New Scientist

WEEKLY 3 March 2018

INSIDE A BLACK HOLE
What it's like in the strangest place in the universe

SAVE OUR SECRETS!
The race to stop quantum computers killing cryptography

DEEP MIND READER
AI knows what other AIs are thinking

WEEDING OUT THE NONSENSE 11 gardening myths buried

WELCOME TO THE UGLYVERSE

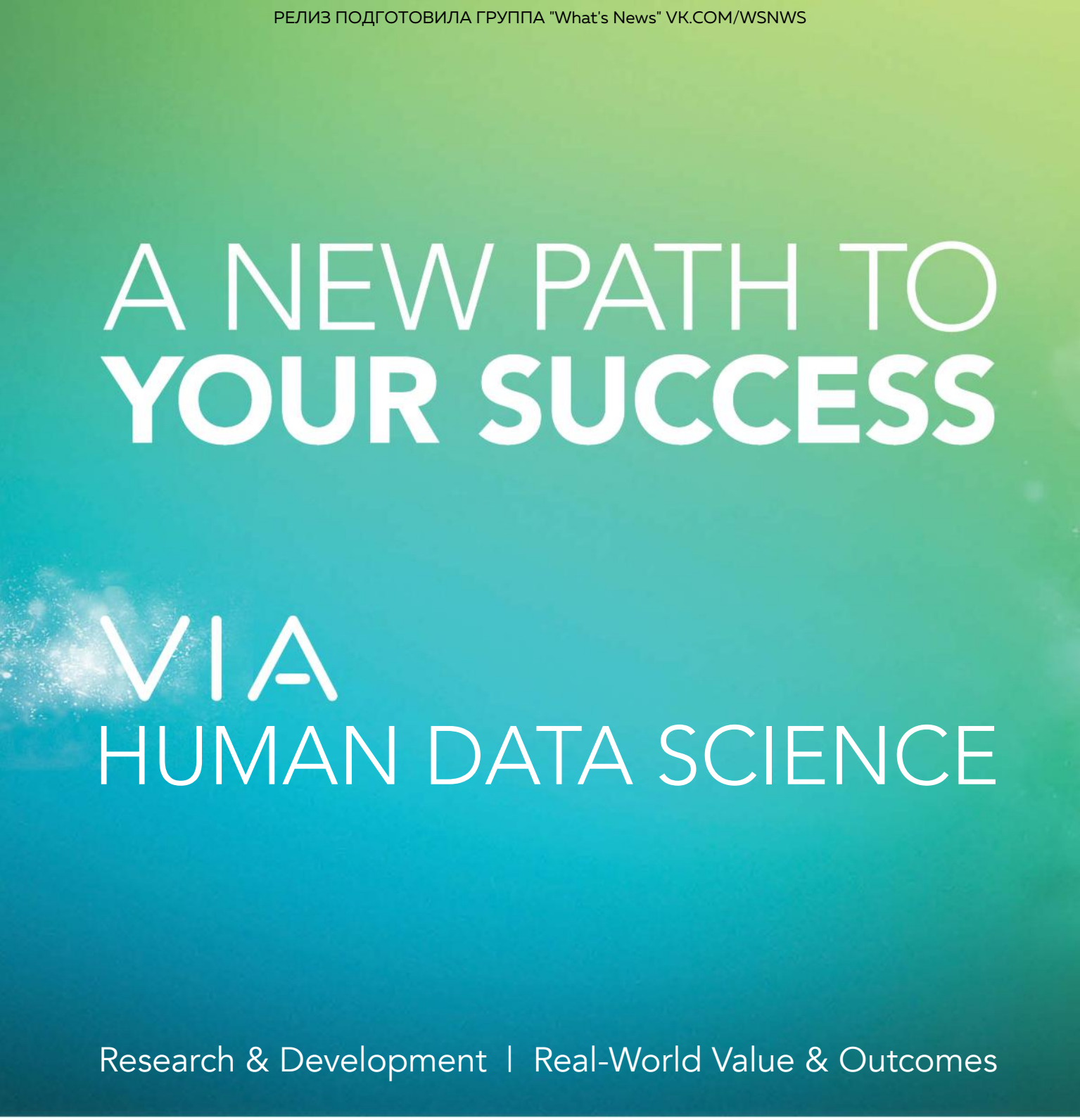
There's nothing beautiful about the laws of nature

No3167 £4.50 US/CAN$6.99

09

9 770262 407282

PLUS CRISPR INVENTOR: "I BEGAN TO FEEL A BIT LIKE DOCTOR FRANKENSTEIN"/ NEANDERTHAL ART/ **VOICE CLONING**/ PION STARS/ **ZOMBIE ANT FUNGI**



IMS Health and Quintiles are now IQVIA™ – created to advance your pursuits of human science by unleashing the power of data science and human ingenuity. **Join the journey at iqvia.com/success**

Commercialization | Technologies

IMS Health & Quintiles are now

IQVIA™

C-HR HYBRID DYNAMIC

- 17% BIK
- 87g/km CO_2*
- Toyota Touch® 2 with Go Navigation
- Adaptive Cruise Control and Blind Spot Monitor

TOYOTA

ALWAYS A BETTER WAY

Choose award-winning company.

PARKERS NEW CAR AWARDS 2018
CAR OF THE YEAR
WINNER
TOYOTA C-HR

If you're tired of the same old thing, then choose a new direction that's perfect for business. Built on 20 years of hybrid engineering, the new Toyota C-HR crossover is a beautiful place to work and, thanks to its efficient petrol-electric power, rewards with exceptionally low emissions and 17% BIK tax. Whether it's meeting clients in town or ferrying family around at weekends, it's time you chose award-winning company to spend it with.

Book a test drive today to experience it for yourself: **toyota.co.uk/business**

ToyotaBusiness Plus

TOYOTA HYBRID

5 year TOYOTA WARRANTY

C-HR Dynamic 5 door Coupe FWD Hybrid 1.8 VVT-i Auto. Official Fuel Consumption Figures in mpg (l/100km): Urban 80.7 (3.5), Extra Urban 68.9 (4.1), Combined 72.4 (3.9). CO_2 Emissions 87g/km. All mpg and CO_2 figures quoted are sourced from official EU regulated laboratory test results. These are provided to allow comparisons between vehicles and may not reflect your actual driving experience. Model shown is C-HR Dynamic with Leather 5 door Coupe FWD Hybrid 1.8 VVT-i Auto at £29,610. Price excludes metallic paint at £545 or pearlescent paint shown at £250. Prices correct at time of going to print.

CONTENTS

New Scientist

Management
Executive chairman Bernard Gray
Publishing director John MacFarlane
Finance director Matthew O'Sullivan
Strategy director Sumit Paul-Choudhury
Human resources Shirley Spencer
Non-executive director Louise Rogers

Publishing and commercial
Customer services manager Gavin Power
Head of data science Kimberly Karman
HR co-ordinator Serena Robinson
Facilities manager Ricci Welch
Executive assistant Sarah Gauld
Trainee PA Emily Perry
Receptionist Alice Catlin

Display advertising
Tel +44 (0)20 7611 1291
Email displayads@newscientist.com
Commercial director Chris Martin
Richard Holliman, Justin Viljoen, Henry Vowden, Helen Williams

Recruitment advertising
Tel +44 (0)20 7611 1204
Email nssales@newscientist.com
Recruitment sales manager Mike Black
Key account managers
Martin Cheng, Reiss Higgins, Viren Vadgama
US sales manager Jeanne Shapiro

Marketing
Head of marketing Lucy Dunwell
David Hunt, Chloe Thompson, Andrew Wilkinson

Web development
Director of technology Steve Shinn
Maria Moreno Garrido, Tuhin Sheikh, Amardeep Sian

New Scientist Live
Tel +44 (0)20 7611 1273
Email live@newscientist.com
Event director Mike Sherrard
Creative director Valerie Jamieson
Sales director Jacqui McCarron
Event manager Henry Gomm
Conference producer Natalie Gorohova

UK Newsstand
Tel +44 (0)20 3787 9001
Newstrade distributed by Marketforce UK Ltd, 2nd Floor, 5 Churchill Place, Canary Wharf, London E14 5HU

Syndication
Tribune Content Agency
Tel +44 (0)20 7588 7588
Email tca-articlesales@tribpub.com

Subscriptions
newscientist.com/subscribe
Tel +44 (0)330 333 9470
Email ns.subs@quadrantsubs.com
Post New Scientist, Rockwood House, Perrymount Road, Haywards Heath, West Sussex RH16 3DH

GALYNA ANDRUSHKO/PANIMONI/SHUTTERSTOCK

CURTIS JOHNSON/AURORA/GETTY

Volume 237 No 3167

News Theory of a machine's mind **6**

On the cover

8 Inside a black hole
What it's like in the strangest place in the universe

40 Save our secrets!
The race to stop quantum computers killing cryptography

6 Deep mind reader
AI knows what other AIs are thinking

34 Weeding out the nonsense
11 gardening myths buried

30 Welcome to the uglyverse
There's nothing beautiful about the laws of nature

Plus CRISPR inventor: "I began to feel a bit like Doctor Frankenstein" (44). Neanderthal art (16). Voice cloning (9). Pion stars (9). Zombie ant fungi (8)

Leaders

5 Scientists need to be aware of the dark side of publicity. The gender pay gap must close

News

6 THIS WEEK Artificial intelligence may have theory of mind. Space slingshot start-up. Arctic warmth

8 NEWS & TECHNOLOGY
Surviving a black hole is possible. Zombie death fungi. Weird particle soup formed early stars. AI steals your voice. Fishy defence against allergies. Quantum communication trick. Did ancient Briton have dark skin? Alt-right's "Twitter" is hate-speech hub. Another world war is still on the cards. Neanderthals invented cave art. Giving birth ages your DNA

19 IN BRIEF Saw-wielding robots. Fake polar bear fur makes bunnies stealthy. Cycling helps older people avoid falls. Sea urchins drill granite

Analysis

24 STIs Why sexually transmitted infections are rising in the West
26 COMMENT Spanish flu's lessons still not learned. "Rock farming" could be part of a climate plan B
27 INSIGHT We still don't know if antidepressants work for everyone

Features

30 The ugly truth There's nothing beautiful about the laws of nature
34 Growing skills Weeding out some of horticulture's hardiest myths
40 Save our secrets! The race to stop quantum computers killing cryptography
44 Director of evolution CRISPR co-inventor Jennifer Doudna on how she felt like Dr Frankenstein

Culture

46 Not the only game Scientists do themselves no favours trying to lord it over philosophers
48 It's show-tell time Cultural clash at the Crick Institute makes for a fascinating new show

Regulars

28 APERTURE
Dumpster-diving eagle
52 LETTERS
Pregnant and in pain
55 OLD SCIENTIST
Marches past
56 FEEDBACK
Unusual baldness cures
57 THE LAST WORD
Riderless motorbikes

THE TECHNOLOGY GORILLAS ARE CHANGING THE WORLD.

DEFINITION of "Gorilla"

A company that dominates an industry without having a complete monopoly."

Investopedia.

Every era has its defining business driver from the Colonies to the Industrial Revolution to the Railways to the Home PC.

We believe we are living through the business era of the Technology Gorillas.

The big question is have you got enough investment exposure to this theme?

Most of the technology gorillas can be found in the Manchester & London Investment Trust plc ("MNL") portfolio.

Manchester & London
Investment Trust plc

www.mlcapman.com/manchester-london-investment-trust-plc/

Available through your stockbroker or platform, including:

interactive investor · HALIFAX · Shareview FROM EQUINITI · HARGREAVES LANSDOWN · Bestinvest powered by TILNEY · AJBell Youinvest · Selftrade FROM EQUINITI · thesharecentre: simply easier

M&L Capital Management Limited ("MLCM") is authorised and regulated by the Financial Conduct Authority and only acts for the funds to whom it provides regulated investment management services. MLCM does not act for or advise potential investors in connection with acquiring shares in Manchester & London Investment Trust plc and will not be responsible to potential investors for providing them with protections afforded to clients of MLCM.

Prospective investors are strongly advised to take their own legal, investment and tax advice from independent and suitably qualified advisers. The value of investments may go up as well as down. Past performance is not a guide to future performance.

MNL Performance, % Total Return

Y/E 31 July 2017	1 Yr	3 Yr	5 Yr
MNL Share Price:	62.0	94.4	72.7
MNL NAV	38.4	79.7	55.4

Source: Bloomberg Finance L.P., MLCM

Investor documentation is available either through the MLCM website or the listed platforms and prospective investors should review these before any decision is made.

New Scientist

Editorial
Acting editor Graham Lawton
Managing editor Rowan Hooper
Head of production Julian Richards
Art editor Craig Mackie
Editor at large Jeremy Webb

News
Chief news editor Niall Firth
Editors Penny Sarchet, Jacob Aron, Timothy Revell, Jon White, Chelsea Whyte
Reporters (UK) Andy Coghlan, Jessica Hamzelou, Michael Le Page, Clare Wilson, Sam Wong, (US) Leah Crane, (Aus) Alice Klein

Features
Chief features editor Richard Webb
Editors Catherine de Lange, Gilead Amit, Catherine Brahic, Julia Brown, Daniel Cossins, Kate Douglas, Alison George, Joshua Howgego, Tiffany O'Callaghan, Sean O'Neill

Culture and Community
Editors Liz Else, Mike Holderness, Simon Ings, Frank Swain

Subeditors
Managing subeditor Eleanor Parsons
Vivienne Greig, Tom Campbell, Hannah Joshua, Chris Simms

Design
Kathryn Brazier, Joe Hetzel, Dave Johnston, Ryan Wills

Picture desk
Chief picture editor Adam Goff
Kirstin Kidd, David Stock

Production
Mick O'Hare, Melanie Green , Alan Blagrove, Anne Marie Conlon

Contact us
newscientist.com/contact

General & media enquiries
Tel +44 (0)20 7611 1202
enquiries@newscientist.com

UK
25 Bedford Street, London, WC2E 9ES
Tel +44 (0)20 7611 1200

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

US
210 Broadway #201
Cambridge, MA 02139
Tel +1 617 283 3213

New Scientist is published weekly by New Scientist Ltd. ISSN 0262 4079.

New Scientist (Online) ISSN 2059 5387

Registered at the Post Office as a newspaper and printed in England by William Gibbons (Wolverhampton)

MARK RICHARDS/DAILY MAIL/SOLO SYNDICATION

Is all publicity good?

TV hypes shaky science. Researchers must understand this

YES, you've seen him somewhere before. This is Cheddar Man, the oldest known "modern" Briton, and that his 10,000-year-old DNA recently revealed that he was dark-skinned. You may also recall that the research was done for a TV documentary, announced via a press release and reported by many news outlets, including us.

Releasing scientific results in this way is notoriously risky, and unsurprisingly there is now some backpedalling going on: Cheddar Man may indeed have been dark-skinned, but we don't know for sure (see page 12).

The whole episode smacks of a publicity stunt to hype up the show. There is some truth in that, but dismissing it outright does a disservice to the scientists.

According to the state of knowledge at the time, the genetic analysis did suggest that Cheddar Man's skin was dark. But science progresses, and since the analysis was done last year, many more genes affecting skin colour have been discovered. Understandably, the new science did not make it into the documentary.

To add insult to injury, the story has now been seized upon by alt-right activists on social media. Many denounced the original conclusion as propaganda, with the "liberal media" and their cronies in academia twisting the truth to justify multiculturalism. This is blatant and hysterical nonsense, but it is the kind of fake news that can be halfway around the world before the truth has got its boots on.

Scientists are understandably hungry for the funding and publicity that a TV documentary can bring, but they need to be more savvy about what they are getting themselves into. TV companies want people to watch their shows; science news outlets cannot resist a juicy story; trolls will be trolls. Whenever science is done by press release, it is science that usually comes off worst. ■

Science's salary shame

LAST month, the UK marked the 100th anniversary of the Representation of the People Act, which granted limited suffrage to women. Universal suffrage was introduced a decade later.

Those who campaigned for equal votes would be dismayed to find that women still face obscene discrimination. This is most apparent in the workplace where, despite equal pay laws, many women still earn less than men for doing the same job.

Recent high-profile cases at the BBC and the supermarket chain Tesco have brought the issue into the public eye. If you thought that science and engineering would be better, think again. Our salary survey in association with recruitment firm SRG reveals a significant pay gap (see page 22).

It goes without saying that this is wrong, and damaging to science. The field is badly paid as it is, and has well-known difficulties recruiting women. The gender pay gap exacerbates both problems.

Iceland recently declared that it would become the first country to strictly enforce its equal pay laws. It is high time the UK and other supposedly modern countries followed suit. ■

Theory of a machine's mind

Artificial intelligence now has an idea of what other machines are thinking

Timothy Revell

MACHINES are getting to know each other better. An artificial intelligence, developed by Google-owned research firm DeepMind, can now pass an important psychological assessment that most children only develop the skills to pass at around age 4. Its aptitude in this key theory of mind test may lead to AIs that are more human-like.

