier thereafter, but nonetheless represented a hardwired ability. Armed with such an instinct, our paths through the mathematical jungle would quickly start to clear.

Innate numeracy

Evidence to support this "nativist" view soon started to accumulate. Elizabeth Spelke at the Massachusetts Institute of Technology and her colleagues showed that 6-month-old children could distinguish between an array of eight dots and one with 16 dots. Then Dehaene and his colleagues reported that the Munduruku Indians in the Brazilian Amazon, who don't have words for numbers larger than 5, could approximately discriminate between much larger quantities, suggesting that this ability was independent of culture.

Other studies indicated that humans instinctively represent numbers spatially on an imaginary "number line", their values increasing from left to right. There was even evidence of numerosity in animals (see "Animal instincts", page 34). This all pointed to an innate number sense that millennia of culture had helped expand.

But before long, some researchers grew uncomfortable with the conclusions of these studies. Might subjects, for example, be distinguishing two arrays of dots based not on the number of dots, but on other attributes such as their spatial distribution or area of coverage? "These are cues that are usually correlated with number, so it would be unwise not to use them," says Tali Leibovich at the University of Haifa in Israel. "If you are an animal in nature and you need to hunt something and need to do it very quickly, you want to use all available cues."

Indeed, on further examination, it seems that people also rely on these non-numerical

cues. Soon, a different hypothesis emerged. Perhaps, instead of having an innate sense of number, we are born with a sense for quantities – such as size and density – that correlate with the numbers of things.

"It takes time and experience to develop and understand this correlation," says Leibovich.

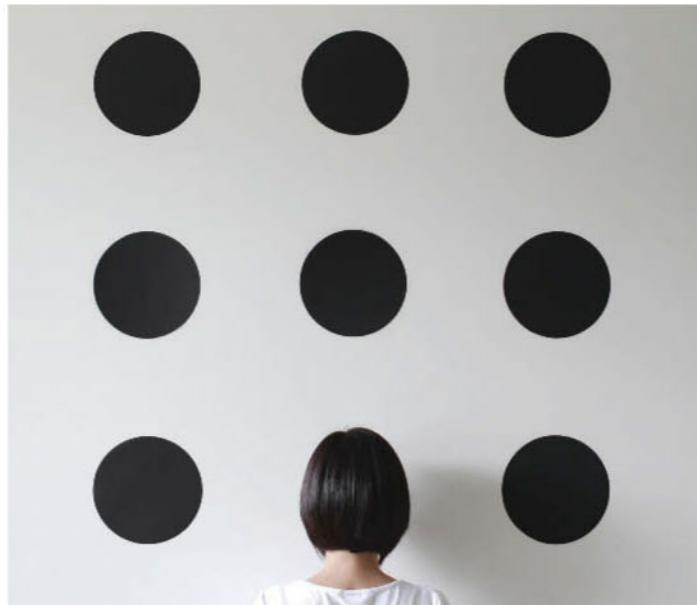
More-refined cognitive tests in children tend to support this view. For example, children younger than about 4 years of age cannot understand that five oranges and five watermelons have something in common: the number 5. To them, a bunch of watermelons simply represents more "stuff" than the same number of oranges.

Even teaching young children to identify the order of numbers – going through the motions of counting – doesn't immediately impart their meaning, says developmental psychologist Daniel Ansari at the University of Western Ontario in Canada. That occurs informally through long-term exposure to parents and siblings. "This points to the strong influence of cultural practices on the learning of exact representations of number," he says.

Study of the cultural aspects of numerical cognition has suffered from bias, says Ansari, in that not enough attention has been paid to data collected from non-industrialised cultures. These findings, he believes, cast serious doubts on the nativist hypothesis.

Take the Yupno people of Papua New Guinea. Rafael Núñez at the University of California at San Diego has learned, for example, that they don't use the supposedly universal mental number line. Also, they have no comparatives in their language to say that one thing is bigger or smaller than another.

**Instinct or culture:
How we grasp
numbers is not all
black and white**



PHOTOGRAPH BY GETTY

This is not to say that the Yupno language is primitive. Far from it. Take demonstratives. In English, there are only four: this, that, these and those, to specify the proximal or distal nature of things. The Yupno, on the other hand, have words to indicate whether something is higher or lower than them in elevation (in keeping with their mountainous terrain), and they have nuanced words to capture not only how proximal or distal something is, but also by how much.

The Yupno are not alone in having a language that doesn't emphasise numbers. Núñez points to a study of 189 Aboriginal Australian languages, of which three-quarters were found to have no words for numbers

above 3 or 4, while a further 21 went no further than 5. To Núñez, this suggests that exact numerosity is a cultural trait that emerges when circumstances, such as agriculture and trading, demand it. "Hundreds of thousands of humans who have language, sometimes very complicated and sophisticated language, don't have exact quantification," he says.

Even languages that do, such as English or French, can only take you so far. Last year, Dehaene and his student Marie Amalric reported the results of scanning the brains of 15 professional mathematicians and 15 non-mathematicians of the same academic standing. They found a network of brain regions involved in mathematical thought that was activated when mathematicians reflected on problems in algebra, geometry and topology, but not when they were thinking about non-mathsy things. No such distinction was visible in the other academics. Crucially, this "maths network" doesn't overlap with brain regions involved in language.

This suggests that once mathematicians have learned their symbolic language, they start thinking in ways that don't involve normal language. "It sounds strange, but it's almost like being able to download an intuition into another world, the world of mathematics, stand back, and let it talk back to you again," says Friston (see "Why do people hate maths?", page 35).

Some of this sophisticated mathematical language certainly develops out of our

WHAT IS MATHEMATICS?

For most of us, maths means numbers, and that's not wrong. The ability to understand and manipulate numbers in the abstract (think addition, subtraction, multiplication and division) is the foundation on which a formidable edifice has been built (see main story). Broadly speaking, this edifice consists of three pillars: geometry, analysis and algebra.

Geometry is probably the most familiar to us. It begins

with a sense of space, codified into principles that describe how static things in space relate to each other, like a triangle's sides.

When you have to consider things that move and change with time, you come to analysis, a field that includes calculus, whether it's integral or differential calculus, or its many variations.

Algebra is what allows us to process knowledge in terms of numbers, symbols

and equations – and it is the backbone of formal higher mathematics. Algebra encompasses such esoterica as group theory (the study of groups, where groups are sets of elements that satisfy certain properties), graph theory (which studies how things are interconnected) and topology (the mathematics of shapes that can be deformed continuously, without breaking and reattaching).

ANIMAL INSTINCTS

The debate over whether our sense of exact numbers is innate has often turned to animals for support. If our distant cousins can be shown to share certain mathematical abilities, then that implies our own must predate the development of culture. Certainly, some individual animals have been shown to display remarkable talent. Alex, an African grey parrot trained by Irene Pepperberg, could correctly identify sets of between two and six objects 80 per cent of the time. Ai, a chimpanzee trained by Japanese primatologist Tetsuro Matsuzawa, could do much the same.

But too much emphasis is placed on research involving animals, says Rafael Núñez at the University of California, San Diego, at the expense of data from human cultures that have sophisticated languages and



RICK FRIEDMAN/CORBIS VIA GETTY IMAGES

yet don't show exact numerosity (see main story).

The animals aren't grasping the symbolic meaning of numbers, he argues. Instead they are simply learning about numbers by association after thousands of tests. It's not unlike how we train animals to do all sorts of things they wouldn't do in the wild. "Are elephants capable of standing on one leg on a little stool wearing a funny hat? Well, yes, if you train them for a long time," says Núñez.

But there is growing evidence that animals are capable of feats approaching numerical ability in their natural habitats. In the early 1990s, lions were shown to distinguish between recordings of one lion and three lions roaring. And in February, at a meeting of the Royal Society, London, researchers reported that some frogs can listen to the calls of competing frogs and either match these calls in number or go one better.

Brian Butterworth of University College London believes such findings show that animals are able to discriminate solely on the basis of numerical information. "We share this with many other creatures," he says.

But these assertions remain contentious. Not everyone agrees that such results demonstrate an animal's instinct for numerosity.

inbuilt sense for numbers or magnitudes, however imprecise it might be at birth. But it probably also leans on many other abilities: language to communicate ideas, working memory to hold and manipulate concepts, and even cognitive control to overcome the kinds of biases apparent in the gambler's fallacy.

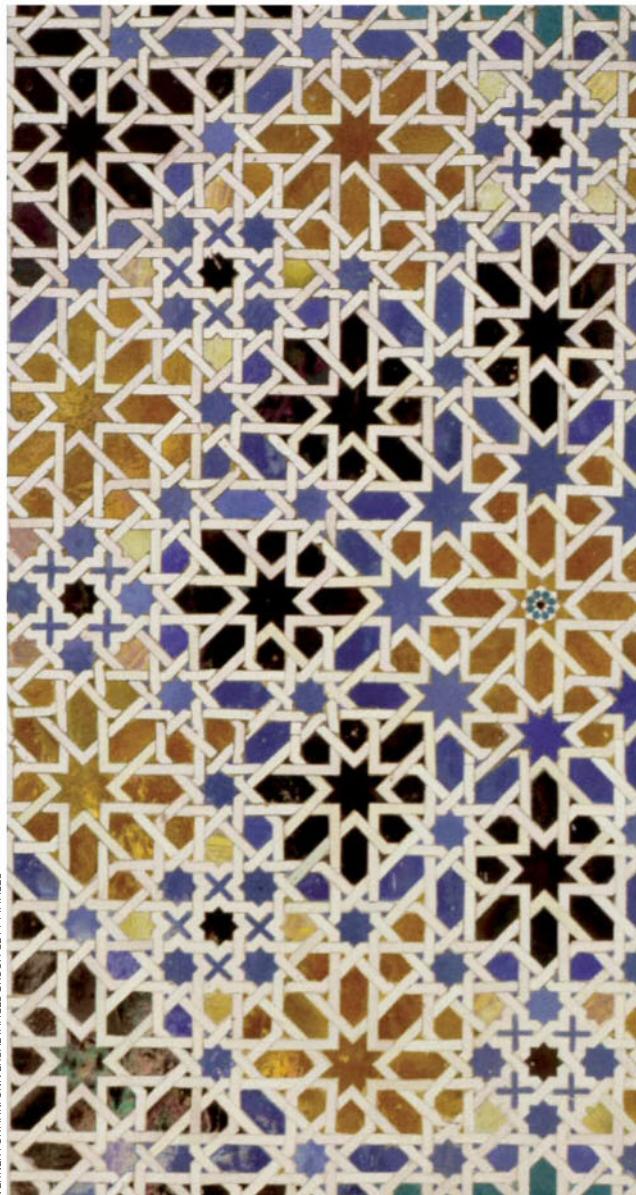
The exact moment when culture transformed whatever instincts we may have had into a recognisable mathematical ability is unclear. One of the earliest pieces of evidence of humans dealing with numbers comes from the Border cave in the Lebombo Mountains in South Africa. There archaeologists found 44,000-year-old bones with notches, including the fibula of a baboon etched with 29 such marks. Anthropologists think that such "tally sticks" were an aid to counting, and represent evidence for an emerging symbolic understanding

related to consciously representing and manipulating numbers.