Most humans regularly think about other people's desires, beliefs or intentions. For a long time, this was thought to be uniquely human, but an increasing body of somewhat controversial evidence suggests that some other animals, such as chimps, bonobos, orangutans and ravens may have theory of mind (see "What do you think?", right). However, the idea that machines could share these abilities is normally reserved for sci-fi.

DeepMind thinks otherwise. The firm created its latest AI with the intention of it developing a basic theory of mind. The AI is called Theory of Mind-net, or ToM-net for short. In a virtual world, ToM-net is able to not just predict what other AI agents will do, but also understand that they may hold false beliefs about the world.

"The AI can predict others' behaviour, and figure out when they have false beliefs about the world"

For humans, the idea that others can hold false beliefs seems very natural, especially if you follow politics closely, or read the comment section on news websites. However, humans don't actually understand that other people can hold false beliefs until around age 4. "It's a classic developmental stage for young children," says Peter Stone at the University of Texas at Austin.

One of the main reasons we know about this is a psychology experiment called the Sally-Anne test. In the test, Anne watches Sally leave an object somewhere, only for it to be moved without Sally seeing. Anne, who has seen everything, is then asked where Sally will first look for the object. To pass the test, Anne needs to be able to distinguish between where the object actually is and where Sally thinks it is. In other words, Anne needs to understand that Sally may hold a false belief about the object's location.

Guess what I'm doing

To mimic this set-up for AIs, ToM-net plays the role of Anne in a virtual world consisting of an 11-by-11 grid, some internal walls and four objects. A different AI agent also inhabits the gridworld and is set a task, unknown to ToM-net, about walking to one of the four objects. The agent is rewarded depending on how optimal its path is. ToM-net has to predict what is going to happen.

In a similar way to the Sally-Anne test, the DeepMind team switches some objects during the experiment. For example, the agent might see its preferred blue object in one location, but would be told to walk to another object first. While concentrating on this sub-goal, the preferred object would be moved and the agent may or may not see this happen, depending on its position.

Surprisingly, ToM-net is able to accurately predict and understand what this agent and others also used are trying to do, essentially passing this form of the Sally-Anne test and exhibiting some basic theory of mind. "It can learn the differences between agents, predict how they might behave differently, and figure out when agents will have false beliefs about the world," says Neil Rabinowitz at DeepMind.

This is a big step. Making

FRANCOIS GOHIER/VWPICS/ALAMY

Endangered whale not having babies

NORTH Atlantic right whales could be extinct by 2040, with no calves born during the most recent breeding season of November to February.

The whales (*Eubalaena glacialis*) are an endangered species. There are only an estimated 430 left, of which 100 are females.

The lack of new calves has been compounded by last year's record premature death toll of 18. Most died after becoming entangled in fishing gear, especially ropes connecting buoys to lobster pots.

"At the rate we're killing them off, these 100 females will be gone in 20 years," Mark Baumgartner of the Woods Hole Oceanographic Institution in Massachusetts said this week. The species could be "functionally extinct" by 2040, he said.

One hope lies with ropeless lobster-catching technologies being developed at Woods Hole. These use novel methods to bring lobster traps up from the seabed – for instance, inflatable bags that create buoyancy and cause the traps to rise.

Arctic hit by record high temperatures

WHILE western Europe copes with freezing temperatures and snow, the Arctic is experiencing record highs.

Temperatures are 35°C warmer than normal for the time of year at Greenland's most northerly point,

CURTIS JOHNSON/AURORA/GETTY

AIs are beginning to comprehend that others see things differently

computer programs that mimic behaviours like theory of mind could improve our understanding of people and other animals, says Christopher Lucas at the University of Edinburgh, UK.

But Alan Wagner at Georgia Tech Research Institute says the 11-by-11 grid set-up is too simplistic for the researchers to claim they have captured the idea of theory of mind.

Outside of the debate as to whether ToM-net truly exhibits theory of mind, there is a possibility it might help make more human-like AIs. "I wouldn't be surprised if this can make things like chatbots seem a lot like humans," says Joanna Bryson at the University of Bath in the UK.

In turn, this may make interactions smoother. "The more our machines can learn to understand others, the better they can interpret requests, help find information, explain what they're doing, teach us new things and tailor their responses to individuals," says Rabinowitz. ■

WHAT DO YOU THINK?

It is difficult to know if animals have theory of mind because we can't ask them what they are thinking. Instead, we use simple tests.

MIRROR TEST
A dot is placed on an animal's face. If it recognises itself in a mirror, it will try to wipe the mark off, demonstrating basic self-recognition – a part of theory of mind. Children do this from about 15 months. Great apes, dolphins, killer whales and Eurasian magpies have passed this test as well.

JOINT ATTENTION
The ability to both guide and follow someone else's gaze is not unique to humans, but it is part of theory of mind. Children learn to do it in their first year or so. Many other primates, as well as dogs and horses, have the ability too.

FALSE BELIEF
Understanding that others can hold false beliefs is perhaps the trickiest test to pass. Children develop this skill around age 4. Some apes and birds may have it too, as well as a new artificial intelligence agent.

Cape Morris Jesup, says Robert Rohde of Berkeley Earth in California, and the site has already spent more time above 0°C so far this year than in any complete year on record. There is no weather station at the North Pole, but scientists suspect it, too, has risen above freezing this week.

This is backed up by Zachary Labe at the University of California, Irvine, who tracks Arctic temperatures. According to his data, the Arctic may be warmer than it has been at this time of year since at least 1958.

A weakening of the polar vortex is to blame. This spinning loop of air normally keeps the cold Arctic air separate from the warmer air further south. The extreme warmth is likely to slow or prevent the formation of Arctic sea ice, which has been shrinking for decades due to climate change.

Facebook in fight against extremism

TO TRY to deradicalise extremists, Facebook is borrowing methods akin to those used to spread radicalism online.

The project was led by a London-based think tank, the Institute for Strategic Dialogue. It scanned far-right and Islamist Facebook pages, looking for hate speech.

When suitable candidates were identified, one of 11 "intervention providers" contacted the profile owners on Facebook Messenger. The aim was to "walk them back from the edge, potentially, of violence", says Sasha Havlicek, the think tank's CEO. The intervention providers were either former extremists, trained counsellors or survivors of terrorism.

However, only eight of the 569 people contacted showed signs of the intervention being successful.

The UK government has repeatedly called on tech firms to do more to fight online extremism. It is also considering an "extremism tax" to cover the rising costs of police work related to online radicalisation.

Ditch rockets and hurl cargo to space

A START-UP called SpinLaunch in California wants to catapult cargo into space, avoiding the need for heavy and expensive rocket fuel.

The concept relies on a centrifuge to spin a payload to high speeds, giving it enough momentum to penetrate the atmosphere.

But whirling a payload around fast enough to reach space would also subject it to g-forces that could damage electronics and rip apart anything remotely fragile. And exiting Earth's atmosphere without burning up would require lots of heat shielding.

"It certainly wouldn't be useful for fragile cargo, e.g. mammals like us," says space-flight consultant Rand Simberg. But he says it could put fuel, supplies or maybe particularly robust small satellites into space.

The payloads would probably also need a boost from small thrusters, or a satellite that can intercept them. "You can't just chuck things into orbit," says Simberg.

SpinLaunch has yet to announce a date for any test launches.

You could survive a black hole's grip

Leah Crane

IF YOU jump into a black hole, you would probably be stretched to shreds – but there is a chance you could survive and end up in a weird place where there is no way to know what will happen next.

We view the world through the lens of determinism, the idea that the past dictates the future: throw a ball, and you can calculate where it will land. But Peter Hintz at the University of California, Berkeley, and his colleagues found that determinism ends inside certain types of black holes. And a person may be able to survive a trip there.

Every black hole has an event horizon, the boundary beyond which nothing can escape. Black holes that have an electric charge contain another boundary within the event horizon called the Cauchy horizon. This is where determinism breaks down.

It was thought that if the object that collapsed to become a black hole wasn't perfectly spherical, the Cauchy horizon should become a singularity, crushing everything that comes near it. This is due to the way gravity stretches time near a black hole. Infalling matter and energy get denser and denser, so that if you tried to cross the Cauchy horizon, you would be hit by a massive wave of it and die. "The amount of stuff that falls into the black hole within an hour of time measured by someone outside the black hole reaches you in an interval of a second," says Hintz.

Hintz and his colleagues calculated that the accelerating expansion of the universe could counteract this deluge and prevent the Cauchy horizon forming a singularity, so it encircles one that is already there. This makes it possible to pass through it without being annihilated (*Physical Review Letters*, doi.org/gcv678). "If you don't hang around for an hour and just cross the Cauchy horizon quickly, it will be a rough passage, but it may not kill you," he says.

"Once you cross that horizon, all of the information about the entire history of the universe behind you is revealed," says Robert Mann at the University of Waterloo in Canada. "But even with all of that information, you cannot predict what happens next." And what happens next could be almost anything.

Any action you take could have nearly infinite possible effects, in part because space-time can deform in unexpected ways. Throw a ball here, and forces beyond your knowledge could make it turn around and hit you in the face.

Hintz says the space beyond the Cauchy horizon could also act like a wormhole. You could escape the black hole into a parallel universe if you steered your spaceship carefully to avoid the crushing singularity at the centre of the black hole.

Because the laws of physics break down at a singularity and the space within the Cauchy horizon isn't shielded from that in any way, the space within that horizon could be filled with all sorts of strange things, says Mann. "[The singularity] could emit elephants, planets, radiation – basically anything," he says.

There is one caveat. This only applies to electrically charged black holes, which are unlikely to exist in the real world. However, Hintz and Mann say rotating black holes – which have been detected – could have similar properties. ■

Beyond a black hole's horizon, a world of weirdness awaits

VICTOR HABBICK VISIONS/SCIENCE PHOTO LIBRARY

Zombie death fungi target the world's ants

FIFTEEN newly discovered fungi can all control the brains of ants in cruel and unusual ways in the moments before killing them.

Zombie ant fungi are parasites that are mostly found in tropical forests. Once inside its host, such a fungus alters the ant's behaviour in ways that favour its own reproduction, for example by compelling the ant to seek a place other ants are likely to pass. The fungus then sprouts a long stalk, sometimes right through the back of the ant's head. Infectious spores bloom at the end, making it easier for the fungus to brush onto another ant.

"Besides their beauty, it's striking how these fungi evolved and are so well adapted morphologically and ecologically to infect their hosts," says João Araújo at Pennsylvania State University.

Araújo and his colleagues have now described 15 new species of zombie ant fungus from the Brazilian Amazon, Japan, Australia, Colombia and the US. They were collected by Araújo or by travelling colleagues.

The 15 species include fungi that force ants to bite into tree trunks, plant stalks or leaves before dying (*Studies in Mycology*, doi.org/ckvd).

One fungus, called *Ophiocordyceps blakebarnesii*, is found in Missouri and infects a species of carpenter ant that builds its nests in dead logs. The fungus compels the ant to die after biting into the wood inside a dead log. There, the fungus can infect a new victim while staying sheltered from the elements.

"The fungus forces the ant to die under moss, and mimics the moss's sex organs. It is unclear why"

In the Amazon, *Ophiocordyceps monacidis* forces a species of odorous ant to die under a type of moss. The fungus mimics the moss's sex organs with its spore-spitting stalks. Araújo isn't sure exactly why.

Unveiling the diversity of zombie ant fungi will help us understand how these sinister parasites evolved, says Araújo. What's more, the fungi might one day be used to control agricultural pests. Joshua Rapp Learn ■

Weird particle soup could form enormous stars

EXOTIC starlike objects made almost entirely of particles called pions could have formed in the early universe. If proven to exist, these cosmic oddballs would be one of the strangest additions to the stellar catalogue.

Pions are light, containing just two quarks, as opposed to more familiar matter like protons and neutrons, which each contain three quarks. The universe was bathed in a primordial pion soup one-ten-thousandth of a second after the big bang.

Now Bastian Brandt at Goethe University Frankfurt in Germany and his colleagues suggest that a massive blob of positively charged pions could have glommed together during this early era. This would have created a star-like ball of an unusual state of matter, called a Bose-Einstein condensate. Its pions would all interact with one another and behave as a single particle.

The Bose-Einstein condensate would oscillate something like a violin string, says Mark Alford of Washington University in St Louis, Missouri. "The available ways in which it can twang do not allow it to twang in the right way that it can start decaying," he says. So, this pion "star" could remain stable even though the particles normally decay within a few hundred-millionths of a second.

The team's calculations suggest that such objects would be roughly 250 times the mass of the sun and about half the size of Jupiter (arxiv.org/abs/1802.06685). This is far larger and more massive than other compact, dense objects such as white dwarfs and neutron stars.

On Earth, we can form Bose-Einstein condensates only by cooling material to ultra-low temperatures. For pions to form a condensate in the hot early universe, the team say it would require a somewhat non-standard model of how the big bang played out, with more positively or negatively charged pions than we typically assume. Adam Mann ■

ANTHONY KWAN/BLOOMBERG VIA GETTY IMAGES

Chinese search giant Baidu claims its speech engine is a breakthrough

AI hears snippets of you, then clones your voice

NEURAL networks can now mimic someone's voice, and all they need for the feat is less than a minute's worth of their speech.

Researchers at China's search engine giant Baidu say the technology could create digital duplicate voices for people who have lost the ability to talk. It could also be used to personalise digital assistants, video game characters or automatic speech translation services.

"A mum could easily configure an audio-book reader with her own voice to read bedtime stories for her kids," says Sercan Arik at Baidu Research, who led the work.

Voice cloning technology has improved rapidly in recent years. Adobe's VoCo, released in 2016, could mimic someone's voice using 20 minutes of audio. Last year, Canadian start-up Lyrebird launched a service letting anyone create a digital copy of their voice based on 1 minute of audio.

Baidu's research builds on its text-to-speech synthesis system Deep Voice, which was trained on more than 800 hours of audio from 2400 speakers. It builds a model of human speech by learning what sounds go with what text and also picks up the idiosyncrasies of each speaker it was trained on.

Now the software is able to synthesise a copy of a voice solely based on hearing snatches of the original. The best version needed 100 snippets, each no more than 5 seconds long, the Baidu team says. But one trained on just 10 snippets performed well enough to dupe a voice recognition system more than 95 per cent of the time, and human evaluators gave it 3.16 out of 4 for mimickry (arxiv.org/abs/1802.06006).

"Digital assistants and banks' telephone services could be vulnerable to synthesised voices"

The team also tried a secondary method that trained a separate model on just the voice to be mimicked. This was less accurate, but Arik says it is also more efficient so could potentially run on a smartphone.

The output is still not totally indistinguishable from the human voice, says Arik, "but it does show a very fundamental breakthrough in that direction".

Even the best synthesised voices contain telltale digital signals that are easily detected by advanced voice profiling algorithms, says Rita Singh, a voice forensic science expert at Carnegie Mellon University in Pennsylvania.

However, most voice authentication systems – used to secure everything from banking services to smartphones – can be fooled because they rely instead on picking up broad statistical features, she says.

In 2014, University of Alabama security researcher Nitesh Saxena showed that a freely available voice morphing tool could trick voice authentication systems 80 to 90 per cent of the time. Unpublished research shows that leading digital assistants and even a major bank's telephone service remain vulnerable, he says.

But while biometric systems can be improved, our own ability to detect fakes can't. This raises the spectre of voice synthesis systems aping someone's voice to commit fraud or sparking fake news by doctoring a politician's speech.

"Humans will, over time, become even more vulnerable to such attacks," says Saxena.

Combining that with approaches like the DeepFake algorithm recently used to transplant celebrities' faces into porn videos could supercharge the problem, Singh says.

"Now the default status is that if there's any video that sounds too bad or too good to be true, it's probably a fake," she adds. Edd Gent ■

Fishy secret to avoiding allergies

Alice Klein

TODDLERS who eat fish at least once a month are less likely to have hay fever in later childhood.

Hay fever – the itchy, sneezy reaction to pollen, dust and fur – is becoming increasingly common in industrialised countries. Some have blamed the fact that children are being exposed to a narrower range of microbes for disrupting the immune system, but diet may also play a role.

To explore this, Emma Goksör at the University of Gothenburg in Sweden and her colleagues asked around 4000 parents about their children's diet and lifestyle at the age of 1, and then again when they were 12.

Consistent with previous studies, they found that those who grew up on farms with animals were half as likely to develop hay fever – perhaps because they encounter more microorganisms in infancy.

But they also found that children aged 1 who ate fish at least once a month were 30 per cent less likely to develop hay fever by the age of 12 (*Pediatric Allergy and Immunology*, doi.org/cks7).

This connection has been hinted at before: for example, a 2003 study found that 4-year-olds were 55 per cent less likely to have hay fever if they had eaten fish in their first year of life. Other studies have found links between early fish consumption and lower rates of asthma and eczema.

"Communities that eat lots of fish generally have lower rates of allergic disease and other inflammatory conditions," says Mimi Tang at Murdoch Children's Research Institute in Melbourne, Australia. Studies have also found that children whose mothers took fish oil supplements during pregnancy were less likely to develop asthma, eczema and food sensitivities.

If fish protects against allergies, this is probably due to its high omega-3 fatty acid content,

JUNKU/GETTY

Eating fish when very young can reduce your chance of hay fever

says Tang. Omega-3s are thought to have anti-inflammatory properties, but diets increasingly contain omega-6 fatty acids instead. These come from vegetable oils, and may provoke inflammation.

The changing balance of these fatty acids may help explain the rise in allergies in recent decades. "We used to think that margarine was good for you because it's not animal fat, but it turns out it's laden with inflammatory omega-6," says Tang.

However, there may be other reasons why fish is linked to fewer allergies. For example, nutrients in fish like vitamin D or particular proteins may have a protective effect. Alternatively, eating fish may be a sign of a healthier lifestyle, says Goksör. ■

Quantum trick sends twice the info in one go

IN THE quantum world, particles can behave as if they are in two places at once. It turns out this bizarre property allows two people to send each other one bit of information using a single particle – something that is impossible in classical physics.

Say Alice and Bob each want to send the other a piece of information in the form of a 0 or a 1. In the classical picture, each has to send the other a particle encoded with that information. They need two particles.

Now, Philip Walther at the University of Vienna in Austria and his colleagues have shown that quantum mechanics can flout this limitation. Their experiment uses a device called the Mach-Zehnder interferometer.

Once a particle enters the device, it is sent into a beam splitter, which either transmits or reflects the particle. Because a quantum particle can be in two places at once, it can be thought of as simultaneously being transmitted and reflected. It is in a superposition, on two different paths.

After a while, these paths meet at a second beam splitter. If the paths are of equal length, the particle always exits the second beam splitter via route A. If you change the length of one path precisely, the particle exits via route B. To use this set-up to get Alice and Bob to exchange information, Walther and colleagues locate Alice midway along one arm of the interferometer and Bob midway along the other. Each can choose to change the length of their part of the device, equivalent to transmitting a 1, or do nothing, equivalent to sending a 0.

When a particle enters the device, if both Alice and Bob do nothing, the particle exits via route A and goes to Alice, not to Bob. If both of them change the lengths of their respective paths, the particle again goes to Alice. But if only one of them takes action, the particle exits the device via route B and goes to Bob, not to Alice.

This set-up can be used to trade two bits of information using only one particle (arxiv.org/abs/1802.05102). For example, if Alice receives the particle and she did not change the path length, she knows that Bob also did nothing and hence transmitted a 0. Bob, who did not receive the particle, also simultaneously knows that Alice transmitted a 0.

"An eavesdropper has no means of telling who sent the message, let alone how to decode it"

It can be used to exchange a secret message, says Walther. If Alice sends a string of 1s and 0s, Bob can generate a random sequence that he uses to decide whether or not to modify the interferometer for each. Based on whether he receives each particle, Bob can decode Alice's message. An eavesdropper only has access to the interferometer's output, so can't tell who sent the message, let alone how to decode it. Anil Ananthaswamy ■

invitrogen

Streamline analysis, expand possibilities

E-Gel Power Snap Electrophoresis System

DNA separation

Simplify DNA electrophoresis with the only integrated gel running and imaging platform

The new Invitrogen™ E-Gel™ Power Snap Electrophoresis System combines the convenience of rapid, real-time nucleic acid analysis with high-resolution image capture. The integrated design helps reduce workflow time and accelerate discovery.

Find out more at **thermofisher.com/powersnap**

ThermoFisher SCIENTIFIC

MARK RICHARDS/DAILY MAIL/SOLO SYNDICATION

The new reconstruction of Cheddar Man, who lived 10,000 years ago

Was ancient Briton dark-skinned?

Colin Barras

A BRITON who lived 10,000 years ago had dark brown skin and blue eyes. At least, that's what dozens of news stories last month – including our own – stated as fact. Now one of the geneticists who performed the research says the conclusion is not certain, and according to others we are not even close to knowing the skin colour of any ancient human.

Cheddar Man's skeleton was found in 1903 in an English cave where it had lain for 10,000 years.

Until a few weeks ago, he was always depicted with pale skin. This makes some sense, as people living at northern latitudes often have paler skin. The reason may be that the lack of pigment allows more of the weak northerly sunlight into the skin, so it can make enough vitamin D. It seems our species reached Europe 30,000 years before Cheddar Man lived, so his ancestors had plenty of time to evolve paler skin.

But a recent DNA analysis suggested that Cheddar Man may have had dark skin. To show this, a team including Susan Walsh at Indiana University–Purdue University Indianapolis read Cheddar Man's DNA. Walsh had helped develop a model that predicts someone's eye, hair and skin colour from their DNA, and the team applied this technique to Cheddar Man.

The most recent version of the model was published last May. It focuses on 36 spots in 16 genes, all linked to skin colour. To test it, Walsh's team had taken genetic data from more than 1400 people, most from Europe and the US, others from Africa and Papua New Guinea. The team had used some of the data to "train" their model on how skin colour lines up with the 36 DNA markers. They had then used the rest of the data to test how well the model could infer skin colour from DNA. The model had correctly identified who had "light" skin and who "dark-black" skin, with a small margin of error.

When the team ran Cheddar Man's DNA through the model, it judged that his skin colour was "dark" or "dark to black".

The research was announced to journalists last month to promote a TV documentary. Now a draft version of the research paper has been published – and it turns out the headlines were overconfident (bioRxiv, doi.org/ckqq).

"The idea that there are only about 15 genes underlying skin pigmentation isn't correct"

Walsh says the study doesn't prove that Cheddar Man had dark to black skin. For one thing, his DNA has degraded over the past 10,000 years. "It's not a simple statement of, 'This person was dark-skinned,'" she says. "It is his most probable profile, based on current research."

We aren't ready to infer the skin colour of prehistoric people from their genes, says Brenna Henn at Stony Brook University, New York. The genetics involved are more complex than we thought.

In November, Henn's team published a paper on the genetics of skin pigmentation in people indigenous to southern Africa – where skin colour varies more than many people realise. Just weeks before, a group led by Sarah Tishkoff at the University of Pennsylvania in Philadelphia had published a separate paper on skin colour genetics in people from eastern and southern Africa.

Both found the same thing, says Henn. "Known skin pigmentation genes, discovered primarily in East Asian and European populations, don't explain the variation in skin pigmentation in African populations. The idea that there are only about 15 genes underlying skin pigmentation isn't correct." It seems that many more genes affect skin colour.

As we are still learning about the link between genes and skin pigmentation in living people, we can't yet tell the skin colour of prehistoric people, says Henn.

That may seem of little practical importance – although the idea that Cheddar Man was dark-skinned generated huge public interest. However, we need to know the limitations of this sort of genetic technology.

Police could one day plug DNA from a crime scene into a model to determine what a suspect looks like. Walsh's model might succeed at this in the US, says Henn, as it was trained on people whose DNA resembles North Americans'. But it may well fail elsewhere.

Henn's team has tested an older model that aimed to predict skin colour from DNA. For southern African people, "it predicted that people with the darkest skins would have the lightest skin". ■

UNHCR
The UN Refugee Agency

WINTER CRISIS APPEAL

WINTER WITHOUT A HOME FOR MILLIONS OF REFUGEE FAMILIES

Can you imagine living in a makeshift shelter, with no eating or warm clothes exposed to every blast of icy wind? This is the reality for thousands of refugee families this winter. Cold and frightened, without adequate shelter, many are struggling to survive.

£75 COULD PROVIDE A WINTER SURVIVAL KIT TO PROTECT A FAMILY FROM THE HARSH WINTER.

© UNHCR/HameedMaarouf

Please help refugee families stay warm and dry this winter.

Give online at www.unhcr.org/wintersupport
or call us on 020 3761 9525

Or post urgently to: UNHCR, York house, Wetherby Road, Long Marston, York. YO26 7NH

UNHCR
The UN Refugee Agency

Please accept my gift of:

☐ **£75** ☐ **£150** ☐ **£225** ☐ **Other £** _____

☐ Please debit my: ☐ Visa ☐ MasterCard

Card no. ☐☐☐☐ ☐☐☐☐ ☐☐☐☐ ☐☐☐☐

Expiry date ☐☐/☐☐

Signature_____ Date ☐☐/☐☐

☐ I enclose a cheque or postal order made payable to UNHCR

See how your donation makes a difference to the lives of refugees.
Please tell us if you are happy to hear more about UNHCR's work:

☐ By post ☐ By email ☐ By phone

First name _____

Last name _____

Address _____

_____

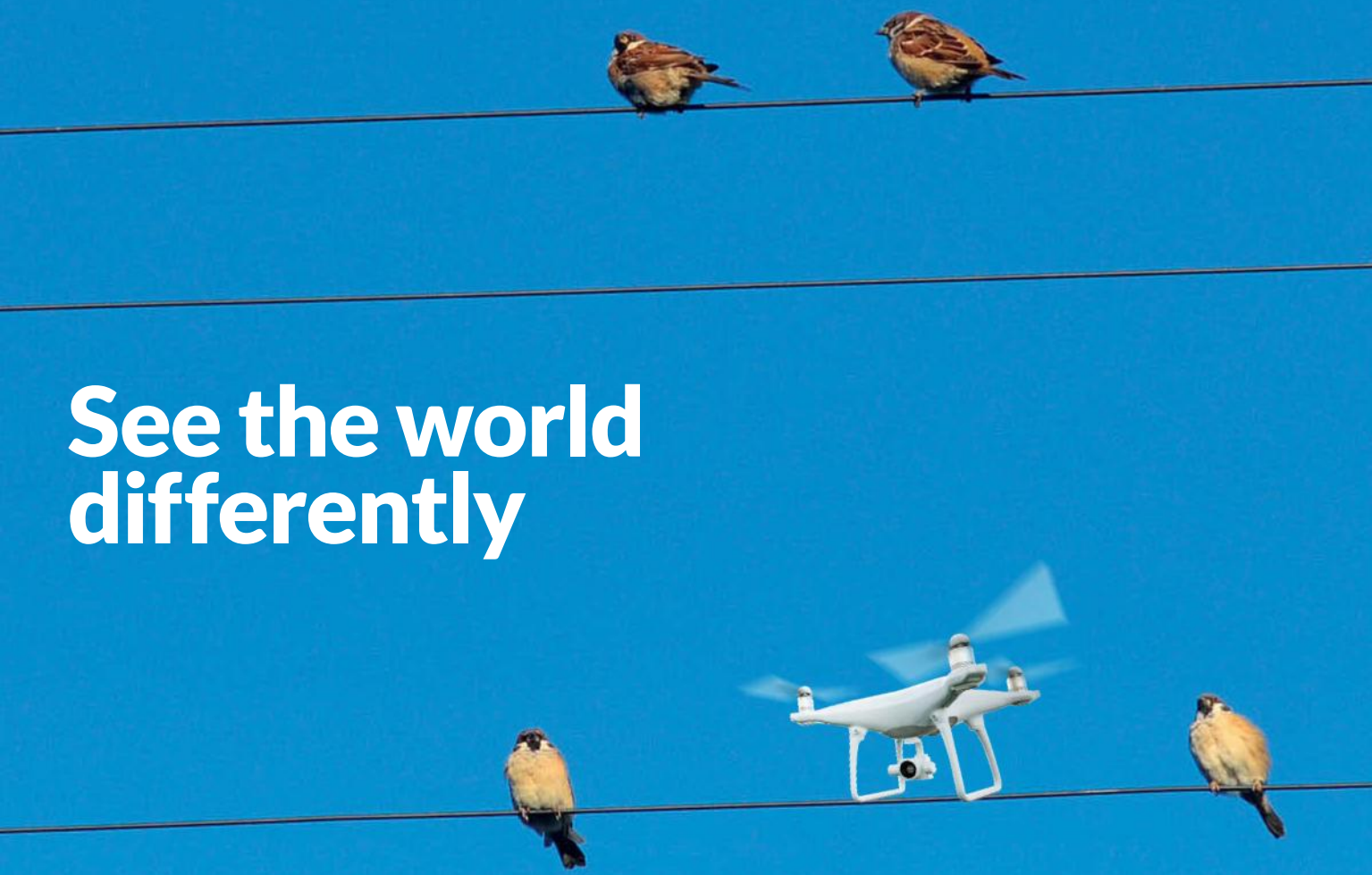
Postcode _____

Email _____

Phone _____

Your donation will support UNHCR's emergency work where refugees and internally displaced people are in need.

NSCPAWI17



See the world differently

Subscribe or give as a gift and save up to 50%
Plus receive the bestselling book *How to be Human* **FREE**

Visit **newscientist.com/10925** or
call **0330 333 9470** and quote **10925**

NewScientist

GAB

Alt-right's 'Twitter' is hate-speech hub

Chris Stokel-Walker

TWITTER has long been criticised for its hateful interactions, but it's not the worst. A look inside the alt-right's answer to Twitter, called Gab, shows just how disturbing online echo chambers can be.

Created by Andrew Torba in response to claims that regular social media suppresses right-wing debate, Gab has a similar design to Twitter and says it champions free speech. But Gab has evolved into a haven for hate speech, according to an 18-month analysis of more than 22 million posts by 336,752 users.

Savvas Zannettou at Cyprus University of Technology and his colleagues cross-checked Gab posts against terms in Hatebase, a database used by governments and non-governmental organisations to track the spread of hate speech. One in every 20 posts the researchers analysed included words in the Hatebase corpus – 2.4 times the rate on Twitter. However, hate-filled posts on Gab were only half as common as on 4chan's /pol/ message board, a notorious home of internet trolls (arxiv.org/abs/1802.05287).

Despite Gab being touted as an alternative to mainstream social media, the researchers found that YouTube and Twitter account for nearly one in every 10 links posted to the site. *Breitbart*, the alt-right news website, is the fourth most popular site Gab users linked to. The *Daily Stormer*, an avowedly neo-Nazi outlet, is more popular on Gab than *The Washington Post*.

Sites like Gab have sprung up in the wake of traditional social media platforms cracking down on hate speech. There's PewTube, an alt-right YouTube, which has more than 10,000 users and WrongThink, similar to Facebook. Hatreon allows people booted off Kickstarter and Patreon for hate speech to seek crowdfunding, while Infogalactic is an alt-right Wikipedia clone.

"The rise of fringe platforms raises questions about the best way to tackle hate speech online"

All of these are far from mainstream, providing a platform for thoughts that can't be stated on the usual social media sites due to strict anti-hate-speech laws.

Gab's app has been banned from Apple's App Store and Google Play because of the site's content. "Gab's mission is to put people and free speech first. We believe that the only valid form of censorship is an individual's own choice to opt-out," say the site's guidelines.

The rise of fringe platforms raises questions about the best way to tackle hate speech online. Patrick S. Forscher at the University of Arkansas, who has investigated the alt-right, is equivocal. "Countering hate speech in the open can communicate a norm that certain kinds of speech are not tolerated," he says. "It's also possible that excluding hate speech users from public spaces could breed resentment and make their attitudes more extreme."

"Broadly speaking, Europeans have a more caveated understanding of free speech," says Matthew Feldman, a UK-based independent researcher of the radical right. "In America, it might be seen as inappropriate or inoffensive, but isn't considered something that should be barred." ■

Another world war could still be on the cards

SINCE 1945, the world has been – comparatively – peaceful. Some believe this "long peace" is the start of a new, conflict-free era. But a recent analysis suggests it is just a blip, and a major war could be around the corner.

The long peace began after the second world war. In his 2011 book *The Better Angels of our Nature*, Harvard psychologist Steven Pinker argued that if we make good choices now, it could well become permanent.

To see if we truly have turned a corner, Aaron Clauset at the University of Colorado in Boulder studied wars that took place between 1823 and 2003. He used data from the Correlates of War project, which gathers data on conflicts. Over the 181-year period, there were 95 wars: one every 1.91 years on average.

Clauset measured the size of each by comparing the number of soldiers killed. The second world war was the worst, killing 16.6 million. He defined a large war as one in the top quarter by military casualties.

Clauset split his study period into three. In the first period, prior to the first world war, there were 19 large wars, one every 6.2 years. But the long peace since the second world war only saw five, one every 12.8 years.

During the middle period, the "great violence" encompassing both world wars, there were 10 large wars, or one every 2.7 years.

This may seem to support the idea that the long peace is a period of unusually low conflict. But statistically, the great violence and long peace cancel out, so the rate of wars over the last 100 years is roughly what it was in the 1800s (*Science Advances*, doi.org/ckrc). So the long peace may not be special. It could be a "statistical fluke", says Clauset.