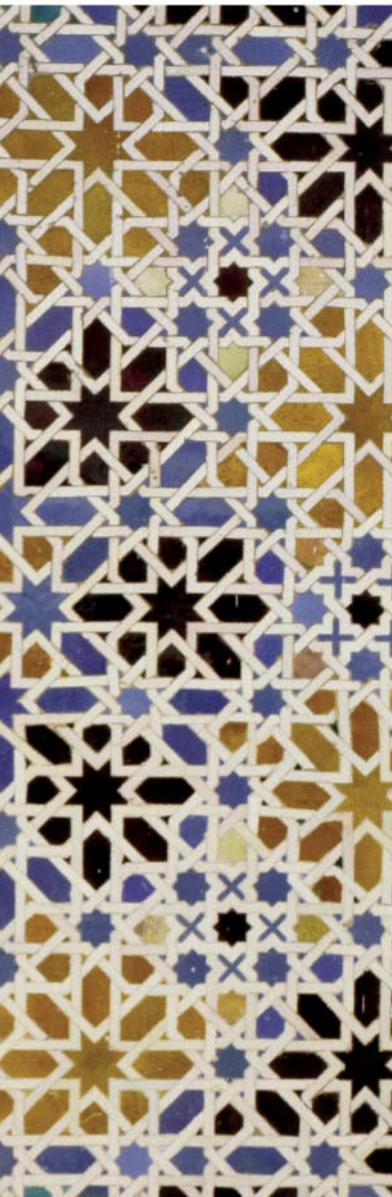
Counting and measuring hit new heights sometime around the 4th millennium BC, in the sophisticated Mesopotamian culture of the Tigris-Euphrates valley, a region in modern-day Iraq. Eleanor Robson at the University of Oxford has argued that mathematics in Mesopotamia was a cultural invention needed to keep track of days, months and years, to measure areas of land and amounts of grain, and maybe even to record weights. And as humans took to the seas, or studied the skies, we began developing the mathematics required for navigation and for tracking celestial objects. But it was always, in the beginning, a product of cultural necessity (and if you think trading-driven mathematics is a thing of the past, think again: some of the most sophisticated

mathematics is being developed for trading stocks and bonds on Wall Street).

With the help of fundamental mathematical tools, humans have built an immense pyramid of mathematical knowledge (see "What is mathematics?", page 33). Over the past 5000 years or so, mathematics has expanded into ever more abstract domains, seemingly further removed from the processes that govern the world around us. And yet, the more we learn about the universe's hidden workings, the more such mathematical innovation seems to describe the things we see. When David Hilbert developed a highly abstract algebra that worked in an infinite number of dimensions rather than the familiar three dimensions of space, for example, nobody could have foreseen its use in the emerging field of quantum mechanics. But soon after, it



WERNER FORMAN/UNIVERSAL IMAGES GROUP/GETTY IMAGES



Mathematics helps us make sense of patterns we see in the world around us

turned out that the state of a quantum system could best be described using such a Hilbert space – with the underlying mathematics remaining key to our attempts to make sense of the quantum world.

The ubiquity of such connections between mathematics and physics led the physicist Eugene Wigner to comment on the “unreasonable effectiveness of mathematics” at describing the natural world. To many physicists today, the success of mathematics as a language speaks to its primacy in the organisation of the universe.

Max Tegmark of MIT is one of these. He thinks the universe is a mathematical structure in that it has only mathematical properties – and we are slowly uncovering this

WHY DO PEOPLE HATE MATHS?

“It is familiar to anyone writing about (or teaching) mathematics: no one very much likes the subject,” writes mathematician David Berlinski in his book *One, Two, Three*.

This distaste, even fear, of mathematics is common – most of us know the feeling. Berlinski says this can be attributed to its use of arcane symbols. Symbols are strange, plus using them in the forms of theorems and proofs

demands great attention, and the pay-off is never obvious (have you ever asked “how is learning algebra going to help me in real life?”). “In mathematics, something must be invested before anything is gained, and what is gained is never quite so palpable as what has been invested,” writes Berlinski.

Maths anxiety, a tendency to panic when asked to perform mathematical tasks, is a very real

thing. But it’s incredibly difficult to study, says developmental psychologist Daniel Ansari at the University of Western Ontario in Canada. When a child displays such anxiety in school, for example, it’s not clear whether it stems from an aversion to mathematical symbols, from an inability to use language to talk about mathematics or from social causes such as an overbearing parent.

structure, brushing away the dust to reveal the theorems and proofs that underpin reality. “It used to be that it was very easy to list the small number of things in nature that you could describe with maths. Now it’s very easy to list the small number of things you cannot,” says Tegmark. Even biology, which long resisted mathematical rigour, is slowly succumbing: witness the proliferation of mathematics in genomics or computational neuroscience.

From this perspective, mathematics is a discovery rather than an invention. For researchers like Núñez, however, that is an overly simplistic distinction. “When the question is asked – is mathematics invented or discovered?” he says, “there is a supposition that it’s exclusive. If you invented it, you don’t discover it, and so on.” But it is not an either-or situation, he says.

Think of the “Elements”, compiled by the ancient Greek mathematician Euclid, which unified all of Greek mathematical knowledge of the time and codified the laws of geometry. Euclid based his work on a series of rules or axioms, one of the most famous being that parallel lines never meet. Over time, the patterns, regularities and relationships that emerged from these “invented” axioms were explored by other mathematicians and proved as theorems. In a sense, they were “discovering” the landscape of Euclidean geometry. But then, thousands of years later, other mathematicians decided to start with axioms that contradicted the ones Euclid set out.

Riemannian geometry, for example, which owes its name to the German mathematician Bernhard Riemann, explicitly relies on the idea that parallel lines can in fact meet. This unorthodox starting point led to the discovery of a rich vein of mathematics that Einstein would use to formulate his general theory of

relativity and describe the curvature of space-time. “The world out there has all kinds of patterns and regularities and ways of behaving, and any creature that is going to build a mathematics is going to have to build it on top of regularities that are constraining the behaviour of the stuff that they encounter,” says Clark.

But no matter which axioms we start off with, mathematics might not be as complete a system of thought as we like to believe. We owe that insight to Austrian logician Kurt Gödel’s incompleteness theorem. Gödel showed that within the bounds of any formal system of axioms and theorems,

“Some ask if mathematics is invented or discovered. It’s not an either-or”

you can make statements that can be neither proved nor disproved. In other words, there are some questions that mathematics can ask, but it will never have the tools to answer.

In which case, perhaps it is too early for us to make any sweeping statements about mathematics being a universal truth. After all, who’s to say that our little corner of the jungle is in any way representative of the whole? But physicists like Tegmark have hope. For him, the biggest hurdle to a mathematical theory of everything is a description of consciousness, the crucible of our own numerical ability. Getting maths to explain its own origins? “That’s going to be the final test of the hypothesis that it’s all mathematics,” he says. ■

Anil Ananthaswamy is a consultant for *New Scientist*

Changing your mind

The menopause has a profound effect on the brain, just like Alzheimer's disease. Could the two be linked, asks Jessica Hamzelou

WE ALL expect the hot flashes," says Lynne Wardale, who started experiencing the symptoms of the menopause around 15 years ago, when she was 48. "I would get them daily, and sometimes they would go on for half an hour. But I wasn't expecting the migraines or the mood swings."

Her sister, Vicki Henderson, experienced intense anxiety when she went through it in her early 40s. "I was short-tempered and experienced a bit of forgetfulness, as well as insomnia," she says.

The menopause directly affects half of us, yet there's a lot we still don't understand about it – not least why it impacts on mood, memory and concentration. But, surprisingly, these cognitive effects may hold the key not only to safely treating this change itself, but also to tackling a disease that presents similar symptoms – Alzheimer's.

Changes in the brain that occur during menopause so closely resemble those seen in Alzheimer's that some researchers suggest it may signal the start of the disease.

"We are trying to find out what happens at that particular time that puts brains at risk," says Roberta Brinton, a neuroscientist studying Alzheimer's at the University of Southern California who has turned her attention to the menopause.

That knowledge might lead to new ways to help women deal with the unpleasant symptoms of the menopause. Even better, it is possible that therapies to artificially boost hormone levels could protect the brain from these changes altogether – potentially staving

off the ravages of dementia later in life.

The menopause essentially signals the end of a woman's ability to have children. As the number of eggs inside the ovaries dwindles, the amount of oestrogen they produce plummets, too. It is the lack of oestrogen – and possibly some of the other hormones released by the ovaries – that is thought to trigger the common symptoms of menopause. These can include hot flushes, fatigue, weight gain, lack of sex drive, and vaginal dryness.

But cognitive effects such as mood swings, insomnia, anxiety and forgetfulness are still often overlooked. This is partly because they may be seen as going hand in hand with ageing. "Another potential reason is that the cultural expectation is that women just endure, even if they may be experiencing uncomfortable or disturbing symptoms," says Brinton.

The brain has plenty of oestrogen receptors, so there's nothing new in the idea that a dive in levels of the hormone can have an effect. But until relatively recently, any impacts on the brain were thought to be associated with reproduction – things like attraction and sex behaviours.

Then an explosion of research over the past decade revealed that a drop in oestrogen can have profound effects on memory, mood and even brain health in both men and women.

These findings raised a red flag with Brinton, who has been trying to understand why women are more susceptible to Alzheimer's disease. "I realised it might be the hormonal transition in perimenopause and ➤

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WHAT'S THE POINT OF THE MENOPAUSE?

Throughout the animal kingdom, females continue to reproduce until they die. But in just three species - humans, killer whales and pilot whales - they live on in good health way past the end of their reproductive years. If an animal's purpose is to pass on its genes to the next generation, what's the point of this unique biological feat?

The most established theory is the "grandmother hypothesis", and comes from research on killer whales. They have a much better chance of living for longer if their grandmothers are around. "The grannies seemed to boost the survival of an offspring, even if it was 30 years old," says Hazel Nichols at Liverpool John Moores University in the UK.