Clauset also estimates that wars as large as the second world war occur on average every 205 years. That implies we need at least another century of peace to be confident the long peace is a genuine departure. Andy Coghlan ■

Neanderthals painted just like us

Michael Marshall

OUR extinct Neanderthal cousins were the first known cave artists in the world.

Many European caves contain prehistoric art, all of which has been attributed to modern humans. There have been past claims of Neanderthal paintings, but the evidence was weak.

Alistair Pike at the University of Southampton, UK, and his colleagues have been studying prehistoric art in the Monte Castillo caves in northern Spain for a decade. In 2012, they reported that a red dot in one cave, El Castillo, was at least 40,800 years old – when Neanderthals were disappearing from Europe and modern humans arrived.

"We couldn't work out whether it was modern humans or Neanderthals that did that painting," says Pike.

Now his team has studied art in three more caves and found older paintings that must be by Neanderthals, since modern humans weren't in Europe at that time (*Science*, doi.org/cks5).

The first cave, La Pasiega, is also part of Monte Castillo. It is a long tube with arches that have been painted. One painting is a symbol made up of red lines (pictured, below). By studying the radioactive decay of a mineral that had been deposited over the painting, the team determined it must be at least 64,800 years old.

A second cave, Maltravieso in western Spain, houses a hand stencil the team dated using the same method to 66,700 years old, making it the oldest known cave art in the world (pictured, right).

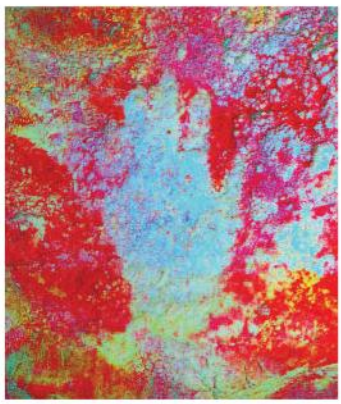
Art at La Pasiega, Spain, predates the arrival of modern humans

P. SAURA

The third cave, Ardales in southern Spain, contains some painted stalagmites. The team dated one painting to between 45,300 and 48,700 years old, while others were at least 65,500 years old. "There's at least two separate instances of painting by Neanderthals," says Pike.

That's not their only art. Dirk Hoffmann at the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany, led a study of Aviones cave on Spain's south-east coast. Prehistoric jewellery – seashells that had been perforated and painted – was found beneath the cave's floor in 2010 by João Zilhão at the Catalan Institution for Research and Advanced Studies in Barcelona, Spain.

The sediments on the cave floor have hardened into rock, preserving them. Hoffman has now dated a mineral layer on top to 115,000 years old (*Science Advances*, doi.org/cks6). This makes the sediments, including the shells, older still, he says.



H. COLLADO

A false-colour image of a 66,700-year-old Neanderthal hand

The finds end a long debate over Neanderthals' intelligence. "The discovery of Neanderthal painting is a smoking gun," says Pike. "It's going to be difficult for anyone to deny that Neanderthals were behaving like modern humans."

What's more, it wasn't a one-off. The caves are far apart, and the artworks were made over tens of thousands of years. "It's very much embedded in their thinking and culture," says Pike.

"There can be no longer any doubt that Neanderthals were, at least cognitively, people like us," says Zilhão. ■

Giving birth adds years to biological age

WOMEN who have given birth seem to have hallmarks of faster ageing than those that haven't – and the difference is equivalent to around 11 years.

That's what Anna Pollack and her colleagues at George Mason University, Virginia, found when they looked at one measure of biological ageing. The team inspected the length of telomeres – chunks of DNA that cap the ends of chromosomes. These shorten every time a cell divides, and shrunken telomeres have been associated with a shorter lifespan, as well as a host of chronic illnesses such as heart disease and cancer.

Pollack and her colleagues looked at telomere lengths in blood samples taken between 1999 and 2000 from 1954 women from across the US. They were all aged between 20 and 44 at the time.

They found that women who had given birth had telomeres that were on average 4.2 per cent shorter than those who had not had children, even after accounting for factors like age, socioeconomic status and body mass index (*Human Reproduction*, doi.org/ckn9). "It is equivalent to around 11 years of accelerated cellular ageing," says Pollack.

The shortening is greater than that seen in studies of smoking or obesity, says Pollack. "We were surprised to find such a striking result."

"Telomere shortening in women who have given birth is equivalent to around 11 years of ageing"

It's unclear whether this is caused by pregnancy, childbirth or raising children. Women who have been pregnant seem to have a degree of protection from some cancers, including breast and uterine cancer, but are more at risk of heart disease and diabetes, thanks to hormonal changes. Pollack wonders if the stress of raising a child may play a role.

Whether the accelerated ageing has an effect on a woman's health will depend on a range of other factors, says Karen Mather at the University of New South Wales in Australia.

Jessica Hamzelou ■

Travel Insurance with you in mind

Travel insurance designed by travellers

- Up to £10M medical expenses
- Available for UK/EU Citizens if you're already abroad
- Cover for cameras and gadgets available
- Extreme sports and activities covered, including trekking and winter sports

Get a quote
truetraveller.com
or call **0333 999 3140**

truetraveller

New Scientist events

UPCOMING INSTANT EXPERT EVENTS

Saturday 24 March 2018

INSTANT EXPERT
CONSCIOUSNESS

Explore what consciousness is, what are out of body experiences, will we ever build conscious machines and much more. Speakers incude Anil Seth, Karl Friston, Susan J Blackmore and three other experts.

Saturday 14 April 2018

INSTANT EXPERT
MENTAL HEALTH

Learn about the many causes of mental illness, what is normal, understanding psychosis, meditation and much more. Speakers include Anne Cooke, Catherine Wikholm, Praveetha Patalay and three other experts.

Saturday 2 June 2018

INSTANT EXPERT
YOU AND YOUR GENOME

Delve into the genetic revolution, nature vs nurture, genetic factors in disease, gene therapies, gene editing and much more. Speakers include Tim Frayling, Lone Frank and four other experts.

Find out more and book tickets:
newscientist.com/events

10am – 5pm at:
Royal College of General Practitioners
30 Euston Square
London

YING CUI

Fabric inspired by polar bears keeps this bunny warm

IT'S a bunny in bears' clothing. A rabbit wrapped in a new textile inspired by polar bear hair keeps all its body heat in, so it stays both cosy and invisible to infrared imaging.

The porous interior structure of a polar bear's fur helps insulate it against harsh Arctic winters. To mimic these pores, Ying Cui at Zhejiang University in Hangzhou, China, and her colleagues dissolved silk in water and dripped a constant stream of the solution through a cold copper ring. When the liquid silk "thread" passes through the ring, ice crystals grow within the thread in layers, similar to the layers of pores in polar bear fur. The frozen fibre is then freeze-dried to leave gaps where the ice was, resulting in well-aligned pores that fill up to 87 per cent of the silk fibres' volume with air. The researchers then wove the fibres together into a textile.

A layer about 0.4 millimetres thick was subjected to temperatures between -22°C and 80°C. The fabric only reached temperatures between -10°C and 64°C, indicating good thermal insulation (*Advanced Materials*, doi.org/ckrj). Like polar bear fur, it also reflects infrared light, making it practically invisible in those wavelengths.

The researchers tested this property by wrapping a layer of their tactical silk around a rabbit. It became almost invisible to an infrared camera at temperatures ranging from -10°C to 40°C. It reflected the light up to twice as well as other commercial textiles.

Tumour clones could guide better chemo

GROWING miniature tumours in the lab could help doctors discover the best way to treat each patient, homing in on the right drugs to use.

Nicola Valeri at the Institute of Cancer Research in London and his team have shown this by taking 110 biopsies from tumours. These were secondary tumours from 71 people with cancers that had spread from the bowel, oesophagus or bile duct.

In the lab, the team grew the cells from these biopsies into miniature tumours, and tested 55 standard chemotherapeutic drugs on each kind, to see which were the best at killing them.

These tests showed with 100 per cent accuracy which drugs hadn't worked when tried in the person who donated the cells. The tests were 88 per cent accurate at predicting drugs that had successfully shrunk tumours in these people (*Science*, doi.org/ckss).

The team plans to test the approach in a clinical trial in which chemotherapy drug selection for each person will be guided by testing balls of their tumour cells in the lab. As well as these cells, the team is also looking at how immune and inflammatory cells from a person might help guide their treatment.

Why bats harbour Ebola and SARS

BATS are a refuge for some of our most lethal viruses, such as Ebola. Now we may know why they let viruses linger in their bodies – it is because flying is such hard work.

Peng Zhou at the Wuhan Institution of Virology in China and his colleagues triggered immune responses in the white blood cells of mice and Chinese rufous horseshoe bats, which harboured the SARS virus. The mouse cells responded more (*Cell Host & Microbe*, doi.org/cks8).

To find out why, they compared the gene for an immune system protein called STING in 30 bat species and 10 flightless mammals. STING triggers an immune response if there is free-floating DNA released by viruses.

In the bats, STING had mutated, weakening the immune response. The exercise of flying also releases DNA, so bats may have evolved a weak immune response to avoid attacking their own tissue.

Beetle nibbles act as camouflage

LEAF beetles disguise themselves as the bite marks they make on leaves while eating.

While many insects hide by mimicking objects like twigs, this is the first case of feeding damage being used as a decoy.

Fredric Vencl at Stony Brook University in New York and his colleagues struggled to pick out leaf beetles on heavily chewed leaves, and decided to investigate.

They analysed photos of 119 species of leaf beetle alongside the size, shape and colour of their bite patterns. Most species resembled their own bite marks (*Biological Journal of the Linnean Society*, doi.org/gcxq58). This trait was widespread in the leaf beetle group, hinting that it has evolved independently several times.

Sea urchins eat through solid rock

SEA urchins can scrape their way through rock to make their homes. This ability has long been suspected but never demonstrated, until now.

Michael Russell at Villanova University in Pennsylvania and his colleagues studied purple sea urchins from the west coast of North America. These animals attach themselves to rock, and prefer to do so in pits and holes.

In the lab, the researchers placed single sea urchins on pieces of soft mudstone, hard sandstone and tough granite. After a year, they checked the weights of the rocks, how the surfaces looked and the amount of erosion.

The sea urchins had eaten holes in all the rocks, although they were slower at doing so on the harder ones. Field studies found that pits in mudstone were about 220 cubic centimetres, compared with 63 cubic centimetres in sandstone and just 45 cubic centimetres in granite (*PLoS One*, doi.org/cksz).

"We were not surprised that they excavate rock," says Russell. "What shocked us was… how fast they were able to form pits."

Russell says the sea urchins' abilities are a by-product of how they eat, using the five sharp teeth on their underside. Even when not chewing food, the teeth are always scraping the rock they sit on, sculpting it in the process.

MICHAEL ZEIGLER/GETTY

For tailor-made molecules, just squeeze here

IT'S a new way to control a chemical reaction: use a pair of diamonds to put the squeeze on molecules. The technique could make it easier to produce custom compounds for pharmaceuticals.

Chemical reactions break molecular bonds and move electrons around. To start one, you can add heat, electricity or light, or physically pull the molecule apart. Now, Nicholas Melosh at Stanford University, California, and his colleagues have simply squeezed a whole molecule.

High pressure is a direct way to create certain molecular changes, such as turning graphite into diamond. This is a symmetrical reaction – because the pressure is coming from all sides, every part of the graphite shifts in the same way to form diamond.

But many important reactions are asymmetrical. For these, we need to apply pressure at a particular location. Melosh and his colleagues did this by placing the part of the molecule where they wanted the reaction to take place between two rigid molecules called carboranes.

They then put this "molecular anvil" inside a larger diamond anvil to squeeze the whole thing to a pressure of 12 gigapascals. That broke atomic bonds in the molecule, a copper sulphide cluster. Electrons moved from the sulphur to the copper atoms, creating pure crystals of the metal (*Nature*, doi.org/ckrm).

It is the first time anyone has kick-started asymmetrical chemical reactions this way. Melosh says this precise control could be useful for building custom molecules on demand.

Saw-wielding carpentry robots

A ROBOT wood-working team is making carpentry as easy as falling off a log.

Jeffrey Lipton at the Massachusetts Institute of Technology was inspired to make robots that keep hands away from blades because of a colleague. He used to work as a carpenter's apprentice under a man who had accidentally cut off each of his thumbs with a saw. Twice.

Lipton and his colleagues at MIT have created a system where users can customise their own designs for anything from a table to a shed. A team of robots cuts out all the parts, and the user puts it together from automatically generated instructions. It is flat-pack furniture, but custom-made.

Two lifting robots pick up a piece of wood, bring it over to a chop saw, and hold it in place while the saw cuts it to size. If you want squiggly edges instead of straight ones, jigsaw robots attached to a customised Roomba vacuum cleaner will take care of it.

Lipton says parts of this system may be commercialised in the next few years. Until then, he says, don't try it at home. "Please don't just strap a jigsaw to a Roomba – unless you're a roboticist."

DAVID HURN/MAGNUM

Keep riding for a surer-footed future

PEOPLE who keep cycling into their later years are at lower risk of the kinds of falls that plague older folk.

A third of over-65s take a tumble each year, and about a quarter of those who break their hip this way die within a year. Injuries aside, the fear of a repeat fall can limit mobility.

Chris Rissel at the University of Sydney and his colleagues wondered whether cycling would help by improving balance and leg strength, key preventative factors for a fall.

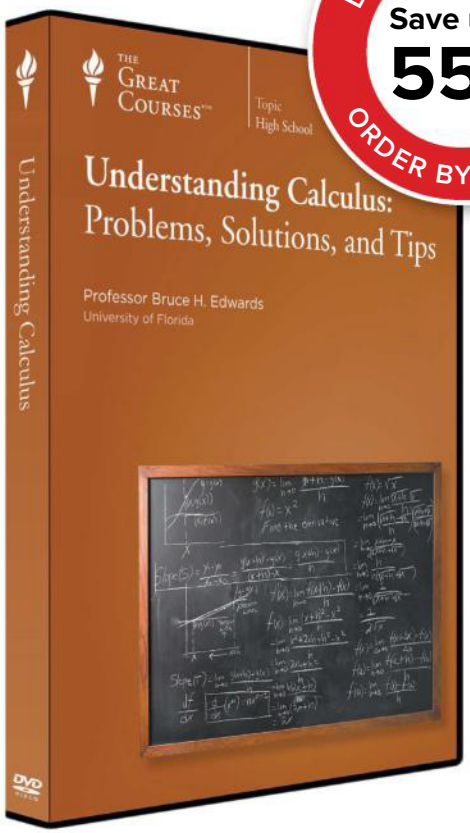
They compared 79 people aged 65 or up who still regularly rode, with 28 others who had stopped when they were younger. All were living in the Netherlands.

The cyclists did better in strength and balance tests (*Journal of Aging and Physical Activity*, doi.org/ckst). "We would expect this to translate to fewer falls," says Rissel.

The research could not tease out whether this effect was down to cycling per se or some trait common to those who chose to cycle in later life. One way to determine this would be to take a group of non-cyclists and assign half to bike training to see if the same differences emerge, a study that Rissel hopes to do.

THE GREAT COURSES®

LIMITED TIME OFFER
Save up to 55%
ORDER BY 17 MARCH



Discover How to Understand the Secrets of Calculus

Calculus is one of history's greatest mathematical breakthroughs, is crucial for improving cognitive skills, and is a prerequisite for admission to top universities. **Understanding Calculus: Problems, Solutions, and Tips** immerses you in this important mathematical field in 36 lectures that cover the major topics of a full-year calculus course in high school at the College Board Advanced Placement AB level or a first-semester course in college.

With crystal-clear explanations of ideas and concepts, frequent study tips, pitfalls to avoid, and hundreds of examples and practice problems, these 36 lectures are your guide to conquering calculus. Award-winning Professor Bruce H. Edwards, coauthor of a best-selling series of calculus textbooks, has crafted an extensively illustrated course suited for anyone who wants to leap into this powerful intellectual achievement. With his exceptional teaching, you'll come away with a deeper appreciation of the beauty of calculus—and a powerful tool for unlocking the secrets of the world.

Offer expires 17/03/18

THEGREATCOURSES.CO.UK/4NSC

0800 298 9796

Understanding Calculus: Problems, Solutions, and Tips

Taught by Professor Bruce H. Edwards
UNIVERSITY OF FLORIDA

LECTURE TITLES

1. A Preview of Calculus
2. Review—Graphs, Models, and Functions
3. Review—Functions and Trigonometry
4. Finding Limits
5. An Introduction to Continuity
6. Infinite Limits and Limits at Infinity
7. The Derivative and the Tangent Line Problem
8. Basic Differentiation Rules
9. Product and Quotient Rules
10. The Chain Rule
11. Implicit Differentiation and Related Rates
12. Extrema on an Interval
13. Increasing and Decreasing Functions
14. Concavity and Points of Inflection
15. Curve Sketching and Linear Approximations
16. Applications—Optimization Problems, Part 1
17. Applications—Optimization Problems, Part 2
18. Antiderivatives and Basic Integration Rules
19. The Area Problem and the Definite Integral
20. The Fundamental Theorem of Calculus, Part 1
21. The Fundamental Theorem of Calculus, Part 2
22. Integration by Substitution
23. Numerical Integration
24. Natural Logarithmic Function—Differentiation
25. Natural Logarithmic Function—Integration
26. Exponential Function
27. Bases other than e
28. Inverse Trigonometric Functions
29. Area of a Region between 2 Curves
30. Volume—The Disk Method
31. Volume—The Shell Method
32. Applications—Arc Length and Surface Area
33. Basic Integration Rules
34. Other Techniques of Integration
35. Differential Equations and Slope Fields
36. Applications of Differential Equations

Understanding Calculus:
Problems, Solutions, and Tips
Course no. 1007 | 36 lectures (30 minutes/lecture)

SAVE UP TO £45

DVD	~~£79.99~~	NOW £34.99
Video Download	~~£54.99~~	NOW £34.99

+£2.99 Postage and Packing (DVD only)

Priority Code: 157869

For over 25 years, The Great Courses has brought the world's foremost educators to millions who want to go deeper into the subjects that matter most. No exams. No homework. Just a world of knowledge available any time, anywhere. Download or stream to your laptop or PC, or use our free apps for iPad, iPhone, Android, or Kindle Fire. Over 600 courses available at www.TheGreatCourses.co.uk.

The Great Courses®, 2nd Floor, Mander House, Mander Centre Wolverhampton, WV1 3NH. Terms and conditions apply. See www.TheGreatCourses.co.uk for details.

New Scientist

How the gender pay gap permeates science and engineering

Women in STEM jobs are paid less than men and the gap shows no sign of shrinking, according to the latest findings from the *New Scientist*/SRG annual salary survey

WOMEN working in science and engineering earn a fifth less than their male colleagues in the UK. And the gender pay gap increases with age and experience. That's the disturbing finding revealed by the 2017 salary survey carried out by *New Scientist* and science recruitment specialists SRG.

The survey paints a stark picture of inequality. The average salary for men working in science and engineering in the UK in 2017 was £41,200, while women were paid £33,000, a difference of 20 per cent.

The UK is not alone in this. Male survey respondents in mainland Europe earned an average of €42,500 (£37,300) in 2017, with their female colleagues 19 per cent behind on €34,400 (£30,200). Among US participants, men averaged $73,000 (£52,200) and women $65,300 (£47,200) – a gap of 11 per cent; other studies have found a larger gulf.

"This chimes with what we see in other sectors and presents a picture that is far from satisfactory," says Helen Wollaston, chief executive of the WISE campaign for gender balance in science, technology and engineering, based in Leeds, UK.

The *New Scientist*/SRG survey gathered online responses from 4300 working scientists, engineers and academics, of which 49 per cent were women. Sixty per cent of respondents were based in the UK.

The results show how women are paid less from the moment they enter science and engineering. The youngest female respondents – aged between 25 and 34 – earned 2.5 per cent less on average than their male counterparts.

The gap then grows with age and experience. Women aged between 35 and 44 earn 16 per cent less than men while those between 45 and 54 earn 23 per cent less. The gap widens to a shocking 35 per cent for women aged 55 and above.

The findings are broadly in line with other studies. Previous research has shown that the earnings of women who return to work following childbirth often fail to keep pace with those of men, including fathers. A 2016 study by Catherine Buffington at the US Census Bureau in Washington DC and her colleagues found that women in the US earned 31 per cent less than their male counterparts within a year of gaining a PhD in science, technology, engineering or maths.

"Women are paid less from the moment they enter science and engineering"

They concluded that 11 per cent of this gap was down to the lower earnings of married women with children. By contrast, men with children saw no drop in earnings.

"The motherhood penalty tends to kick in post-35 when women may want to take time out of the workforce," says Maria Miller, chair of the UK House of Commons Women and Equalities select committee. "When they want to get back to work, often either part-time or with flexible hours, they find many sectors don't have a proper response to that."

The gender pay gap varies across UK industries. For example, men in the pharmaceutical industry enjoyed average salaries of £45,200, with women 22 per cent behind on £35,100. The gap in biotechnology is 10 per cent.

The Association of the British Pharmaceutical Industry admits that the gender pay gap is a concern. "We know that average pay gaps can be affected by a variety of factors but equal pay for equal work is not only a fundamental principle, it is the law," a spokesperson told *New Scientist*.

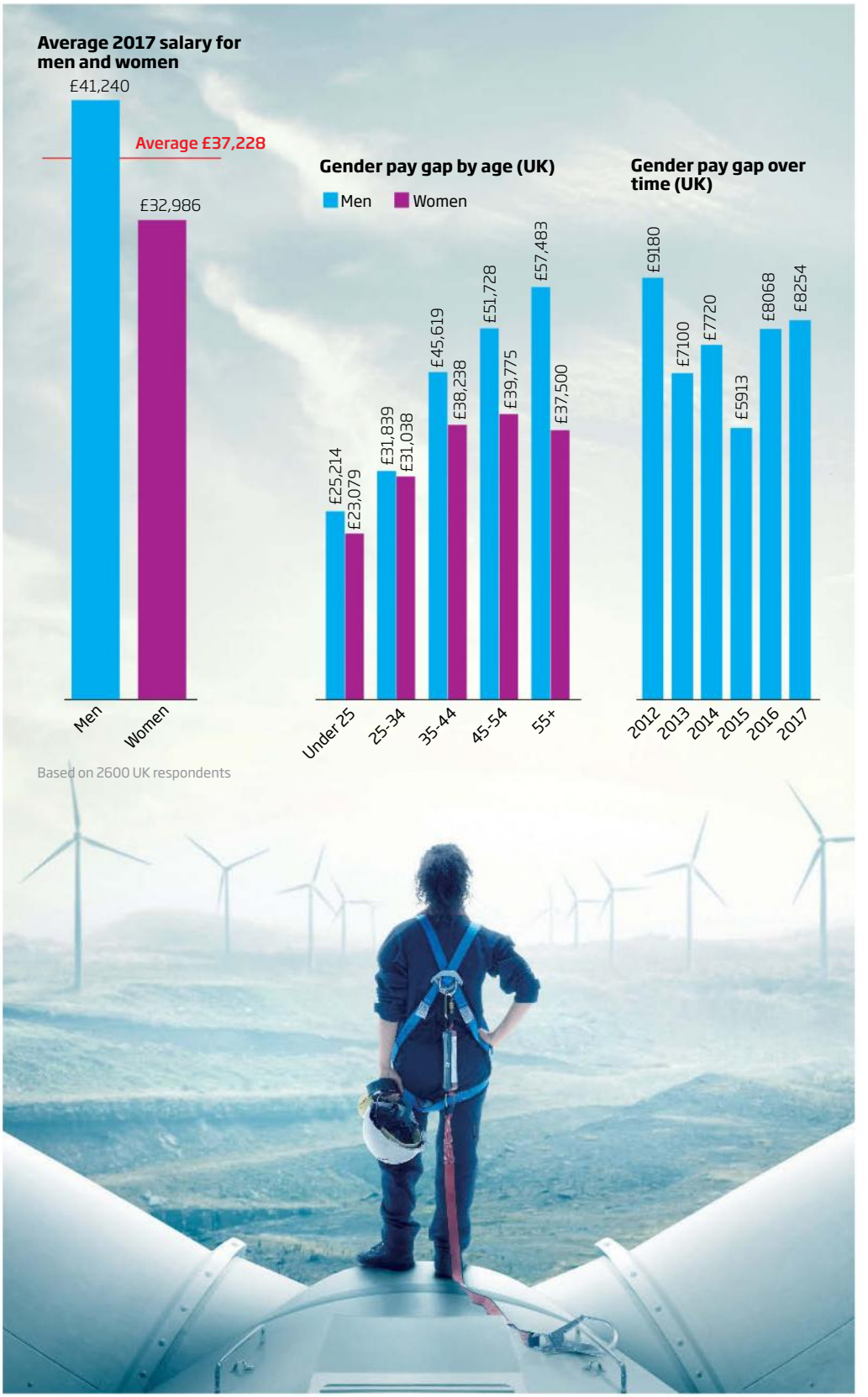
But there has been little change over time. The gender pay gap in the UK has hovered around 20 per cent since 2012, in *New Scientist*/SRG salary surveys.

And a recent Institute of Fiscal Studies report concluded that while the overall gender pay gap in the UK shrunk from 28 per cent to 20 per cent between 1993 and 2016, it grew slightly among graduates from 21 per cent to 22 per cent over the same period.

New UK laws require employers with 250 staff or more to publish data on their male-female pay disparities by April. Miller says this will help reduce inequalities in the long term, but called for it to be extended to smaller organisations. She adds: "The most important change we could make would be improve the right to day-one flexible working."

Changing the laws relating to parental leave could help reduce the gap, says Miller. "Until we get fathers more involved in those earliest years, women will continue to find it difficult to get the right balance between their work and family life." **Nic Fleming** ■

This article was written and edited independently by *New Scientist*



OLI KELLETT/GETTY

TRACING THE ORIGINS OF INEQUALITY

The precise origins of the gap between men's and women's pay are hard to pin down. One factor is that women are often disproportionately employed in lower-paying sectors and jobs. In 2014, Claudia Goldin at Harvard University showed that if the proportions of men and women in different occupations were equalised in the US, this would cut the overall earnings disparity by 32 per cent.

The *New Scientist*/SRG survey is consistent with this phenomenon: male respondents were better represented in higher-paying industries. For example, the highest paid sector is engineering where the average salary is £46,100. Here, male respondents outnumber women by three to one.

By contrast, the average salary in biotechnology is significantly lower at £36,800. But in this industry, female respondents outnumber men.

Jessica Schieder and Elise Gould at the Economic Policy Institute in Washington DC point out that women disproportionately choose lower-paying sectors as a result of deeply rooted, societal biases.

Helen Wollaston at WISE agrees. She tells the story of a teacher telling the mother of a 13-year-old from Huddersfield, UK, that her daughter was "too friendly" to be a scientist.

Wollaston believes these kinds of stereotypes drive women away from higher-paid fields. "Nobody is deliberately saying to women they can't choose the physical sciences, but culturally, they are encouraged to go into the less-well-paid life and health-related sciences," she says.

But even when these factors are taken into account, numerous findings suggest that a significant gender-based disparity remains. "The data show that when women have the same titles and jobs in the same industries, and after controlling for other factors, a wage gap persists that is left unexplained by anything other than societal biases and discrimination," says Heather Metcalf of the US Association for Women in Science.

Keep it clean

Why have sexually transmitted infections been increasing in the West and what can we do to stop them, asks **Alice Klein**

SEXUALLY transmitted infections are on the march. In Australia, where the figures for 2017 have just been released, rates of syphilis, gonorrhoea and chlamydia are the highest they have been since national recording began in the 1990s.

The story is similar in England and the US, where rates of these STIs have been climbing over the last decade (see graphs, right).

This uptick is alarming because these diseases were thought to be on their way out. In the 1940s, penicillin was tipped to eradicate syphilis, as swathes of soldiers infected during the second world war were cured. Gonorrhoea rates also plummeted in the 1980s, as fear of HIV spurred safer sex practices.

One factor in the resurgence is simply that we are doing more testing, particularly for chlamydia, says Rebecca Guy at the University of New South Wales in Australia. People with the disease don't normally show symptoms, but since the first accurate chlamydia test became widely available in the early 2000s, testing has increased, meaning more and more silent infections have been picked up.

But that isn't the whole story, says Nigel Field at University College London. Another driver may be the popularity of dating apps like Tinder and Grindr, which make it easier to hook up with more people, he says. That generally isn't a problem if people use condoms, but online daters appear to be less likely to practise safe sex.

A large study by Field and his colleagues found that men in the UK who used online dating services were six times more likely to have had sex with five or more people in the previous year, compared with those who didn't. They were also 1.5 times more likely to have had sex without a condom with two or more partners in that time. Similarly, a recent study of 500 male and female US college students found that those who used dating apps were twice as likely to have had unprotected sex in the previous three months.

"British men who use online dating services are more likely to have sex without using a condom"

It is hard to tell whether dating apps are simply an indicator of risky sexual behaviour, or actively driving it, says Field. "It might be the case that people who already had lots of casual unprotected sex are more likely to use dating apps."

Regardless, these services might make it easier for high-risk people to have sex with more partners and spread STIs, he says. They may also link up different groups of people who might otherwise not have had sex, allowing greater spread of STIs.

But let's not be too quick to blame technology alone. Condoms, one of the best defences against STIs, have fallen out of favour as people become less scared of HIV. Antiretroviral drugs have increased the life expectancy of people with HIV to over 65 in Europe and North America and drastically reduced transmission rates.

Public health campaigns encourage people to get tested for STIs

Moreover, since 2012, pre-exposure prophylaxis (PrEP) medicines have been available to some high-risk groups to protect them against contracting the virus. Taken together, this has led some HIV-positive men to ditch condoms.

A survey last year in Melbourne, Australia, of almost 3000 men who have sex with men found the proportion who always used a condom during casual sex dropped from 48 per cent in 2013 to 30 per cent in 2017. At the same time, PrEP use increased from 1 to 16 per cent.

Syphilis, gonorrhoea and chlamydia don't have the same fear-factor as HIV because they are bacterial infections that can be treated with antibiotics. However, many people don't get symptoms, so they don't know they are infected. Down the track, untreated infections can lead to pelvic inflammatory disease, infertility, ectopic pregnancy, arthritis and other health problems. It is estimated that chlamydia increases the risk of infertility by about 30 per cent, for instance.

More worryingly, bacterial STIs are starting to develop resistance to antibiotics. Gonorrhoea has developed the strongest resistance, and reports have already emerged of strains that don't respond to any available antibiotics.

JOEL CARILLET/GETTY

Time for sex ed

"If we run out of effective antibiotics and gonorrhoea continues to increase, we'll have a much bigger problem on our hands," says Guy.

The first step to reversing the climb in STI cases is education, says Field. This starts in school, but high-risk adults should also be targeted, he says: "For example, ads reminding people to use condoms and get tested could be built into dating apps."

There is clearly room for improvement here. A survey released by the health department of Queensland, Australia, last month found that 60 per cent of 15- to 29-year-olds incorrectly believed the contraceptive pill offered protection from STIs, while 52 per cent believed the withdrawal method did the same.

Personalised feedback could also work, says Melissa Lewis at the University of North Texas. Her research group recently used this approach to reduce risky sexual behaviours in young adults in the US.

They surveyed 1000 people aged 18 to 25 to find out how often they drank heavily, had casual sex and used condoms. Those at the riskier end of the spectrum were emailed personalised feedback showing how they compared with their peers. One month later, they reported adopting safer practices. "People don't like standing out from the pack," says Lewis.

Making STI testing easier and more accessible is also important, says Field. People often shy away from getting tested because they don't want to have an awkward chat with their doctor.

To get around this, researchers at the London School of Hygiene and Tropical Medicine recently sent text messages to 1000 people aged 16 to 30 with a link to an online provider of DIY testing kits. Those who signed up were posted a kit with instructions on how to collect their own samples. After mailing them back, they received their results within seven days.

The study found that 50 per cent of people who received this message completed the DIY test. In comparison, when 1000 other people were sent a text message with details of their local sexual health clinics, only 27 per cent went for a test.

For people who test positive, public health experts have also devised ways to take the cringe factor out of notifying former partners. Free online services like inSPOT, Let Them Know, and Don't Spread It now allow people to send anonymous emails or text messages to former sexual partners to recommend they get tested.

The ultimate aim, of course, is the development of vaccines that prevent people from catching STIs in the first place. But these are still a fair way off.

One of the most promising candidates is a chlamydia vaccine that is being tested in an initial clinical trial at Imperial College London after proving highly effective in mice. So far, the trial has found the vaccine to be safe in humans, but whether it prevents infection is still being evaluated.

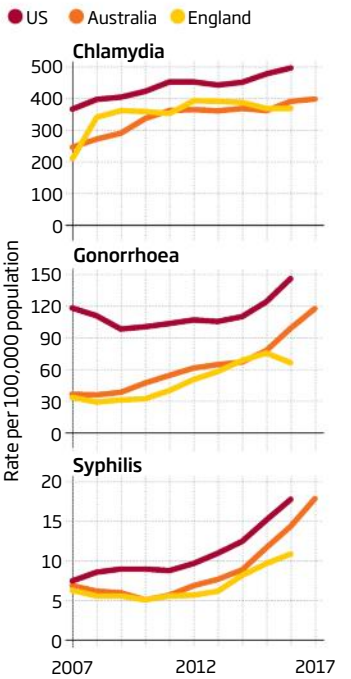
"It is estimated that chlamydia increases the risk of infertility by about 30 per cent"

No gonorrhoea-specific vaccines have made it to clinical trials yet, but a study published last year found that the meningococcal B vaccine offered surprising cross-protection against gonorrhoea. In 15,000 young people in New Zealand, the vaccine reduced gonorrhoea infections by 30 per cent. Syphilis vaccines are still in the preclinical testing stage, but several look promising in rabbits.