Similar effects have been seen in human populations. Historically, a woman's daughter is more likely to have more children if the grandmother is there to help.

Another theory, the "mother hypothesis", is based on the fact that childbirth becomes a riskier prospect as women age. At some point in a woman's life, taking care of her grandchildren is a safer way to ensure the survival of her genes than having her own children.

Or, it could be that there is a "mismatch" in the way that various parts of the body age. The female reproductive system might simply be more vulnerable to ageing. And if the effects aren't seen until around the age of 50, by which time many women will have already had children, there is no evolutionary pressure for change.

DO MEN HAVE A MENOPAUSE?

The male "andropause" is much more difficult to study because it is not as dramatic as the menopause. Research is starting to suggest that a rapid drop in hormone levels around the menopause could cause brain changes that relate to the onset of Alzheimer's disease in women (see main story). But men tend to experience a far more gradual decline in testosterone, of around 2 per cent a year from the age of 30. "This slow decrease may explain why men are less affected by Alzheimer's disease," says Amandine Grimm, at the University of Queensland in Australia.

Even so, testosterone is also thought to protect the brain, as well as to regulate the brain's metabolism - much like oestrogen in women. This means therapies that counter this drop may ease the symptoms - which can include depression and mood changes - and may also help those at risk stave off Alzheimer's disease later in life.

menopause that appears to be the kick-starter for Alzheimer's in some women," she says.

This idea also fits with findings from Brinton and others that oestrogen has a protective function on the brain. One form of oestrogen called oestradiol, for example, ramps up activity in the brain cells' mitochondria - essentially, their energy factories. The extra energy boost helps cells recover from damage associated with the normal wear-and-tear of ageing.

"You can imagine that if there is this drop in oestrogen, the brain becomes more sensitive to damage, and that could lead to the death of neurons," says neuroscientist Amandine Grimm at the University of Queensland in Australia, who studies the ageing brain.

And a fall in oestrogen levels doesn't just cause the brain to produce less energy, it also seems to change the type of energy it uses.

For most of our lives, the brain's fuel of choice is glucose. "The brain is the most glucose-dependent organ in the body," says Brinton. At least, it is until menopause hits. Brinton has found that, as mice go through their equivalent of menopause, the amount of glucose metabolised by their brains drops dramatically, by about 25 per cent.

Hungry brain

When body tissues are faced with a shortage of glucose, they enter a "starvation response", and turn to fats as a backup source of energy. Something similar seems to happen in the brain. Over time, it appears that the brain resorts to a readily available source of fats - myelin, the fatty white sheaths that coat the majority of brain cells and ensure that brain signals travel quickly. "We have found that the brain will catabolise the white matter for fuel," says Brinton. In short, the brain starts to eat itself.

Most of Brinton's research has been in mice, but in work yet to be published, she and her colleagues have tentative results suggesting that something similar happens in the brains of some women going through the menopause. "We see that there is a decline in glucose metabolism, a change in white matter volume and grey matter volume, and an increase in beta amyloid production relative to men," she says.

This switch could account for some of the symptoms of menopause. For instance, fatty molecules are a much less efficient energy source than glucose, and their metabolism is known to create a lot more heat. Animal studies suggest this excess heat in the brain

could trigger hot flushes. But could these changes also signal the start of Alzheimer's disease? Two-thirds of people with Alzheimer's are women. And although most are diagnosed in their 70s, we know that the disease starts to develop around 15 to 20 years before symptoms start to show - which is when the menopause occurs.

Research in people with Alzheimer's disease backs up the idea. Using a type of brain scan that measures how much glucose is being metabolised across different brain regions, in 2005 Lisa Mosconi at New York University and her colleagues found that reduced glucose metabolism is a hallmark of Alzheimer's.

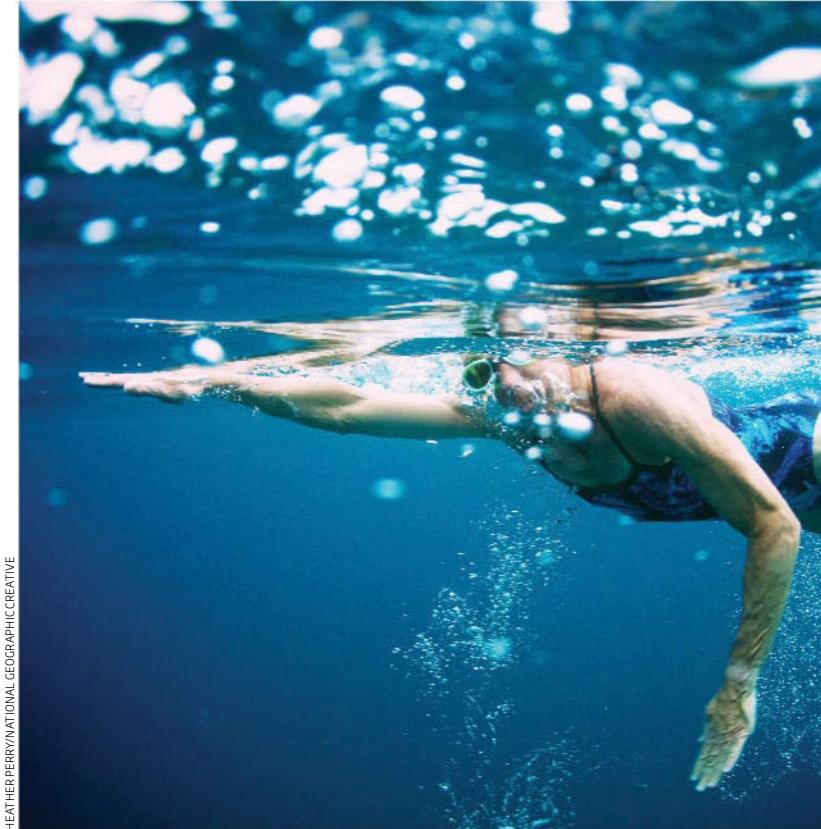
"Lisa and I had a conversation, after which she went back and looked at her dataset for women who were perimenopausal or postmenopausal," says Brinton. "Her findings completely match our animal work - that there is a decline in glucose metabolism with the menopause." Last year, Brinton was awarded a \$10.3 million grant to further research the link between the menopause, the ageing brain and Alzheimer's.

If a lack of oestrogen might cause so many problems for the brain, it makes sense to replace it in menopausal women. "If we are going to intervene in Alzheimer's disease, we're much more likely to be successful if we identify women at risk at the time that these mechanisms are at play," says Brinton. "Perhaps we can change the risk."

Some studies do suggest that hormone replacement therapy (HRT), which was a popular treatment in the 1980s and 1990s, could help older women stave off dementia. But the theory was dealt a massive blow by the results of the Women's Health Initiative Memory Study - a huge trial of HRT in 7500 women in 2005.

It found that HRT actually seemed to hasten cognitive decline and increase dementia risk. It also suggested HRT put women at an increased risk of breast cancer and cardiovascular disease. The study was halted and the treatment's reputation was left in tatters.

But the study was flawed. For a start, the women in the trial were given a formulation of hormones called conjugated equine oestrogens. "They have about 10 active oestrogens, and they come from pregnant horses," says JoAnn Pinkerton at the University of Virginia in Charlottesville, who is executive director of the North American Menopause Society. Beyond the fact that humans are very different from horses, the hormonal milieu associated with pregnancy is far removed from that of a pre-menopausal woman.



HEATHER PERRY/NATIONAL GEOGRAPHIC CREATIVE

What's more, all the women in the study were over 65 – well past the menopause. By this age, it is likely that the brain has adapted to low levels of oestrogen, and that the number of oestrogen receptors has diminished.

This could mean there is an optimum time for HRT treatment, during which the benefits could outweigh the risks. "The hypothesis is that there is a limited window in which the brain is responsive," says Pinkerton. "If there is too long a gap between symptoms and treatment, there won't be an effect." That's because HRT seems to work better on healthy brain cells – once they become sickly, they are too far gone to be rescued. This theory chimes with more recent guidelines suggesting that HRT seems to be, on the whole, beneficial for women who take it around the time of menopause.

But this doesn't mean HRT should be prescribed for all women going through it. For a start, not everyone experiences unpleasant symptoms, and not all menopausal women eventually develop dementia – although Brinton would like to investigate whether there is a link between the severity of cognitive symptoms and later onset of dementia.

Increasing your lifetime exposure to these

Keeping active can counter menopausal symptoms, and give a cognitive boost

hormones is also known to increase the risk of breast cancer, especially in people who are already vulnerable. "If used in the long term, we see an increase of just under one case per 1000 cases of breast cancer," says Nick Panay, a consultant gynaecologist and board member of the International Menopause Society.

Yet women shouldn't feel afraid to try HRT if they are experiencing unpleasant symptoms, says Pinkerton. "We used to recommend 'the lowest dose for the shortest amount of time', but it is important that we allow the treatment to be appropriate." Exactly what makes for the

"Drugs that target specific organs are the future of menopause treatment"

most appropriate treatment for any individual woman is still being figured out.

An altogether better solution might be to use oestrogens that only work on specific organs. A hormone that protects the brain but bypasses the breast, for example. "These drugs are already in development," says Jacob Raber at Oregon Health and Science University in Portland. "They are definitely the future [of menopause treatment]."

It's possible a nutritional approach may also protect the brain from these changes, says Brinton. "Here the idea is for the brain to use lipids that are fed to you," she says. Such ketogenic diets, as they are known, have already been found to benefit some people with epilepsy. But a high-fat diet might not be the best option for people who are already at risk of weight gain. Nor does it fit with evidence that a healthy Mediterranean-style diet rich in fruits, vegetables and grains has a positive impact on brain health. Keeping active, in contrast, has no downsides and can also counter menopausal symptoms, says Pinkerton. For instance, we know that exercise can boost mood and cognition and can increase bone mass.

Still, Brinton believes the best hope for treating menopause symptoms – and potentially staving off Alzheimer's – will be individually tailored hormone therapies given at exactly the right time. "We are in an age where we can bring a precision medicine approach to hormone therapies," she says. "We can start to ask questions about what hormone therapies are best for particular women. That's the exciting new frontier for women's health in latter years." ■

Jessica Hamzelou is a reporter at *New Scientist*

EARTH'S PULSE

By watching the whole planet's surface rise and fall, we can save many lives, says John Pickrell

APART from the enormous tortoises and wealth of other wildlife, the Galapagos Islands are home to thousands of people. Some 200 live on Isabella Island, the archipelago's largest landmass, which they share with Cerro Azul, an active volcano. So when scientists picked up signals suggesting the volcano was stirring, they were justifiably worried.

The quiverings underneath the volcano were detected at the Geophysical Institute in Quito, Ecuador, in March. The scientists acted fast. First, to be on the safe side, they issued a warning to residents. Then they rang a team that they hoped could confirm if an eruption was imminent.

While most geoscientists rely on ground-based measurements to help interpret the planet's inner manoeuvres and rumblings, the crack squad on the end of the phone thinks it has a faster, better method. Earth's hidden activities manifest themselves as subtle bulges and dips on its surface. So, find a way to follow such movements, and we would open a new window into the realm below. That could help us discover hidden fault lines, track the underground course of magma streams and learn how earthquakes change the delicate balance of Earth's tectonic plates. More importantly, it could save lives.

What happens in the bowels of the planet is a mystery, but we have a decent idea about the nature of the first few hundred kilometres beneath the surface. Tectonic plates, at most 250 kilometres thick, float on a layer of molten rock. Sometimes, those plates move suddenly against or away from each other, creating earthquakes. And at spots we call volcanoes, the liquid rock spills onto the surface.

To study the plates and these hazards, geologists often use seismometers to detect vibrations, track surface movements by attaching GPS devices to the rock, or measure

Sometimes volcanoes with no history of eruption go up without warning



ARCTIC IMAGE/ALAMY

emissions of gases such as sulphur dioxide, which hint at magma on the move deep below. Each deployment of these methods generally gives us information on just one locality, meaning we can only monitor a tiny fraction of Earth's surface.

But there's no reason in principle why we can't have a global picture. Enter, interferometric synthetic aperture radar, InSAR for short. This satellite-mounted radar technique, developed by NASA in the 1970s, bounces radio waves off Earth's surface. From this, you can work out the distance between the instrument and the surface, and by comparing measurements taken days or weeks apart, visualise the average surface movement – to within a few millimetres.

Instruments like this have circled the globe aboard satellites since the early 1990s. But they didn't cover the whole planet and the time between measurements was long.

Now "an incredible game changer" is on the scene, says geophysicist Tim Wright at the University of Leeds, UK. It comes in the form of the European Space Agency's pair of Sentinel-1 satellites, dedicated to continuous InSAR measurements. Analysing those readings is a UK research consortium called COMET. "What makes it stand out is the attempt to eventually cover the whole world,



THE ASAHI SHIMBUN VIA GETTY



Using satellites, we can follow the path of magma flows while they are still underground

that incident in the Galapagos. When the Ecuadorian researchers got through to COMET, they wanted to know what was going on. "We were able to send back a result within about 12 hours," says Wright. There was certainly something brewing below Isabella, but thankfully the analysis showed magma was moving 5 kilometres beneath the ground, meaning an imminent eruption was unlikely.

The tortoises and the local people were safe, but there are plenty more threats around the world. Obviously active volcanoes such as Santorini in Greece and Mount Etna in Italy are permanently watched. "But many others are not monitored, especially those in the developing world," says Tamsin Mather, a volcanologist at the University of Oxford. Yet sometimes they do blow, as was the case with Japan's Mount Ontake in 2014, which killed 60 people, and Calbuco, Chile, in 2015, when thousands were evacuated. Then there are "zombie volcanoes": those that are deforming but aren't watched, because they haven't erupted in many thousands of years.

The solution might simply be to monitor them all. That's what Mather and the other COMET scientists are planning. The satellites are already collecting images of most of the planet's surface, including every land volcano. For now, the team is processing a backlog of data and putting it into a public repository. The next step is to develop an algorithm to parse the data in real time and flag up any suspicious bumps so a warning can be issued. This should be running by the end of the year.

The system might not work in all cases, says Matthew Pritchard of Cornell University in New York, because deformation is difficult to detect under heavy vegetation, for example. But fieldwork can fill those gaps, which will be a relief to Mather. She finds visiting volcanoes awe-inspiring, with fire fountains thundering and clinking lava flowing past, while the ground pulses with energy.

Put the satellites and fieldwork together and it will usher in an "era of global volcanology", says Pritchard. Monitoring volcanoes over time will allow us to build up a database and match specific patterns with actual eruptions. "We want to be able to say: 'The volcano is showing these symptoms – what's the likelihood of an eruption?'" says Mather. If we can do that, it truly will be a game changer. ■

if all goes to plan," says Roland Bürgmann of the University of California, Berkeley.

InSAR is handy for many things, including tracking ships and icebergs. But its promise in geoscience was demonstrated in 2014, after the first satellite, Sentinel-1A, was launched. The Icelandic volcano Bárðarbunga had begun to release magma, so COMET scientist Andy Hooper, also at the University of Leeds, looked into it.

As lava began to shift in a chamber beneath the volcano's crater, the team saw a bulge forming along a nearby surface rift. Using InSAR images, they followed the bulge as it travelled 47 kilometres over six months, eventually coming to the surface and spraying out lava equivalent to more than half the volume of Mount Everest. The long, convoluted path the lava took was a big surprise, says Hooper.

By November 2016, Sentinel-1B was in action too, meaning both satellites could be called upon when a magnitude-7.8 earthquake struck near Kaikoura, New Zealand.

Normally, earthquakes are relatively simple. Even a magnitude-8 quake might only rupture a few segments along a single fault line. But the Kaikoura one ruptured an interlinked network of 12 faults – some sliding towards each other, others thrusting apart. "It's

probably the most complex earthquake ever observed with modern tools and it has completely changed the way that we think about earthquakes," says Wright. The find is prompting seismologists to re-evaluate earthquake hazard models, which state that if several interconnected faults did rupture, they would do so in separate earthquakes, with each creating the strain necessary for the next.

Hidden faults

Until quite recently, we had surface deformation data for only a handful of earthquakes. And since quakes may only repeat once every 10,000 years in some places, we haven't yet seen the range of ways they can play out. But with COMET, there should be records for perhaps 40 quakes every year.

One implication is that COMET could discover hidden fault lines. Our maps of these lines are based on records of quakes, but these sometimes happen where we've never seen them before. One example is the magnitude-6.6 quake that hit Bam, Iran, in 2003, killing more than 26,000 people. Data from Sentinel-1 should allow the COMET team to spot things like this in advance.

Bulge-watching could also help us decide what action to take, as was demonstrated by

John Pickrell is a science journalist and author based in Sydney, Australia

Facing down a tsunami of hate

When game designer **Zoë Quinn** became a lightning rod for internet abuse, her life as she knew it was destroyed. Her fightback continues

WHEN Zoë Quinn picks up, she sounds a little on edge. "My phone came up 'No caller ID', which always makes me feel a bit nervous," she says. "You understand why I might be a little stand-offish at first."

Quinn is a games developer in the US who co-founded Crash Override Network, a group that helps those subjected to online abuse. She is better known as a key target in the storm of abuse dubbed "Gamergate" – one of the most sustained and coordinated hate campaigns the internet has ever seen.

And she lived to tell the tale. Her new book, *Crash Override*, is both autobiography and manual for dealing with the hate wars raging online. The first thing Quinn tells me is that online abuse is worse than most people think. Four in 10 people in the US have been harassed online, according to a recent Pew survey. Twitter is notorious for people posting racial and misogynistic abuse, for example, but anywhere that provides a public forum lets people vent the worst they have to give.

"YouTube is a dumpster fire even worse than Reddit, and Reddit is a goddam joke," says Quinn. Reddit – one of the largest online discussion sites, branding itself the front page of the internet – is increasingly popular with white supremacists, she says.

Don't feed the trolls, people say. But it is useless advice when the internet wants to destroy you. Quinn has received so many death threats she has lost count. Her home address and phone number were posted online. She has had 5 am phone calls from strangers detailing how they plan to rape her. Her father was harassed. Dead animals have been put in her mailbox. Nude photos were stolen, plastered across the internet and sent to family, friends and colleagues.

Before Quinn's hell began on 15 August 2014,

things were looking up. Her game *Depression Quest* – which simulated the experience of someone with depression – had seen modest success and she was becoming a name in the indie developer scene. Then her ex-boyfriend posted a 9000-word character assassination on websites popular with gamers, including salacious details of alleged infidelities. He accused Quinn of sleeping with a games journalist. Boom! For anyone desperate to find it, here was "evidence" that Quinn had exchanged sex for good reviews of her game.

Warped perception

It made no sense. For a start, the journalist had never even written about Quinn's game. But for thousands of gamers with a warped perception that women were changing the industry for the worse, the accusation rang true. Within minutes of the document going up, her phone started buzzing as people began to hound her on social media. A few hours later, she was "doxxed" – her phone number and address published online.

"People don't understand how this sort of thing can happen over less than nothing, so they think there must be some truth to it," says Quinn. "The rumour persists because people don't bother to look it up. Even if they do, there's so much garbage on the internet, it's hard to tell what's true."

Within weeks, the mob organised a crusade against what it framed as corruption in the games industry. Some websites cracked down on users who supported the harassment – and were in turn accused of censorship. Still, each credulous story from mainstream news sites gave the campaign validation. "The adults running these outlets should have damn well known better," says Quinn. "Every scrap of

legitimacy the abusers got was a new circle of hell for me. That's the shocking part, and arguably the most upsetting."

Gamergate is viewed as one of the internet's darkest hours. The storm blew itself out after a year or so, but for those on the campaign's most-wanted list, it has never really ended. Though the hounding is now less intense, says Quinn, "there's still a large community of dedicated stalkers".

Her coping mechanisms have become routine. Every so often, she'll lose a day rushing to shut hackers out of her online





accounts. When one goes down, she quickly changes details across others as a precaution, changing passwords and phone numbers. "I'm so used to all of this shit, I forget other people haven't been face down in it for years."

Hate campaigns like Gamergate achieve remarkable levels of coordination thanks to the strength of the communities behind them. "There's a shared bonding, people are making friends," says Quinn. "They have their own in-jokes and mascots." She understands the attraction of an activity done with other people who share your views – especially ones

you couldn't share with anyone at work. "If you said to someone face-to-face a lot of the things people say to me online they'd be like, 'What the hell is wrong with you?'" But that's what draws people in and sustains their abuse. "When what you're doing with other people is a dirty secret, there's an allure to it."

Where are these people? All around, says Quinn. "The person screaming at minorities online might be the person at work who makes you uncomfortable with their jokes," she says. "Maybe it's slightly racist stuff. Maybe it's the embarrassing high-school friend you make

excuses for." People find each other online and build a movement.