In the meantime, the focus remains on improving education and testing. The internet may be both a friend and foe – facilitating STI spread via dating apps, but also providing a platform for targeted awareness campaigns and anonymous testing and partner notification.

Until vaccines become available, the most important public health message is still the same as it was during the second world war, when posters urged soldiers to use condoms to protect them against STIs. Their advice? "Crossing your fingers won't prevent venereal disease, but a prophylaxis will". ■

STI rates have been climbing for the past decade



SOURCE: US CENTERS FOR DISEASE CONTROL/ PUBLIC HEALTH ENGLAND/ AUSTRALIAN GOVERNMENT DEPARTMENT OF HEALTH

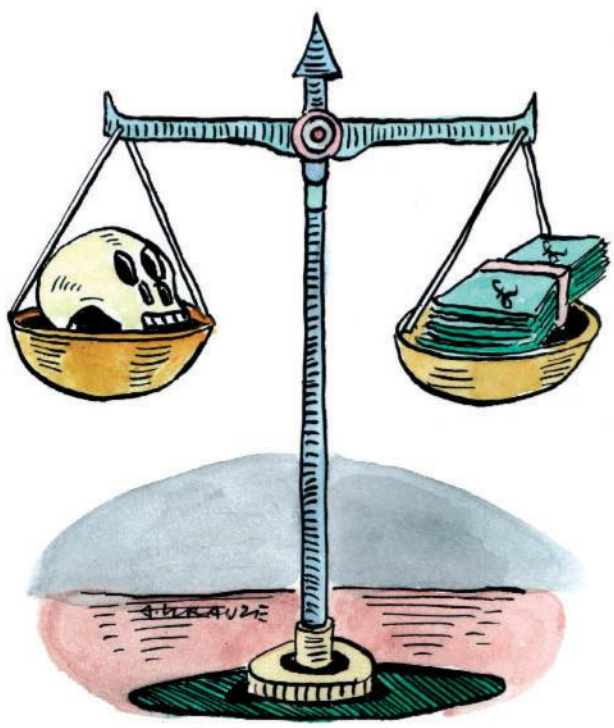
Spanish lessons please

We ignore the social factors that were at play in past flu pandemics at our peril, warns **Laura Spinney**

WITH hopes high that the northern hemisphere flu season is about to recede, it seems a good time to point out that, unlike annual outbreaks that fade as spring arrives, flu pandemics don't respect seasons. A hundred years ago, the worst such pandemic on record was just starting – the first case was recorded on 4 March 1918 – and north of the equator it wouldn't peak until the autumn.

In this centenary year of Spanish flu, a lot of ink has been spilled on the inevitability of another flu pandemic. One aspect that gets little attention, yet holds vital lessons, is that mortality in 1918 was massively skewed by social and economic inequality.

In poorer parts of Asia, you were 30 times more likely to die than in richer parts of North America or Europe. Even within wealthy cities, telling patterns emerged. In New York, death rates



were highest among immigrants. In Paris, the fact that the flu was most lethal in the wealthiest districts was puzzling, until it became clear who was dying – not property owners, but servants in cramped and draughty quarters.

Although inequality wasn't the only thing shaping death rates, it accounted for a significant part of the variability. The same was true in the 2009 flu pandemic. In England, the mortality rate in the poorest fifth of people was triple that among the most affluent.

Pandemic preparedness committees have yet to take such lessons into account. They still define vaccine priority groups using medical criteria such as pregnancy or age, not social ones.

The WHO, European Union and countries including the US know of the link between socio-economic status and health, and many nations have vowed to

In dust we trust

Coating farms with basalt could cool the planet – so let's try it, says **Olive Heffernan**

ONE geoengineering option has always seemed the sanest: enhanced weathering. No need for space mirrors to deflect sunlight or to risk food riots by using crops as fuel. Just scatter rock dust.

Common silicate minerals react with carbon dioxide, binding it in stable compounds that wash into the oceans. If silicates were crushed and spread widely, more CO_2 would bind faster, offsetting emissions. The CO_2 would be locked away forever, more or less, and the run-off is alkaline, so it would make the oceans less acidic.

But like many geoengineering ideas, this one has problems. Most propositions suggest dusting cropland and other surfaces with olivine-rich rock, because it weathers quickly and can capture a tonne of CO_2 per tonne of mineral. The olivine, however, would have to be mined on a vast scale. And as it weathers, it releases toxic metals that could get into the food chain.

Now researchers have laid out a vision for enhanced weathering with fewer drawbacks, by using basalt on cropland in place of olivine. It is less toxic, and richer in phosphorus, a plant promoter.

"There is growing interest in probing geoengineering options. Those in the know sense a need for plan B"

Although basalt has one-third of the carbon-capture potential of olivine, if it were applied at a rate of 10 to 30 tonnes per hectare a year to two-thirds of the world's most productive cropland, it could capture 0.5 to 4 gigatonnes of carbon per year by 2100. What's more, it could boost crop yields, cut fertiliser use, replace the soil additive limestone and be spread with existing farm equipment.

Still, it would take a lot of rock. One alternative is to get the mineral from industrial waste: basalt dust from construction and sugar-cane ash are candidates. Another is to use only the most productive cropland, where the

reduce it. There is an odd gap between this thinking and that of pandemic committees. They might argue that they can't address all of society's ills, but to ignore social disparities is to undermine a lot of what they do.

If a new pandemic flu hit Europe, it isn't hard to imagine where it would find the easiest pickings: the refugee camps of Italy, France and the Balkans. Being in such cramped and unsanitary places makes people sitting ducks. Flu would spread from there, and although the poor might die in larger numbers, the rich would not be spared.

What would taking social inequality into account mean for pandemic committees? Inviting social scientists, perhaps even a historian or two, to join them, and identifying social indicators that correlate best with pandemic vulnerability. Alongside biomedical indicators, these would guide vaccination priority and other public health measures.

More generally, it would mean recognising that a pandemic isn't a purely biological phenomenon – it is also a social one. ■

Laura Spinney is a science writer based in France and author of *Pale Rider: The Spanish flu of 1918 and how it changed the world* (Jonathan Cape)

effect is likely to be greatest. This land is, conveniently, in the most carbon-polluting places: China, India, Europe, the US and Russia.

There is a growing interest in exploring the pros and cons of geoengineering options. Those in the know sense the need to firm up plan B. What's needed is a field trial. In this case, a good site, with ready infrastructure, is the UK.

What's uplifting about this new idea is that it not only revives the possibility of this approach, but also offers hope for the efficacy of geoengineering more generally. ■

Olive Heffernan is an environment writer

INSIGHT Antidepressants

BJARTE RETTEDAL/GETTY

We still don't know if antidepressants work

Clare Wilson

ANTIDEPRESSANTS really do work, and should be taken by millions more people, claimed newspaper headlines last week. The reality is more nuanced.

The positive press was triggered by a study that found these medicines do have a small benefit, contradicting previous claims of ineffectiveness (*The Lancet*, doi.org/gcx763).

The work, by a respected group of researchers, reviewed over 500 trials of 21 different drugs, involving more than 100,000 people with depression. Media reports say the new findings should put the controversy to bed.

Let's not be too hasty. Previous studies found that antidepressants don't work in people with mild-to-moderate depression. Most of the people in the review had more severe depression. So it is good news for that group, but it doesn't resolve the controversy.

Mild depression is more common than the severe form, so we still don't know how much antidepressants help most people. Nor does the new study reveal how well they work for the other conditions they are often recommended for, such as anxiety.

Ineffectiveness is only one of the criticisms. Another is that people aren't properly warned about possible side effects, such as disabling agitation. There are even concerns that the drugs can trigger suicidal thoughts, although this is thought to be rare.

The latest study suggests the benefits of antidepressants outweigh the harms, because for most of the 21 medicines, drop-out rates were no higher in those taking the drugs than in those taking a placebo. This implies people felt the benefits were worth any side effects, say the authors.

"This study is good news for severe depression, but we don't know whether this is the case for milder forms"

There is a problem, however. Studies that analyse past trials, as this one does, can only be as good as the numbers fed in. Experience has shown that pharmaceutical firms can slice and dice their data to make the results look better than they really are.

For example, a 2001 study of the antidepressant paroxetine, not included in this recent review, showed similar side-effect rates in those taking the drug and a placebo. When independent researchers got their hands on all the data in 2015, however, they found paroxetine was linked with more self-harm and threats of suicide.

One source of confusion over such a widely used group of medicines is that antidepressants affect everyone differently. One of their most consistent psychological effects is described as a blunting of emotions. Some people dislike this, saying they feel like a zombie. Others find it helps relieve their low moods.

Such diverse reactions might explain why the popular debate can be so polarised. Arguments against antidepressants can verge on an ideological opposition to medical help – a dangerous stance when they can be a lifesaver.

On the other hand, some proponents say they are as crucial for treating depression as insulin is for people with diabetes. Yet the idea that antidepressants work by correcting a "chemical imbalance" in the brain has been largely discredited.

If you have a personal stake in these questions, it must be frustrating that almost every month the pendulum of opinion seems to swing back and forth. As is often the case in science, the reality may lie in between. ■

Need a listening ear? UK Samaritans: 116123 (samaritans.org). Visit bit.ly/SuicideHelplines for other countries

American dumpster

BEHOLD the bald eagle: national animal of the United States, featured on the seal of the president, where it clutches 13 arrows and an olive branch; a bird sacred to many Native American cultures. Here it takes the role of dumpster diver, scavenging rotten meat from an Alaskan supermarket.

Fisher and photographer Corey Arnold took the image in Dutch Harbor, an isolated island town in the Bering Sea. Its population is about 4700 humans, 500 to 800 eagles. Local people call the birds Dutch Harbor pigeons. It's quite a comedown for such a magnificent animal.

These predators, with wingspans of up to 2.3 metres, are opportunists. Fish make up by far the largest proportion of their prey, followed by other waterbirds, such as geese. But they also scavenge carrion and, particularly in Alaska, like to frequent garbage dumps.

Arnold, based in Portland, Oregon, began to fish seasonally to earn money as a teenager. A few years later, he started photographing the things he saw at sea. Now he is a professional photographer with his own salmon boat for summer fishing. This image has been nominated for a 2018 World Press Photo award.

Rowan Hooper

Photographer
Corey Arnold
coreyfishes.com

NICKKONT/PANIMONI/SHUTTERSTOCK

The ugly truth

Physicists have long believed the universe must be beautiful. What if they're wrong, asks **Daniel Cossins**

PAUL DIRAC wanted to be seduced, and he wasn't afraid to admit it. In a 1963 essay recalling his role in discovering the strange-but-true laws of quantum theory, he wrote "it is more important to have beauty in one's equations than to have them fit experiment". That might sound odd. Experiment, after all, is the ultimate arbiter of an equation's ability to explain natural phenomena. But for a theoretical physicist like Dirac, experiments could be misled: only beauty was incorruptible.

An almost religious devotion to beauty remains commonplace among theorists of fundamental physics, even if the standards of attractiveness have changed over time. One vision of elegance in particular has surged to the fore: the principle of naturalness. Broadly speaking, it is the belief that the laws of nature ought to be sublime, inevitable and self-contained, as opposed to makeshift and arbitrary.

But what if they aren't? That's the disquieting possibility being entertained by a growing band of physicists in the aftermath of what should have been the breakthrough discovery of the decade, the snaring of the Higgs boson in 2012. The discovery of the Higgs, at CERN's Large Hadron Collider (LHC) near Geneva, Switzerland, confirmed a long-held theory about how particles acquire mass. But what we have – and haven't – found alongside it could have profound consequences for how we view reality, says Michael Dine, a theorist at the University of California, Santa Cruz. "We might find that nature is not natural in the way we thought."

Even among particle hunters, the word "natural" has a few different meanings. At its broadest, it encapsulates the notion that the universe ought to be plausible, rather than the extraordinarily improbable outcome of some cosmic roulette wheel. "Naturalness is the belief that it's not all coincidental, that there is a reason behind things," says Ben Allanach, a theorist at the University of Cambridge. "It's the idea that it can't just be chance."

That might sound a tad vague, but theorists have a more precise working definition, known as "technical naturalness". Formulated in the early 1980s by Gerard 't Hooft at the University of Utrecht in the Netherlands, it was designed to flag up any sign the universe's existence might depend on unattractive hidden coincidences. In simplified terms, this boiled down to saying that theories or models should not contain constants whose values differ too much from one another. Unless some larger, more comprehensive theory can justify a disparity, none of the numbers that dictate how the universe behaves should be more than a factor of 10 apart.

The goods aren't odd

This makes physicists suspicious of numbers that don't fit in. Think of it this way: if your hundredth consecutive spin of a roulette wheel landed on the same number, it would challenge even your most broad-minded assumptions of fair play. It is just so ridiculously unlikely that it begs for explanation. Maybe there's a magnet in the ball, or a tiny invisible string? The same logic applies to forces that are unusually weak or strong, or particles with a mass that is stubbornly high or low: something else must be going on.

To some extent, modern physics has always proceeded along these lines, seeking ever more streamlined explanations for an ever more complicated universe. Lately, though, particle physics has barely proceeded at all. True, the so-called standard model of particle physics is successful, capable of describing all known particles and three of the four fundamental forces in a compact set of equations. But it says nothing about gravity or dark matter, suggesting that something even bigger is waiting to replace it.

What's more, we might be guilty of looking at the standard model through rose-tinted glasses. While its equations are mostly natural, there are a couple of awkward exceptions. The energy density of empty space, known as the cosmological constant, is 120 orders of magnitude lower than we would expect. And then there's the Higgs. Its own mass, it turns out, is almost unbearably light. "It seems that nature does not, or at least not quite, follow my recommendations," says 't Hooft.

To fulfil its function as the universe's mass-giver, the Higgs is supposed to interact with every other particle in existence via its associated Higgs field. That's a complicated process, and one that should bestow the Higgs with some mass: about 10^{-8} kilograms or, in the units particle physicists use, about 10^{19} gigaelectronvolts (GeV). That's enormously heavy in particle terms. So why, when we measure it, does the Higgs come out as such a featherweight – with barely 125 GeV to its name? One outlandish option is that its inherent mass is an enormous negative number, just enough to cancel out the additional mass provided by the interactions and leave behind 125 GeV. But that poses an unnaturalness problem of its own: why should two huge, apparently unrelated numbers cancel out so neatly? ›

"Naturalness is a cognitive bias – one that physics would do well to eliminate"

The answer is to make those numbers related. The prime candidate to restore the Higgs to its natural state is supersymmetry, or SUSY, an overarching theory that introduces a heavy twin for every known particle. The addition of these superparticles or "sparticles" would drive the Higgs mass down exactly as much as the known particles drive it up, rounding out the equations and returning the Higgs to a mass that qualifies as technically natural. SUSY is also mathematically elegant, in that it could unify three of the fundamental forces while simultaneously explaining dark matter, the mysterious stuff thought to hold galaxies together.

Looking for sparticles

Faced with such a good-looking multitasker, most physicists were convinced that SUSY would do the trick. They expected that sparticles would soon show up at energy scales just beyond the Higgs, and physics would roll victoriously on. Lovely. Only it didn't work out like that. In fact, searches for these new particles at three generations of accelerators, including the mighty LHC, have come up empty-handed.

Of course, the particles might still be lurking out there. The LHC's last-ditch search is due to finish at the end of 2018, but with the collider's latest run shining a light into the darkest corners of their suspected habitat, we are rapidly running out of places to look. That means we are stuck, unless we revisit the logic that led us to dream up these superpartners in the first place. "Supersymmetry predicts particles that the LHC should be able to see, and that's what is making me suspicious that we've got the wrong end of the stick when it comes to naturalness," says Allanach. "I'm not yet convinced we have… but I'm suspicious."

Indeed, more and more physicists are beginning to waver, even those who have spent their entire careers wedded to the principle. Gian Giudice, head of theory at CERN, recently conceded that naturalness "may not be the right tool to make further progress". In an essay posted online last year, he even went so far as to describe the current situation as a "turning point" in theoretical physics.

For Sabine Hossenfelder, a theorist at the Frankfurt Institute for Advanced Study in Germany, there is only one way to turn – away from naturalness. In her upcoming book *Lost in Math: How beauty leads physics astray*, she questions not only its usefulness, but its logical consistency. Naturalness says that, like the rigged roulette wheel, the Higgs mass is highly improbable. But with the wheel, we have a lifetime of experience that tells us how unlikely it is for the same outcome to recur repeatedly – what physicists call a probability distribution. We only have one universe, says Hossenfelder, so there is nothing to compare it with.