All this makes the internet sound like a lawless place, but Quinn is quick to point out that isn't the case. "The internet has laws, it's just very selective on what matters."

In her experience, the police have been at worst completely unsympathetic and at best unable to help even if they wanted to. The internet doesn't map onto police jurisdictions and, at times, Quinn was unable even to file a complaint. If it happens online, it is always someone else's problem. But there was no one else. That's where *Crash Override* comes in. After a few years of frustrating first-hand experience, Quinn knows what kind of help those subjected to abuse need. She has the

"YouTube is a dumpster fire even worse than Reddit - and Reddit's a goddam joke"

contacts at websites who can delete malicious material quickly and she knows what practical steps you can take to defend yourself.

Given that many abusers are heterosexual white males, I ask Quinn if it matters that she's being interviewed by one. She says a woman might have a better understanding of what it is like to be abused. "Men of colour get it more. Gay men get it more." But it depends on who you're writing for, she says. Perhaps a white male can speak to a non-minority audience more easily. "Getting people to realise this is a real problem is a huge first step," she says.

That is why she wrote her book, though she knows it will bring a spike in abuse. "Whenever I do anything, people pop up and say, 'Oh, it's that professional victim Zoë Quinn.' There are thousands of people ready to twist what I say into a weird balloon animal, something that'll make people start coming after me again."

Yet despite all that, Quinn is upbeat about the future. "I'm an optimist, though it depends on what day you get me." Her unlikely positivity comes entirely from seeing the difference just one person can make. "What we do online matters," she says. "It's so easy to hurt somebody, but it's just as easy to bring people up and look after each other. The internet is made of people, and people have got to step up. At least, let's not surrender the internet to those who scream the loudest." ■

By Douglas Heaven

Zoë Quinn's new book is *Crash Override: How Gamergate (nearly) destroyed my life, and how we can win the fight against online hate* (PublicAffairs)



Ending the world with a nod and a wink

Cyberwarfare is as much about rhetoric as it is about bits, finds **Nina Jankowicz**

The Darkening Web by Alexander Klimburg, Penguin Press



IN LATE June, I was leaving for a flight from Kiev's Boryspil Airport as news broke that Ukraine was the victim of another massive

cyberattack. ATMs, gas pumps and supermarket checkouts were frozen. Government computers appeared to be seized by ransomware. Chernobyl's radiation monitoring system was affected. There were reports that

the attack had grounded planes at the airport. Not that I could get there: I couldn't seem to catch a cab on a single ride-sharing app. The attack spread with frightening speed, but I eventually made it to Boryspil, where everything seemed to be functioning normally. Frankly, though, the thought of hurtling through the air in a metal tube guided by computers during a global cyberattack did give me pause.

It's this type of worldwide cyber-chaos – the type that could down airplanes, turn off respirators and plunge millions into darkness – that Alexander

Klimburg warns of in *The Darkening Web*. And it's much closer to crippling our societies than world leaders would like to believe.

Deadly ignorance

Klimburg, a strategic analyst in this field, compares cyberwarfare to the threat posed by nuclear weapons. But there is one critical difference: while "the horror of the nuclear mushroom cloud [has been] burned into the minds of a generation of decision makers", there is little understanding within government, never mind outside

Cyberwarfare attacks citizens' minds as well as their infrastructure

it, of the consequences of all-out cyberwar. Without such a basic understanding, along with a more transparent policy, we risk being plunged into total cyber-conflict.

Having put the fear of God in us, Klimburg tells the story of the internet: how it was built and how it is governed – as a way of asserting US dominance, according to a few nations. He also talks about hackers, who are not the "400-pound guys" of President Trump's imagination, but complex beings who just as often work for governments as against them. We find out how they exploit the internet's vulnerabilities.

One of the key vulnerabilities in US cyber-policy, Klimburg says, is "cyber-innuendo". If governments were teenage boys, Washington would be the kid boasting about his latest escapades with the prettiest girl in class. His embellishments on a kernel of truth are meant to inspire shock and awe, but succeed in egging other boys on to sharing or pursuing even fiercer strategies of their own. Information about US cyber-dominance is established through strategic leaks, but these only serve to encourage actors like Russia and China to beef up their own capabilities and train their sights on the US and, increasingly, on their own people.

In China, for example, the Great Firewall "protects" citizens from problematic content, and political discussions are deflected by government contractors. Citizens' behaviour on social media is meticulously monitored and may soon be assigned a government "social credit score".

The Russian cyberthreat is, by contrast, meant "not to compete with the United States and the West, but somehow to catastrophically weaken them". Klimburg does a fine job explaining the various structures within Russia's security services that handle cyberwarfare.

His definition encompasses not only the hacking to which the West has now grown accustomed, but also the widespread information warfare equally capable of influencing policy and populations.

Despite being well aware of the dangers of Russian information war, Klimburg falls victim to it, referring to the Russian invasion of eastern Ukraine as an “insurgency... and resulting civil war”. This is exactly the narrative that Russia peddled after it invaded Ukraine’s sovereign territory, sending troops, weapons and money to so-called separatists in the Donbas for three

In China, behaviour on social media may soon be assigned a government ‘social credit score’

years, at a cost of 10,000 lives. With his knowledge of Russia, Klimburg should know better than to buy into this lexicon.

Klimburg’s warnings regarding Russian cyber-aspirations, however, are on the money. He does not think the US election was turned around solely by Russia’s campaigns and incursions. Still, his recommendations might have helped the Obama administration retaliate while evading charges of partisanship. Klimburg argues that governments should be clear and transparent about what types of cyberattacks they face and what “deterrence by cyber-means” should entail.

Time treats books in strange ways. Seven months into the Trump administration, which is actively working to unravel the freedom of the internet and aiding the spread of disinformation from the Oval Office itself, *The Darkening Web* feels less like a work of advocacy, more like a cry for help. If only we had known, perhaps we could have staged an intervention. ■

Nina Jankowicz is a foreign affairs specialist based in Washington DC

A whale called Hope

The giant mammal stages a takeover, finds **Shaoni Bhattacharya**

Whales: Beneath the surface, London's Natural History Museum, until 28 February 2018

THERE is no escaping Hope, the spectacular centrepiece in the Hintze Hall entrance gallery of London's Natural History Museum. All 4 tonnes of the 25.2-metre-long skeleton of a blue whale are suspended in mid-air from the Victorian vaulted ceiling – a perfect outing for late summer visitors or parents with fractious younger children.

I was in the museum to see its latest exhibition, “Whales: Beneath the surface”, but it was the majestic Hope that captured my attention, as she seemed to dive straight at me as I entered the building.

This is no accident. She is in a lunge-feeding dive mode, says Lorraine Cornish, head of conservation at the NHM, who

worked on the project for three-and-a-half years. Hope's hefty mandibles are open and she is off-centre to recreate the moment when blue whales corkscrew in to capture krill. “It was a really challenging pose to get her in, but we wanted to be scientifically accurate and make her dynamic in the space,” says Cornish.

Suspending her from the ceiling involved mathematicians and structural engineers. At her lowest point, Hope is about 4 metres above the floor, while her highest tip is about 13.5 metres up.

Hope had been on view at the museum since 1934, hanging above a life-sized model of another blue whale until October 2015, when the work to move her started. She was taken down piece by piece and then spent

Hanging Hope took the skill of mathematicians and engineers

10 months in a pop-up lab at the museum before being moved to an adapted aircraft hangar in Oxfordshire for conservation work.

The team used lidar scanning to create a 1.5-metre-long 3D printout to work out how to articulate her skeleton. They also used high-resolution scanners, and made CT scans of her tail section to gather data.

The whale exhibition also held my attention, with fascinating specimens, including the skeleton of the whale that lost its way in London's Thames river in 2006. Also on display is the vertebra of a blue whale and jars containing strange pickled humpback whale fetuses at different developmental stages.

The show explains many aspects of whales, from their evolution from small land animals 50 million years ago, to the ability of some of them to use echolocation, as well as their cultural and social complexities.

Opening at the same time as Hope means the exhibition can't really compete – unless you start there and leave Hope until the end. After all, what can match a whale diving right at you, mouth agape?

But Cornish hopes visitors will take home another message. Once abundant, blue whales were hunted to just 500 individuals before a ban on commercial whaling came in during the 1960s. Now they are at a healthier level – 20,000 individuals. “We were one species that almost annihilated another, and we have brought them back from the brink,” she says. “Tread lightly.” ■



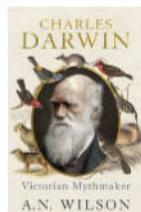
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Shaoni Bhattacharya is a consultant for *New Scientist*

Reduced fact content

Hostile biography of Darwin is deeply flawed, says **John van Wyhe**

Charles Darwin: Victorian mythmaker
by A.N. Wilson, John Murray



A. N. WILSON has written many biographies, his subjects ranging from Queen Victoria to Hitler. His latest, about Charles Darwin, begins with the startling sentence: "Darwin was wrong." Wilson argues that "Darwin offered to the emergent Victorian middle classes a consolation myth... there was something inexorable, natural about their superiority to the working class."

According to Wilson, Darwin told his contemporaries "that their land-grabs in Africa, their hunger for stock-market wealth in the face of widespread urban poverty, their rigid class system and their everlasting wars were not things to be ashamed of, but actually part of the processes of nature". Darwin's theory, Wilson concludes, is just an ersatz religion.

Wilson maintains that Darwin's theory isn't the basis of current knowledge. He thinks Darwinism was about extreme gradualism over geological time. But Darwinian gradualism simply means that one animal can't all of a sudden give birth to a new species. The current view of life on Earth is precisely one of lineages branching from common ancestors. This, and not the speed of change, is the core of Darwin's theory.

The other component of Darwinism, according to Wilson, is "that evolutionary progress happens by conflict". Here is the

common misunderstanding that the struggle that occurs because some animals live and some die means conscious fighting.

Darwin's theory, as any competent reference work describes, is about the differential survival of individual living things based on tiny differences between them. This in effect filters living things to become adapted to a changing world. DNA evidence indicates that all living things are related genealogically on a vast ever-branching tree of life. This is Darwinism. Wilson instead erroneously describes variations in "species", not individuals, and he mocks a "Darwinian" scenario in which

the short-necked ancestors of today's giraffes were supposedly "panting to reach those leaves, but without success". This is not Darwinism, this is Lamarckism.