Why, then, is naturalness so widely revered? "Personally, I think it's a cognitive bias," says Hossenfelder – one that physics would do well to eliminate.

But not everyone is so keen to embrace the ugly-verse. For one thing, renouncing beauty as a guiding principle skirts dangerously close to embracing the circular logic of the anthropic principle, which says the universe has the properties it does because it is the one we live in and think about. For many, that is the ultimate cop-out. "The problem with the anthropic argument is that it is a retreat from scientific enquiry," says Allanach. "It is accepting that we'll basically never know."

Hossenfelder argues that abandoning technical naturalness does not necessarily lead us down the anthropic road to scientific paralysis. "There is nothing wrong with saying your constant has this value, period," she says.

Most theorists aren't ready to give up on naturalness just yet, though. Allanach, for example, says that while he has seen his colleagues express frustration at the lack of evidence for supersymmetry, he does not get the impression that the field is somehow in revolt against naturalness as a guiding principle. In fact some, like Dine, still hold out hope that SUSY particles could exist at higher energy scales than predicted – higher, perhaps, than any collider can reach.

But for those pining after naturalness who have fallen out of love with SUSY, an alternative theory has emerged to console them. Rather than seeking a natural explanation for the Higgs mass by invoking scores of new particles, it goes one better: invoking billions of alternative universes.

The proposed existence of such a multiverse is nothing new. Cosmologists have long

A natural universe builds complexity from simple laws

ILONA WELLMANN/MILLENNIUM IMAGES, UK

suggested that in the moments after the big bang, the exponential ballooning of the universe wound up producing regions so far removed from one another as to qualify as separate universes. The exact number of them remains unknown, but could rank as high as 10^{500}, each with its own unique physical properties.

There is of course no evidence that such a landscape exists, never mind how many universes it contains or what properties they have. Even so, the existence of a vast number of possible configurations could represent the probability distribution that critics like Hossenfelder accuse naturalness advocates of needing. While the vast majority of these universes might well have a Higgs with a more reasonable mass, we could simply be stuck in a statistical outlier. "The only real model for why these numbers like the Higgs mass and the cosmological constant are so strange is this landscape model," says Dine.

That might seem to lead us back to the anthropic cul-de-sac: perhaps, among all these many different universes, we are in the only one with a Higgs that is light enough to support the structures that ultimately give rise to life and to humans to ponder such matters. But most theorists want something stronger. They want a mechanism that guarantees the Higgs would wind up looking the way it does in our cosmic neighbourhood. And while the landscape might not be the ultimate answer, it could be a step in the right direction. "It gives me some hope that we'll find our way to a rational explanation," says Dine.

In fact, some believe we could already have found it. Rather than conjuring up billions of particles in billions of alternate universes, what if all these alternative Higgs bosons had existed in our very own universe, and some hidden process selected the one we see today? That's essentially what a team led by Nima Arkani-Hamed at the Institute for Advanced Study in Princeton, New Jersey, has proposed with their theory of *N*naturalness. It introduces *N* copies of the standard model, where *N* is a large number, that exist simultaneously in the same universe. These copies would all be identical apart from the Higgs mass, which of course influences the masses of all other particles in each copy.

Justifying our existence

Then something must have selected for the copy with the light Higgs we see today. According to Arkani-Hamed and colleagues, it could come down to hypothetical particles called reheatons, which contained all the energy of the early universe. Too energetic to exist for long, the reheatons would eventually have decayed into particles lighter than themselves, including any low-mass Higgs, thereby regifting energy to the universe. As the Higgs mass we see is just about as light as it's possible for a Higgs to get, particle families such as ours would have been preferentially chosen.

"The reheating process in the early universe chooses that standard model out of all other copies," says David Pinner at Princeton University, who was one of Arkani-Hamed's collaborators on the theory. Evidence of this selection process could be detectable in the afterglow of the big bang, he adds, using future telescopes.

If you think this looks suspiciously similar to the sort of improbable fine-tunings and cancellations that naturalness is supposed to guide us away from, you are not alone. "Some of these explanations get ridiculously complicated, much more so than simply putting in a constant and accepting it for what it is," says Hossenfelder. "They almost look like religious explanations where you introduce angels you can't observe."

At the end of the day, naturalness, like beauty, is in the eye of the beholder; one person's simple solution is another's rococo monstrosity. But like Dirac, most theorists still want to be seduced. If this means they must update their visions of beauty to suit changing times, or even abandon them altogether, then so be it. "The deepest breakthroughs in physics took place when a contradiction forced researchers to re-evaluate their assumptions," says Nathan Seiberg at the Institute for Advanced Studies. "The problems with naturalness should be viewed as an opportunity rather than a reason to quit." ■

"They almost look like religious explanations, introducing angels you can't observe"

Daniel Cossins is a feature editor at *New Scientist*

Growing skills

Which gardening tips are worth the effort? **Penny Sarchet** prunes back some of horticulture's hardiest myths

MIKE HARRINGTON/GETTY

Potty

THEY SAY:

Improve water drainage by covering holes at the bottom of pots with broken pot shards and a layer of gravel

The advice, which may even be on the label your plant came with, makes intuitive sense. But it disobeys the laws of physics. Following it could end up waterlogging the soil and suffocating your plant's roots.

It all comes down to water's surface tension. "Water is held up in narrow spaces with a strength that is inversely dependent on the width of the space," says Martin Chaplin of London South Bank University. As a result, it will not move easily from the narrow spaces between dirt particles to the wider ones that separate gravel.

Only once the soil layer becomes nearly saturated will water flow into the coarser gravel layer, says Stephen Neethling at Imperial College London. At that point, having a gravel layer will indeed offer more routes for water to escape than a single hole at the bottom of the pot. But it is probably best not to waterlog your pots in the first place.

If you have been covering the holes with shards to stop earth falling out, try using pieces of nylon or mesh instead.

Squashed together

THEY SAY:

Don't grow melons and squash next to each other because they can generate hybrids

Some members of the melon family (cucurbits) do cross-pollinate, but this is rarely a problem. You needn't worry about plants that belong to different species, like honeydews and cucumbers. But pumpkins, courgettes, gourds and some other squashes all belong to the same species. A bee could pollinate one with the pollen from another.

Despite this, you will still get the fruit of the mother plant. If courgette pollen fertilises a pumpkin flower, for example, you will get a pumpkin. You will only end up with weird hybrids if you collect the resulting seeds and plant them the following year, or if one falls on the ground and self-propagates.

Decorative gourds have become pretty fashionable, so you may not mind a hybrid or two. And none of this matters if you buy new seeds each year. If, however, you are collecting seeds from your prize cucurbits and want to protect their genetic heritage, you probably shouldn't grow different varieties within a kilometre of each other.

Mad plants and Englishmen

THEY SAY:

Water droplets left on leaves can magnify the rays of the midday sun, burning the plant

This advice probably only holds true in very specific circumstances and depends on how hairy your plant's leaves are, according to Gábor Horváth of Eötvös Loránd University in Hungary.

In experiments with maple leaves, Horváth and his team found it was impossible to burn them using water and sunlight. In part, this was because water droplets cool a leaf's surface on contact, making it harder to scorch. What's more, the sun's rays have to be at just the right angle to focus through a droplet onto a leaf. The team calculated that the burn risk would be greatest in the early morning or late afternoon. But

"If a plant is starting to wilt, don't wait. Terminal wilt could set in"

sunlight at these times is too weak to cause damage. Finally, the odds of a drop being held perfectly still on a smooth leaf for long enough are slim at any time of day.

The situation was different with hairy leaves. Hairs can hold water drops above the leaf surface, so they don't touch and cool it. The team found that if a droplet sat at just the right height, the midday sun could sometimes burn a floating fern leaf.

Even though the risk is small, you should still avoid watering in the middle of the day. It's a waste: much of the water will evaporate. Watering in the morning is best. It is less likely to encourage fungal infections than watering in the evening, when leaves stay wet for longer. But if a plant is starting to wilt, don't wait, regardless of the time of day. Terminal wilt could set in, and then it is too late.

A lot at stake

THEY SAY:

Stake a newly planted tree or shrub to protect it from gusts of wind that can tear the roots before they become established

Here's the rub: wind helps saplings become strong. "Wind stress encourages root growth and trunk thickening," says Linda Chalker-Scott at Washington State University. As the trunk flexes, the disturbance triggers a process called thigmomorphogenesis. This has been linked to a suite of chemical changes within plants. They switch on genes that help thicken cell walls and lay down lignin, a strong woody polymer. All this hardens the stem, which then sends signals down to the roots, telling them to boost their growth so the plant can brace against the wind.

The end result is shorter and stockier plants. The process also restricts the growth of branches and leaves, so the trunk and roots can better support their weight. Trees that are staked too tightly or for too long grow taller and thinner, and are more likely to snap or be uprooted once the stake is removed. The same applies to just about any plant – even veg like broccoli.

"My suggestion is to wait for a day or two and see how [a sapling] does," says Chalker-Scott. "If it starts to lean, then you can go back and stake it." There are a couple of exceptions. Providing support makes sense if your garden is exposed to constant strong winds, for instance if you live on a windy coastline. In that case, it is best to use a stake no more than two-thirds of the sapling's height and to attach it loosely using a flexible tie so the whole trunk can sway a bit. If you use wire, run it through rubber hosing first to avoid damaging the bark.

Flowers are another exception. We have bred ornamental plants to produce large, flamboyant blooms, often without also selecting for a strong plant structure to support them. If you are a fan of heavy flowers such as peonies, delphiniums or stocks, you will probably want to stake them up while they are in bloom purely for the sake of your display.

Partners in grime

THEY SAY:

Choose your mix of plants correctly so they encourage each other's growth and keep pests at bay

GAP PHOTOS/LEIGH CLAPP

Nasturtiums are said to be a sacrificial plant, protecting beans from aphids and cabbages from cabbage white caterpillars; mint may deter some beetles, flies and aphids from damaging a range of vegetables and roses; French marigolds have a pungent odour that is supposed to keep whitefly away from tomatoes… Sadly, these pairings are a charming idea with very little evidence to back them up.

Decades of research have thrown up conflicting results. Back in 1979, a study of cabbage pests found that pennyroyal, garden nasturtiums, peppermint and French marigolds made no difference. Other studies have suggested that peppermint and African marigolds offer some protection against onion fly and cabbage root fly. Contrary to folklore, a comparison of many companion plants found that this isn't because of their smell. Instead, pests appear to lay fewer eggs on their target hosts if they are distracted by other plants.

The roots of African and French marigolds release chemicals that may suppress some nematode pests. But effects vary and the same marigold could deter some of the pests and boost others. There are 15,000 species of nematodes out there, so it is unlikely that you will know exactly which species is a problem in your garden.

In the end, it's all a bit fuzzy. Companion planting may work, but is probably just too complicated to put into practice.

Purple patch

THEY SAY:

If your prize hydrangea won't turn blue, try using vinegar or coffee grounds to acidify the soil

KRISZTINA KOVACS/EYEEM/GETTY

Hydrangea blooms are touted as a litmus test for soil pH: blue means the soil is quite acidic, pink means the pH is 5.5 or higher. But it's not that simple. Most hydrangeas have white blooms that go green or pink as the plants age, regardless of the pH. And only two species – French hydrangea (*Hydrangea macrophylla*) and mountain hydrangea (*H. serrata*) – change colour depending on their soil.

The switch is due to a single pigment whose hue depends on its chemical structure. Aluminium ions from the soil bind to the pigment, changing its colour. Having few or no aluminium ions gives pink flowers, having a lot of them yields blue ones, and being somewhere in the middle turns your hydrangea purple. But even when there is plenty of aluminium, the flowers may still be pink or purple. This is where pH comes in: aluminium ions are more freely available and easier for plants to absorb in acidic soils.

If you are desperate for blue blooms, your best bet is to buy a solution of aluminium sulphate. The sulphate will acidify the soil, ensuring the aluminium ions can get into the plant. Watch out though: too much aluminium will poison the hydrangea and potentially its neighbours too. Lime (calcium hydroxide) will decrease the acidity of the soil, so can make your hydrangeas pinker. And always remember that colour changes usually take a growing season or two to show up.

> "Most hydrangeas have white blooms that change with age, not pH"

Chop chop!

THEY SAY:

If you want more flowers and less plant, cut back your late-flowering perennials in late spring

This one's a winner. Halving the size of plants such as sedum, rudbeckia, echinacea and helenium in late spring is known as the Chelsea chop, after the Royal Horticultural Society's annual Chelsea Flower Show in London. The aim is to get more flowers in one season. It works because it stops apical dominance – when hormones produced by the growing tips of a plant stop side-shoots forming. Cut the growing tips and you will get bushier plants with more opportunities for flower buds.

A daff idea

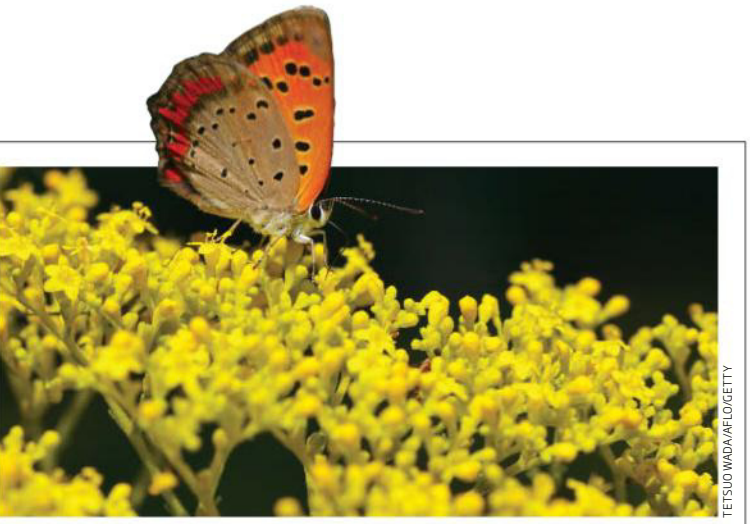
THEY SAY:

Tidy up your daffodils by tying up their large leaves after they flower

Leaving daffodil leaves in place after their big show is over is a must: they will carry on photosynthesising and storing energy in the bulb. Tying them in knots may look tidier but it's a bad idea. It damages the leaves and hampers photosynthesis. The result may be an inferior display the following year.

Instead, just cut off fading flowers, which stops the plant from putting too much energy into producing seed.

D. HURST / ALAMY STOCK PHOTO



TETSUO WADA/AFLO/GETTY

4 WAYS YOUR ECO-FRIENDLY GARDEN MAY BE HARMFUL... AND HOW TO FIX IT

1

If you don't use pesticides you may think your garden is organic. But plants you bought from a garden centre probably contain chemicals that were used in the nursery that grew them. One study found this is even true if they are labelled "pollinator-friendly". Of 29 such plants, two were uncontaminated. More than 70 per cent had been treated with neonicotinoid insecticides, which are strongly suspected of being bad for bees. The researchers say that gardeners who don't want to put pollinators at risk should buy plants at organic nurseries or grow them from seed instead.

2

Take a moment before you plant a mix of generic wild-flower seeds in your garden. If you live in or near a natural area and the seed mix you use is from elsewhere, your "wild" flowers may escape and compete or hybridise with local wild populations. This may also be a risk in urban areas, where regional plants must work extra hard to survive. Competition from non-local seed mixes could be one challenge too many. Native wild flowers are, by nature, opportunistic and resilient. Set aside a patch for them, and they will grow there on their own – they just may not be the colourful mix you were hoping for.

3

Think that your prize-winning roses and dahlias are good for local wildlife? Sadly not. Many ornamental flowers are double ones: they have genetic mutations that replace their sexual organs with extra petals. As such, they don't produce as much pollen, and extra petals can confuse pollinators looking for nectar. Hawthorns, Japanese anemones, clematis and hollyhocks are all good for bees in their natural form, but have pollinator-unfriendly double cultivars. To help pollinators, it is best to stick with single dahlias and dog roses, and avoid plant varieties with "flore pleno" (full flower) in their name.

4

Not all plants that make nectar or pollen are good for bees – many are toxic. When bees take nectar from oleanders back to their hive, the toxins in it become more concentrated as it dries and can wipe out a whole colony. Rhododendron nectar is so toxic for bees that beekeepers tend to keep hives closed during their flowering season. Honey made from rhododendrons is even unsafe for us to eat. A quick online search should tell you which plants will offer a nutritious meal for bees and which are a poisoned chalice.

MAARIGARD/DORLING KINDERSLEY/GETTY IMAGES

Suckers on the vine

THEY SAY:

Pinch out side shoots for a good tomato crop

This depends on which of the two types of tomato plant you have: determinate or indeterminate.