Wilson's book contains numerous factual errors, such as "if Darwin were correct, there would be hundreds, thousands of examples" of transitional fossils. There are. Darwin's first grandchild did not die in childbirth as Wilson states. A fragment of Wallace's letter to Darwin from when Wallace was

"Wilson invents and condemns a towering ambition Darwin had to be a universal genius"

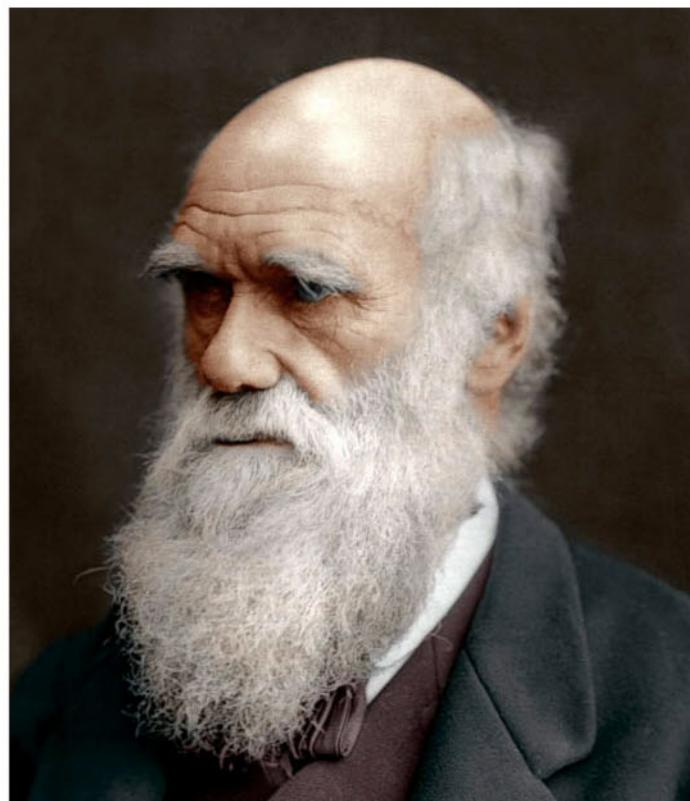
living in Ternate does not survive. "Darwin believed that his own theory... made it impossible to believe in the Bible." Not so. The first 50 pages of Darwin's evolution notebook are not missing. (Wilson copied this claim from a conspiracy-laden essay, "Darwin, Coleridge, and the theory of unconscious creation", published by Loren Eiseley in 1965.) The missing pages were located and published in 1967.

Wilson claims Darwin "never" persuaded the scientific community in Britain during his lifetime "that one species could evolve into another". In fact, Darwin was world famous for having done so. There are very, very many more errors. Footnotes lead to incorrect references and many dates are quite wrong. It's hard to see how any care for either historical or scientific accuracy could result in such a book.

Throughout, Wilson bashes Darwin for supposed arrogance, dishonesty and incompetence, and trots out a long line of old anti-Darwin myths: for example, that Darwin stole ideas from Edward Blyth, whom Wilson mistakes for an evolutionist. Wilson invents and condemns a "towering ambition" Darwin had "to be a universal genius". And eugenics and Nazi race laws are also blamed (incorrectly) on him.

The book claims to be a "radical reappraisal of one of the great Victorians, a book which isn't afraid to challenge the Darwinian orthodoxy". But it is one of the most unreliable, inaccurate and tendentious anti-Darwin books of recent times. ■

Painted in a corner: "mythmaker"
Charles Darwin

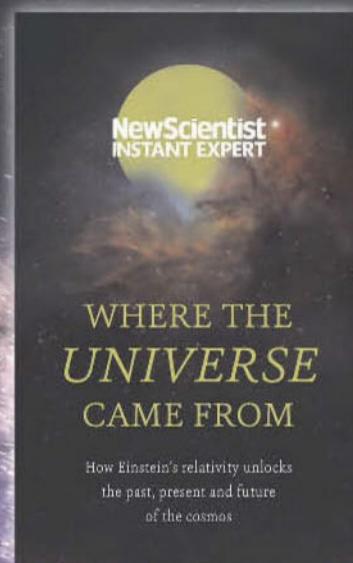
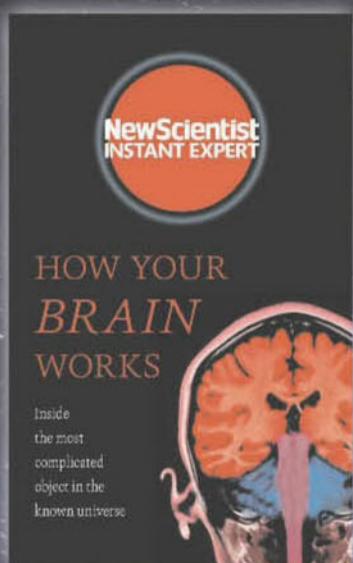


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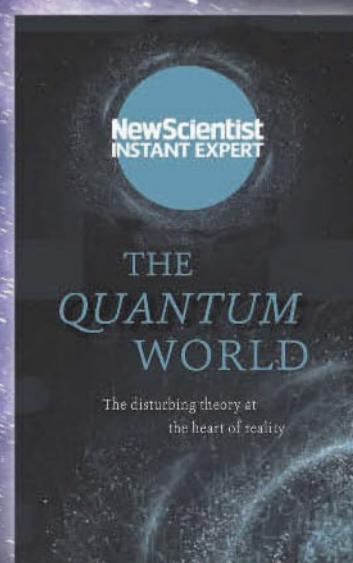
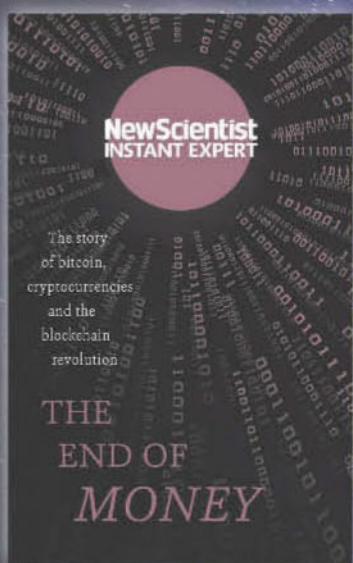
John van Wyhe is a historian of science at the National University of Singapore

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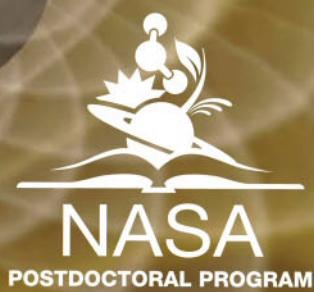


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Fermi GBM Observations of LIGO Gravitational Wave event
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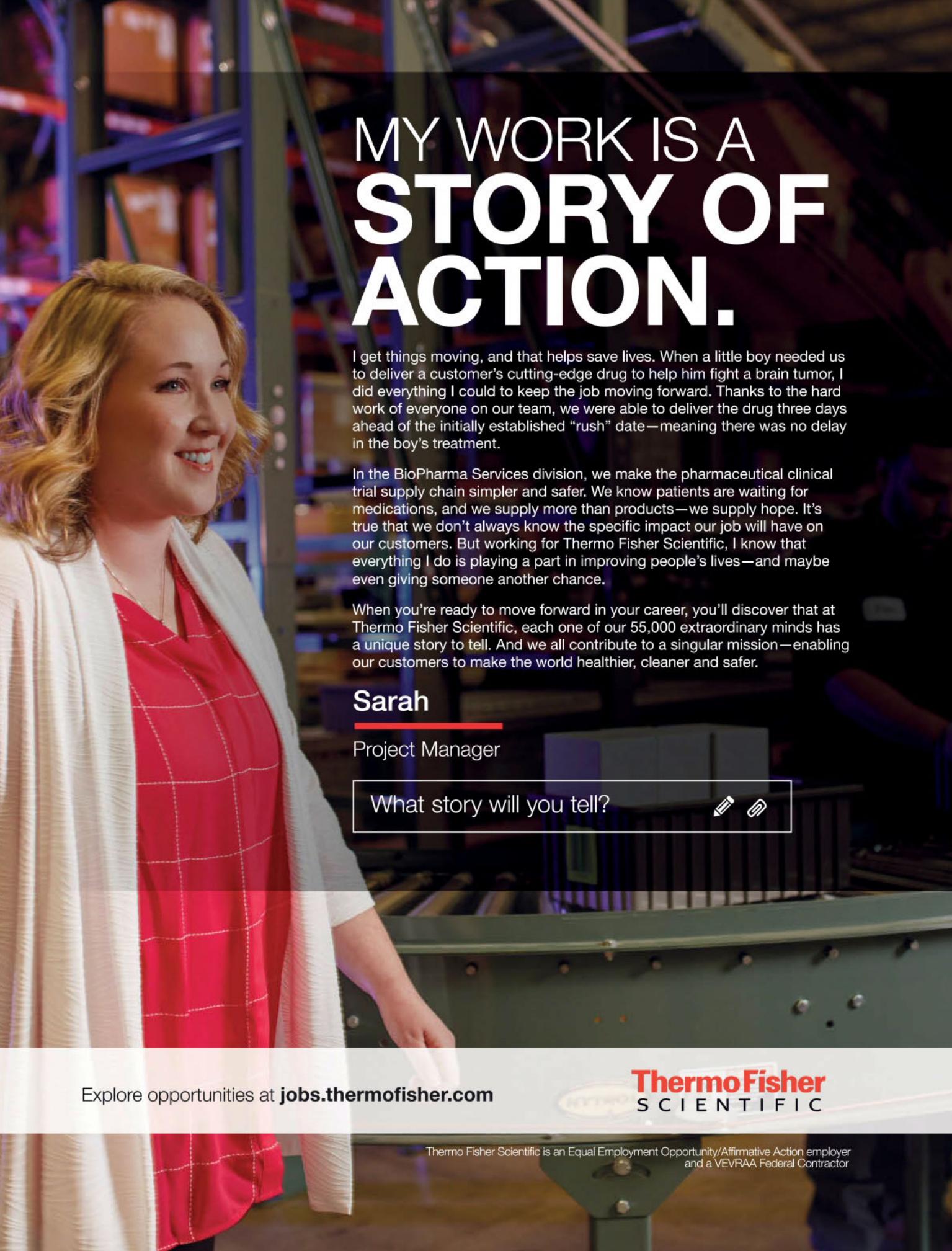
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EDITOR'S PICK

We should measure fairness accurately

*From Mark King,
Brisbane, Queensland, Australia*
Ben Collyer reviews three books on the past and future of inequity (29 July, p 42). To improve equity, it will be important to develop more convincing measures of inequity, so we can identify the real trends and deficiencies. Most statistics seem to

concentrate on wealth owned or ratios of income, which can be misleading. I am not convinced that someone with \$2 billion is twice as well off as someone with \$1 billion.

In Australia, there is a factor of 12 financial gap between the top and bottom fifth of the population. But is it not more important to consider the ratio of life expectancy, calorie intake, number of children – or just people reporting a happy life?

The kind of people who accumulate wealth in our society may well value different things to the kind of people who don't. They may, for example, not value having a large family. Even so, it would be fascinating to look at how a variety of measures have changed over the centuries. We might even find that some gaps in some places were closing rather than widening.

Hugh Walton, hero of china clay computing

From Steve Alker,

Rudgwick, West Sussex, UK

Feedback mentions a pub in Cornwall, UK, named for William Cookworthy, the 18th-century chemist who discovered china clay in the area (5 August). It would be nice if there were one called The Walton after Hugh Walton, a member and fellow of the Operational Research Society. In 1974, Walton almost single-handedly saved English China Clays from going bankrupt.

He used an analogue computer called the Simutron, which his firm made, to optimise the blending of clays from, I think, 15 clay pits into 50 or so products, each to a specific formula.

Walton's use of the simplex algorithm for optimising planning problems on an

analogue machine was astonishingly ahead of its time. There are 1,307,674,368,000 ways of blending 15 clays and it needed to be worked out thrice daily. The firm's mainframe would do it, but it took a week and no one could play with the results. Walton's Simutron did it in seconds. He sold the firm two machines at £84,000 each and also used them to solve a labour dispute.

The editor writes:

■ For a photo of the Simutron and more detail, see bit.ly/Simutron

Implausible camouflage can be explained

From Larry Bellamy,

Newnham, Gloucestershire, UK
You report that the ankylosaurid *Borealopelta markmitchelli* was reddish-black on top with a pale belly, and that such

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 **"Nobody funded it. I did it in my free time between caring for cancer patients"**

Skyler Johnson answers a Twitterer's "Gee wonder who funded this study" on "alternative medicine" outcomes (19 August, p 4)

countershading helps many animals conceal themselves from predators today (12 August, p 17). Am I missing something? I can understand the logic of this camouflage in aquatic animals and birds on the wing. These can have their predators above and below them. What predator would have seen the ventral surface of an ankylosaur against the sky?

The editor writes:

■ It's about an optical illusion. When sunlight hits a body from above, an animal's back is well-lit and its belly is in shade, so this opposite colour pattern is thought to make the animal harder to see.

Sourcing and selling cod in Viking days

From Andy Bebbington, London, UK
You say that the only explanation for the DNA match between

"ancient cod" found in northern waters and today's cod from the Viking site at Haithabu, now in Germany, is transportation in freeze-dried form by Vikings (12 August, p 7).

Might the match result, instead, from the migration of the then "northern German" cod to the north-east Arctic, over the intervening centuries, in response to environmental pressures?

*From Bob Cory,
Altringham, Cheshire, UK*

The idea that the Vikings would carry frozen cod 2000 kilometres to "sell in distant markets" is extraordinary. Is it not more likely that they took it on their journeys for food and, when they arrived, unloaded what was left and said words to the effect, "Thank gods we can now eat some fresh fish – let's leave that garbage here for when we're desperate"?

The editor writes:

■ We didn't have space to say that the researchers considered cod migration and concluded it was unlikely, not least on the basis that records of the Norwegian fisheries since the 12th century show little change in the geographical distribution of fishing effort. Nor could we find room to say that there is a 9th-century textual account of a Viking chief coming down to Haithabu from the north-east Atlantic with goods to trade, including walrus tusks for Alfred the Great in England.

how she reluctantly accepted not sharing the Nobel prize in 1974 (5 August, p 42). If I remember correctly, the astronomer Fred Hoyle publicly criticised the Nobel Committee for her omission.

When Hoyle didn't share the 1983 Nobel for physics, despite his fundamental contribution to stellar nucleosynthesis being at least equal to that of William Fowler, some astrophysicists believed his omission was partly due to this stance.

Of course, his unorthodox views of cosmology must have played their part. And he also wrote science fiction...

Jocelyn Bell deserved a Nobel, Fred Hoyle said

*From Noel Cramer,
Thônex, Switzerland*
It was interesting to read the account of the discovery of the first pulsar by Jocelyn Bell, and

Does nuclear power count as clean energy?

*From Eric Kvaalen,
Les Essarts-le-Roi, France*
I agree with most of Michael Le Page's piece on the stalling ➤

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growth of "clean energy" (5 August, p 22). But he is counting nuclear power in this category. Some people might disagree, since we haven't solved the problem of nuclear waste. If you exclude nuclear, clean renewable energy certainly has gone up in the past 25 years.

And I disagree with the statement that total energy use is "dominated by industries like aviation and shipping". Transport as a whole forms only 26 per cent of end-use energy. Other industry uses about 54 per cent.

Aluminium isn't very good for energy storage

*From Peter Urben,
Kenilworth, Warwickshire, UK*
You report that dousing a novel alloy of aluminium with water could offer a portable source of hydrogen for fuel cells (12 August, p 14). It has never been difficult to persuade aluminium, or its alloys, to react with water, producing hydrogen. Just add alkali. But the hydrogen evolved represents only half the energy inherent in the metal. The rest appears as useless

heat – which risks the reaction running out of control, as sometimes happens when preparing spongy metal catalysts from aluminium alloys.

Recycling aluminium oxide back to aluminium, by forming the fluoride and electrolysing it, is also none too energy-efficient.

Quantum entanglement as evidence of simulation

*From John Gordon,
Datchworth, Hertfordshire, UK*
There is speculation that we could live in a simulated universe running on a massive computer (for example 3 September 2016, p 30). Not having a reputation to lose, I am free to wonder if there is evidence we may have missed.

When writing a simulator for a game, it is normal not to waste resources simulating details that the player can't see and that aren't immediately relevant.

So there would be no point in simulating processes at the subatomic scale – unless, of course, that is precisely what the player decides to focus on. Others have suggested we should look for

skimping on details done to economise on computing power, such as the states of tiny items being left undecided unless they suddenly become relevant on being "observed".

But once the state of one of a pair of entangled particles is measured and decided, it would make sense to then set the state of the partner particle while we still have the data to hand. If the perception either of physical separation or of real time were also part of the simulation, the status of the other particle would appear to be decided instantly, which to the observer would seem like "spooky action at a distance".

Why there is something rather than nothing

*From Nicholas Beck,
Habère-Lullin, France*
Geraint Lewis says in an online comment piece that we can't ignore the possibility that we live in a universe fine-tuned for life (posted 28 June). We know of a long list of parameters that can't vary by much if life is to exist. So is the universe fine-tuned to

favour life? No, but it might have selected for complexity.

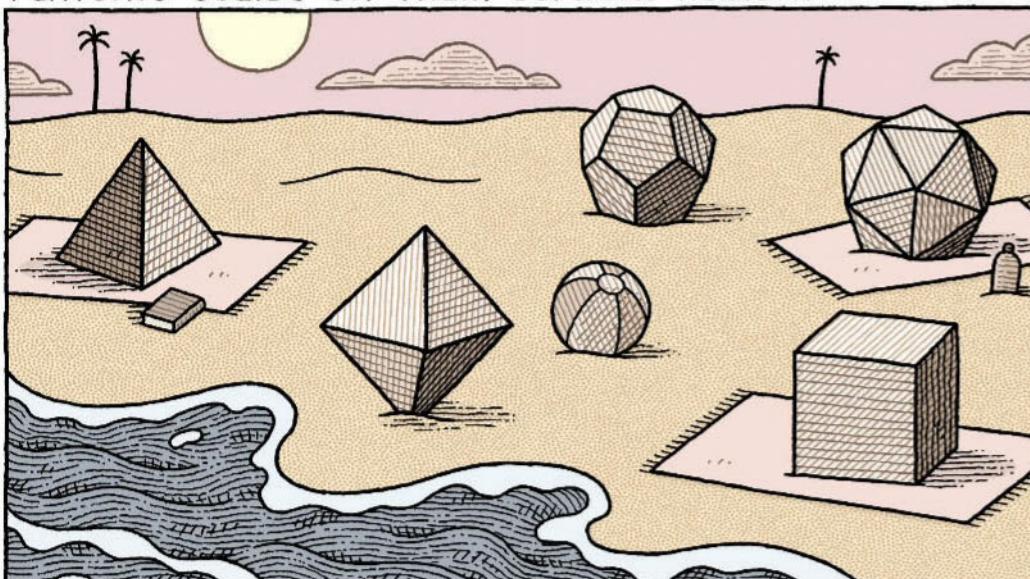
Why is there something rather than nothing? Because there is only one way for there to be nothing: it is a single permutation floating on a vast ocean of possibilities. From this perspective, a universe favouring complexity is much more likely to exist than a simple universe.

Some eggs may need more pointy ends

*From Bruce Denness,
Whitwell, Isle of Wight, UK*
Simon Carter wonders whether there may be a relationship between the shape of birds' eggs and the nature of the nest in which they are laid (Letters, 29 July). Pigeons get this wrong by laying a smooth egg with pointy ends in a nest consisting of a few poorly selected twigs. It is not uncommon to find broken pigeon eggs on the ground beneath. They would be better advised to lay a non-slippery egg with sharp corners – a cube or pyramid perhaps – that would catch on the sides of the open lattice. But for the sake of comfort, the delivery process may require attention.

TOM GAULD

PLATONIC SOLIDS ON THEIR SUMMER HOLIDAY



For the record

- Forget the angels: more than 10 trillion (10^{13}) iron atoms, arranged in a lattice with a spacing of 287 picometres between them, fit on the surface of a 1-square-millimetre pinhead (19 August, p 38).
- The researcher whose work on activated charcoal and antibiotics we reported is Jean de Gunzburg (19 August, p 7).

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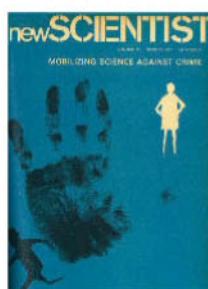
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OLD SCIENTIST

What did Daedalus talk about in September's past?



DREADCO/PETER JONES



FEW readers will know the name of David E. H. Jones, who died on 19 July. For many, however, his alter ego, Daedalus, will stand out in their memories of *New Scientist*. The imaginary inventor's musings were a fixture in the magazine from 1964 until the 1980s.

Daedalus proposed "plausible schemes" for the likewise fictional company DREADCO. These thought

experiments switched between flights of fancy and satire, but often anticipated real discoveries. Determining when the soul leaves the body, and pressure-formed soap whose bubbles explode on skin have yet to find their moment, but his 1966 suggestion of a "hollow molecule" of carbon had its vindication in the 1996 Nobel prize in chemistry, awarded to others for the discovery of fullerenes.

In tribute, this month's Old Scientist looks at what our resident maverick was developing in September's past. In our 1 September 1966 issue, Daedalus suggested sloping the water in canals to increase the speed of boats. The gradients would be created by "magnetic densifiers" and time-consuming locks would be a thing of the past.

The 18 September issue three years later carried a proposal for a drill made of vapour. The idea was that an iron vapour jet would whack into an iron plate and each atom in the jet would knock an atom off the far side of the plate – like a tiny Newton's cradle.

The following week, Daedalus had dreamed up the "inverted aqualung": a transparent, sealed suit filled with water that a dolphin could wear on land. Its flippers would fit in large paddles to give the cetacean traction in air and propel a railcar upon which it was mounted. The unfortunate beast would be "able to explore the world freely before diving back into the pool".

Such ideas emerged from an amazing, inquisitive mind, and one that derived great pleasure from the (probably) implausible. As Daedalus wrote in 1981, "DREADCO succeeds only because it is run for the satisfaction and entertainment of the staff, particularly me." **Mick O'Hare** ■

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PAUL MCDEVITT

WE CAN safely report that the apocalypse is cancelled: contrary to fringe predictions (26 August), famously non-existent planet Nibiru didn't appear during the Great American Eclipse, and Earth was rocked by nothing more than a deep sense of cosmic awe. If anyone is interested in purchasing 500 cases of surplus military rations, please write to Feedback with your best offer.

Still, we can't help but be rattled by this close encounter with an imaginary Armageddon. Which leads us to an email from Daniel Hackett, who has been thinking about making humans more robust.

"Our gene pool is much smaller than our population would suggest, giving poor resilience when an epidemic strikes. We might need to intervene genetically to create diversity," he says. Daniel had a very creative interpretation of diversity in mind, such as gradually reducing the stature of humans so that we consume less resources, reducing our burden on the planet.

He also suggests adding genes

for chloroplasts in human skin, so that our verdant children could harness the energy of the sun and skip meals on occasion. Feedback has performed the necessary calculations and, sadly, our measly surface area doesn't provide much in the way of a solar panel, even if we add genes to give our little green children a more liberal attitude towards nudity.

But this did get us thinking: how could humans be genetically engineered, conceivably, to weather all storms in the future? What selective improvements could protect our species from climate change, disease epidemics, cosmic volleys and other threats to humankind? Your suggestions please.

ALSO entertaining novel forms of nutrition is Ros Hancock, who spies an advert for StreamZ dog collars inserting itself into his Facebook feed.

He is told: "the StreamZ material contained within the collar is designed to create day-to-day improvements in canine

vitality, by rebalancing compounds and minerals in the body." Yes, it seems that even dogs aren't immune to the vague health claims on offer from mysterious magnetic jewellery (or rather their owners aren't).

Who knew our pet pooches were so unbalanced in the first place? In an effort to sniff out further answers, Feedback visited the StreamZ website, where we find out the technology powering this innovation is "a patented 360° layer of StreamZ smart-material containing five separate multi-directional low-frequency polarity fields". Right then.

It all has the whiff of a shaggy dog story to Ros, but StreamZ contends that "companies and products like ours would simply not survive if they claimed false results". Take that, fake news!

Feedback is wondering if there is an opening here for Gwyneth Paltrow's crystal-strewn Goop brand to expand into the pet-care market. However we're not sure if dogs will be as willing to subscribe to yoni balls as they are to StreamZ collars.

In the meantime, Ros says his dogs "reckon their compounds are already well-balanced, and I'm sure they'd rather I spent the money on Frozzy's, the lickable frozen yogurt for dogs".

BEING inquisitive, "not to mention prurient", Eugene Doherty goes online to find the epithet given to Tilly Schilling's life-saving engine valve (12 August). He discovers the answer to his question, but also "that in 2011, the Wetherspoons chain opened a pub in Farnborough, near the RAF base where she worked, named the Tilly Shilling in her honour."

ALSO alerting us to this fact is Phil Corrigan, who adds that "while we're on the subject of pubs named after aeronautical engineers, there is also the Reginald Mitchell in Stoke, named after the inventor of the Spitfire" – the very same plane Shilling's device kept airborne.

DESPITE being impressed by our innovative hyperdimensional household ornaments (19 August), John Davies awards us a C- for geometry. "A cube in 3D space has eight corners, as any fool knows," he says. "So 'octagonal' applies to any real world cube."

ON THE pronunciation of Joule (26 August): Ian Watson says that during the 1980s, his organic chemistry tutor at the University of Cambridge, Peter Sykes, managed to pronounce it "jarl".

"I took it at the time to be a point of minor, cultivated eccentricity, analogous to the brightly coloured socks he wore for lectures," says Ian. "I discussed the matter at least once with a fellow student, but Sykes was far too intimidating a figure for us to ask directly about his choice."



AND more pronunciation problems abound. "Living in France, I soon realised that the word Focus in Ford Focus has to be pronounced pretty much the same as in English," says Terence Hollingworth. "A French pronunciation would be 'faux cul', the meaning of which derives from a tradition at one time for women to pad out their skirts to appear more voluminous than they actually were."

Nowadays the idiom is used to describe a hypocrite, he says, though "the Spanish meaning of *pajero* in Mitsubishi Pajero is even ruder."

Richard Keyworth thinks Anglian Water should hire better copy editors. "Make the most of your sewerage services" exhorts a mailing, alongside the company slogan, "Love every drop"

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Hay fever fever

With the Australian spring comes seasonal allergic rhinitis, or hay fever. But why do humans have a physiological response to pollen and dust? I can't see any benefit to suffering from sore eyes, a scratchy throat and nasal congestion. So why does it occur?

■ One of the main tasks of the human immune system is to orchestrate a response to infections by pathogenic microorganisms including bacteria, fungi and parasites. Immunoglobulin E (IgE) antibodies specialise in combating the latter.

Pathogens are recognised by some characteristic molecules they possess called antigens, which, more often than not, are molecules of protein. But when a protein derived from a mould spore or plant pollen looks very much like a protein of a pathogen microorganism (a phenomenon called molecular mimicry), the immune system identifies it as

"Most people react to antigens in a mild way that causes no symptoms and goes unnoticed"

an antigen and opens fire as if a microorganism is about to invade.

The result varies, from scratching and nasal congestion to a life-threatening anaphylactic shock, and the underlying mechanism, which involves IgE antibodies, is called a Type I hypersensitivity reaction,

or allergic reaction – from ancient Greek (*állos* meaning "other" and *érgon* meaning "work" or "activity").

An allergy is a superfluous reply to an otherwise innocuous environmental antigen. Most people react to them, but in a mild way that causes no symptoms and goes unnoticed. Others have a genetic predisposition for a fiercer response. These "atopic" individuals – from the Greek word *atopia*, meaning "placelessness" – produce between 1000 and 10,000 times more IgE antibodies than non-atopic people.

Recent evidence indicates another possible evolutionary significance of allergy, as a part of our defence against toxins. It has been shown that repeated exposure to bee and viper venom confers resistance against subsequent potentially fatal doses of these poisons, and that happens via a Type I hypersensitivity reaction.

Even carcinogens like aflatoxin produce that kind of reaction, and maybe that is why allergy-prone people develop fewer cancers in tissues of the body that communicate directly with the external environment.

The bottom line is that either allergy is an immune system false alarm or a physiological anti-toxin adaptation. But its most potent role seems to remain the irritation of thousands of noses every year.

*Ilias Nikolakopoulos
National and Kapodistrian University of Athens, Greece*

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■ While researching why a professional gardener like me should suffer from the inconvenient curse of hay fever, I found a paper that suggested that the allergic reaction of hay fever was the immune system's response to the pollen grains trying to "implant" in the wet membranes of the human eyes and nose.

The pollen grains release a cocktail of chemical signals and stimulants that are designed

"I read that hay fever is the immune system's response to pollen trying to implant in human eyes"

to help the growth of a pollen tube into the female part of the flower, but have an irritating effect on the human mucus membranes.

Grass species are wind-pollinated and release huge amounts of pollen into the air – so it's no surprise that some of it ends up trying to pollinate us.

The paper also suggested that the main hay fever culprit in the UK is pollen of a particular grass called "Timothy" (*Phleum pratense*).

This is a common agricultural crop that grows twice as tall as most wild grasses and accounts for a large proportion of pollen because of its abundance. What's more, its pollen is particularly aggressive in its biochemical amorbusness.

*Nicholas Hall
St Just, Cornwall, UK*

This week's questions

WATER WORKS

Is hard or soft water better at removing dirt and bacteria?

*Patrick Jamison
Ascot, Berkshire, UK*

SPIRALLING BACKWARDS

If there's no friction in space, why do the arms of spiral galaxies sweep backwards?

*John McIntyre
Yackandandah, Victoria, Australia*

FEEL THE HEAT

We sweat to cool our bodies by evaporation, but when we wipe the sweat away – a natural reaction in humans – are we defeating that function and making ourselves hotter?

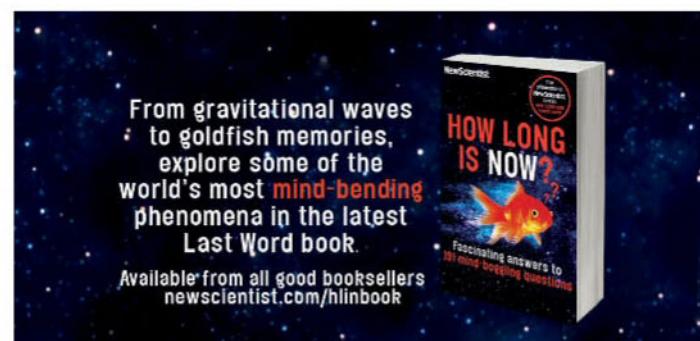
Do we also hasten dehydration by making our bodies sweat more, to replace what we've wiped away? In other words, should we just leave the sweat to do its job?

*Howard Bobry
Nehalem, Oregon, US*

APOCALYPSE THEN

In the book, *The Hitchhiker's Guide to the Galaxy*, the Vogons demolished Earth. They said it would take approximately 2 minutes, so how much energy would they have needed to obliterate our planet? Would kicking the planet out of its orbit have been more energy efficient than simple destruction?

*Katka Kessler
By email, no address supplied*



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