All plants grow thanks to dome-shaped bundles of cells called meristems that make new tissue. The main shoot of a determinate tomato plant doesn't grow upwards indefinitely. After a while, its meristem switches into reproductive mode, makes a flower, and the plant sends out a limited number of side-shoots – called suckers. They grow from the inside of branches, usually at a 45-degree angle. You can leave them be in determinate plants. They shouldn't become too numerous or reduce your crop.

But in indeterminate tomato plants, the main shoot's meristem never makes a flower. Instead, the shoot just carries on growing and the plant keeps sending out new suckers. Indeterminate plants are good for trellising but they can become large and unmanageable, so you may want to prune off the meristem from the top of the main stem and remove some suckers.

Just how many you should remove comes down to a delicate balance. The more suckers your plant has, the more opportunities it will have to flower and make fruit. But all this growth can use a lot of energy, which may mean you get smaller tomatoes. Having said that, if it has more leaves, it should be able to make more energy by photosynthesis, so it may be able to compensate.

The best advice is to prune bit by bit, and observe the effects. Over the years, you will get a feel for how many suckers you will need to remove to get the right balance between the number of tomatoes and their size.

Dodgy grounds

THEY SAY:

Dump coffee grounds in the garden to fertilise your plants and cut waste

Spent coffee grounds generally contain a lot of nitrogen, which is why some people believe they make great fertiliser. It's a hipster match made in heaven. To test it, Sarah Hardgrove and Stephen Livesley at the University of Melbourne grew broccoli, leeks, radishes, violas and sunflowers in soil that contained fertiliser, spent coffee grounds or both. All their plants grew less well with the coffee grounds. Other studies suggest caffeine and polyphenols in the grounds may be toxic to plants in high concentrations.

If you are dead set on recycling your grounds, it might be a better idea to compost them. This should make the most of the nitrogen they contain, while lowering the concentration of harmful chemicals. That is unproven though, so it may not be worth the risk.

And finally . . . your happy place

THEY SAY:

Gardening makes you more cheerful and healthier

Yep. For starters, gardens practically make you younger. A 2003 study in the Netherlands found that having 10 per cent more green space in your surroundings brings health improvements roughly equivalent to being five years younger, even when other possible influences like socio-economic status are taken into account. Several studies have found that people who tend allotments are healthier and have higher self-esteem and well-being, and that each session on their plot is linked to a decrease in the level of the stress hormone cortisol.

So there's even more reason to get outside and get growing. ■

Penny Sarchet is *New Scientist*'s deputy news editor

INFINITY AND BEYOND

Your ultimate guide to mathematics

Zero, infinity, wonder numbers, probability and statistics, symmetry and reality, computational complexity, maths and your brain, and much more.

Buy your copy from all good magazine retailers or digitally.
Find out more at **newscientist.com/thecollection**

NewScientist

S.O.S.
Save Our Secrets

Quantum computers will make mincemeat of our strongest encryption – is there any way to outsmart them, asks Michael Brooks

THE online message board is littered with enigmatic statements. "The DME system does not reach the claimed level of security," says one. "We looked at the EdonK KEM and found an attack," declares another.

If that sounds vaguely ominous, think again – it is even worse than it seems. The message board is a blow-by-blow account of an ongoing battle between humans and machines. At stake is nothing less than the cybersecurity that underpins modern society. If we lose, then everything from our WhatsApp chats and medical records to government secrets will be wide open to attack. Nothing will be safe.

The danger lies in the fact that, before long, someone will build a quantum computer that can crack our most powerful encryption methods – the mathematical tricks that turn data into unreadable secret code to hide it from prying eyes. The only way to defend ourselves is to build codes that even the most powerful machines conceivable cannot crack. Which is exactly why some of the world's smartest mathematicians have been attempting to invent a whole new class of encryption algorithms.

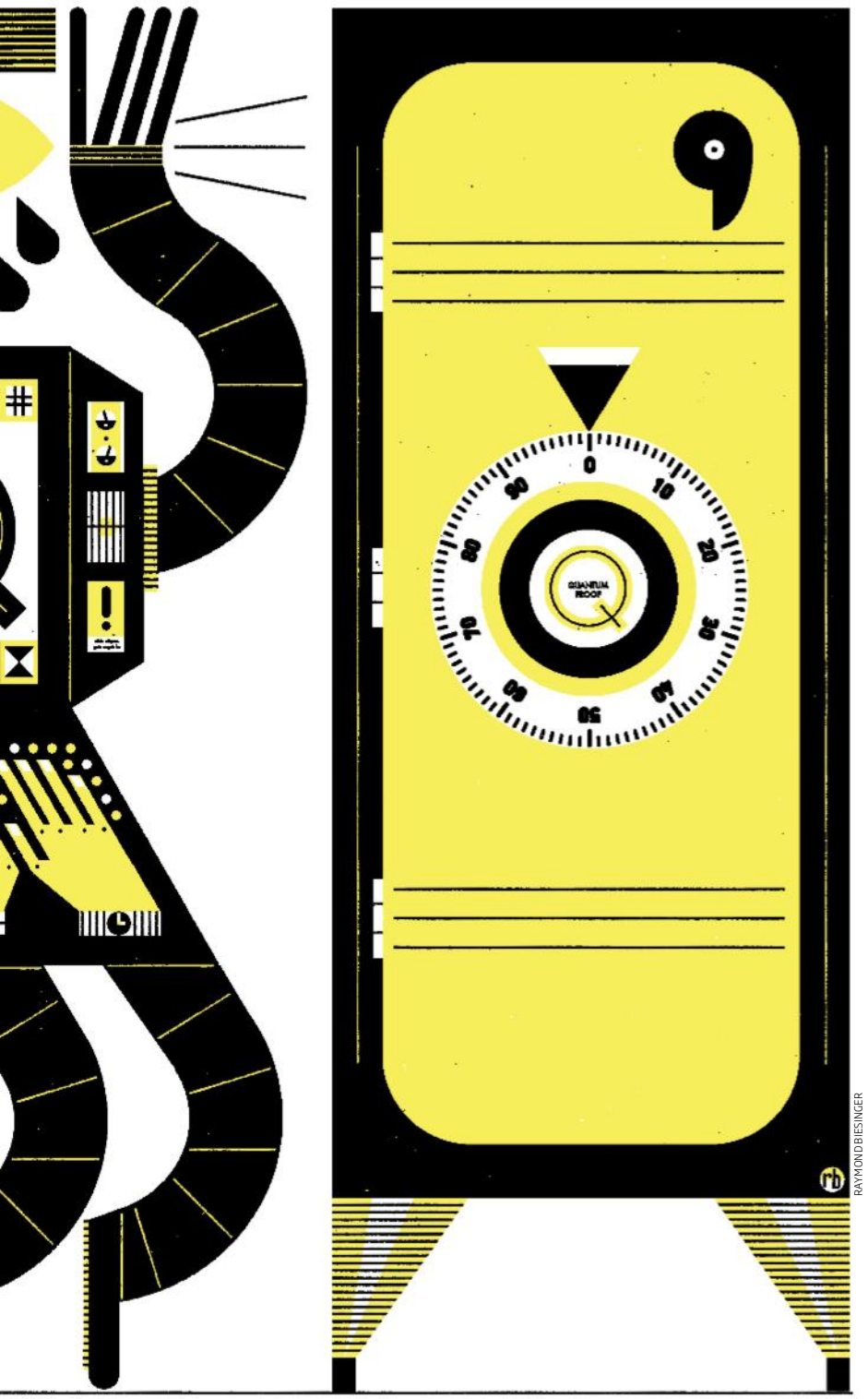
Having submitted their best designs to the post-quantum cryptography group at the National Institute of Standards and Technology (NIST) in Maryland, scores of teams are now engaged in a global race to identify the most secure by trying everything they can think of to crack each other's codes. If we find an algorithm that survives every attack, it will emerge as the 21st-century's gold-standard digital padlock. But for all the competitors, an almost existential question lingers at the backs of their minds: is it even possible to outsmart a quantum computer?

Encryption is as old as civilisation. Although the techniques have moved on over the centuries, the core idea remains unchanged: convert plain text into some sort of code that only you and your confidantes can decipher. These days, the most widely-used digital encryption schemes, or cryptosystems,

"There's a 50:50 chance all our secrets will be exposed before we can secure them"

are based on a mathematical "trapdoor": a function that is easy to calculate, but extremely difficult – impossible, ideally – to reverse without a cryptographic "key".

Take the RSA cryptosystem, for example. We rely on it to protect vast reams of data, from credit card details online to state secrets, and it is based on a trapdoor known as factoring. This involves a large number that is made public and two secret prime numbers that multiply together to produce it. Anyone can make a secret message using the public number, but only those who know the two smaller numbers can then read it. If you're not in the know, the only way to break this



RAYMOND BIESINGER

encryption is to pick a pair of numbers, multiply them together and see if the result matches your target. If it doesn't, you pick another pair and try again – and again, and again. The sheer laboriousness of the process is what makes the RSA cryptosystem secure.

The exercise is akin to translating a text from an obscure language such as Volapük – devised by a German cleric in the 19th century – to English, says Miklos Santha, a computer scientist at the Centre for Quantum Technologies at the National University of Singapore and an entrant to the NIST competition. "Having a Volapük-English dictionary makes this task relatively easy," he says. "But if we only have an English-Volapük dictionary, even though the information is in there somewhere, the translation will take a lot more time."

Ahead of the curve

Elliptic curve codes, another trapdoor scheme currently in use, are a little more abstract. Here you start with an equation that will create a particular kind of curve when plotted on a graph. The encryption capacity comes from having a series of simple operations that describe movement between points on the curve. If you know only the starting point and the final point, it is extremely difficult to work out what moves happened in between.

Cryptosystems based on factorisation and elliptic curves do the job – for now. The problem will come when we build computers that use the strange laws of quantum physics to bring an exponential leap in processing power. The first proper quantum computer is not yet up and running, but progress in recent years has been swift enough to persuade against complacency. And already there is a technique, known as Shor's algorithm after its creator, the MIT mathematician Peter Shor, that would allow quantum computers to unleash their power on factorisation problems.

No one knows how long it will be before we see a computer with enough qubits, or quantum bits, to make use of Shor's algorithm. But Michele Mosca of the Institute for Quantum Computing in Waterloo, Canada, has estimated the odds. He reckons there's a 1 in 6 chance that a quantum computer will be able to break RSA and elliptic curve cryptosystems by 2027, and a 1 in 2 chance ›

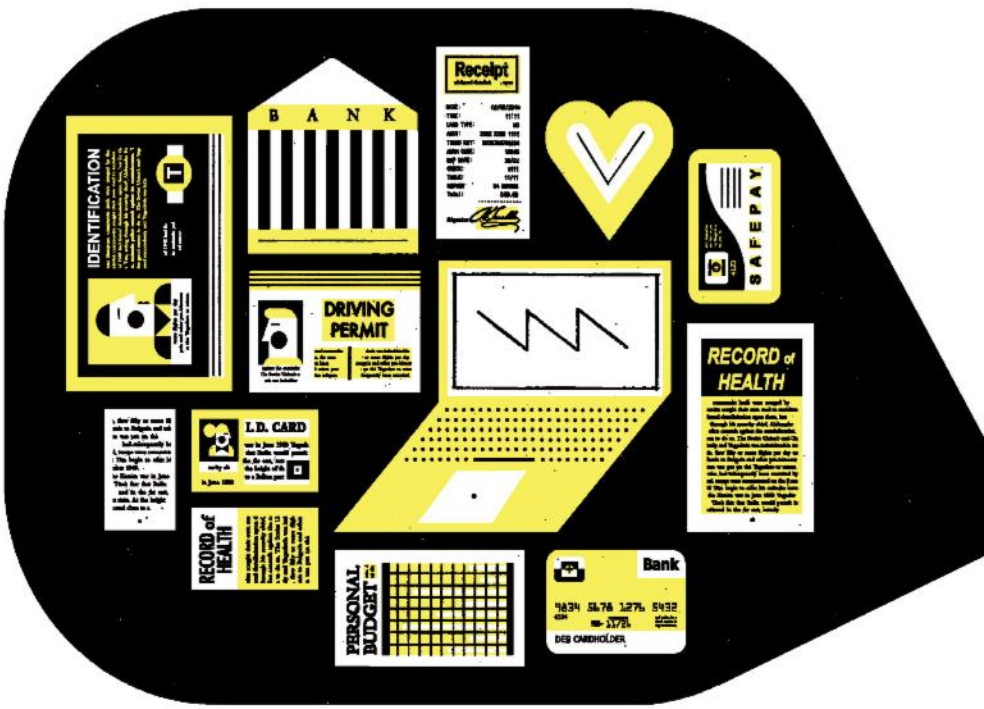
this will happen by 2031. If he is right, there is at least a 50:50 chance that all our secrets will be exposed before the new standard is established (see "The waiting game", right). All of this has moved the US National Security Agency to admit that it "must act now".

But how? How can anyone expect to design a quantum-computer-proof cryptosystem if we don't yet have a fully functional quantum computer to put it through its paces? Well, we already have a good idea of what these machines will be capable of, so the solution is simple enough to state: you build an algorithm based on mathematics so fiendishly

"The rivals are meeting to pick over the carnage from their attempts at sabotage"

complicated that even a top-notch quantum computer couldn't break it.

Broadly speaking, that will involve one of three strategies. The first, called code-based cryptography, is derived from the tricks that prevent errors creeping into our digital data. All computer systems contain a certain amount of noise, from heat or stray electrical signals, and once in a while this can flip a binary digit from 1 to 0 or vice versa. Error-correcting codes are designed to spot such anomalous flips, and reverse them. Cryptosystems based on such codes, on the other hand, deliberately put errors in – preferably enough to obscure the message. "If you know how it was constructed, you can remove the errors. But someone who doesn't have that secret key can't decrypt the message," says Dustin Moody, a mathematician in NIST's post-quantum cryptography group.



There are also lattice-based cryptosystems, based on navigating through a multidimensional arrangement of points. The security comes from something akin to knowing the shortest route between A and B.

Then there is the multivariate approach, which entrusts its secrets to some of the basics of algebra. It uses equations called quadratic functions, but with lots of different variables. "It turns out that it's really quick to evaluate a quadratic function if you stick in numbers for the variables," says Moody. "However, if someone gives you the answer but doesn't tell you the secret input, it's hard to work backwards and figure out what the input was." That's why the HFEv-signature protocol, which is a multivariate-based cryptosystem, has been unbreakable since its creation in 1996.

We already know – as far as is possible – that these schemes potentially offer quantum-proof encryption because there are only a handful of ways in which a quantum computer can attack the underlying maths, and none of these methods can crack these new schemes. The trouble is that building a working cryptosystem from these mathematical tricks is maddeningly difficult.

As if the maths isn't tricky enough already, it has to be implemented in ways that don't inadvertently introduce weaknesses – bugs that can render the algorithm vulnerable even to classical computers. "Quantum-proof is not the only measure: the classical security is also extremely important," says Lily Chen, a project leader in NIST's cryptographic technology group.

Mike Hamburg, a senior security engineer

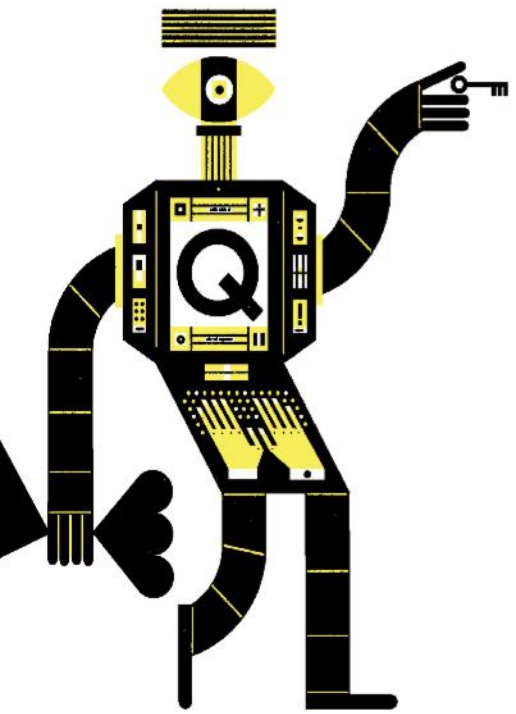
QUANTUM VS QUANTUM

We already have a brand of cryptography that's safe from the threat of quantum computers – it's called quantum cryptography. Alas, there's a catch.

This method ensures that no one eavesdrops on the process of exchanging a cryptographic key, the string of digital bits used to decode an encrypted message. The digits of the key are encoded in pairs of particles called photons. These photons are then entangled, establishing a quantum link between them. This means that any eavesdropper will disturb the entanglement, leaving a clear trace of their snooping. The idea has already been used to secure communications during a 2007 election in Switzerland, and a number of commercial systems are available. Sorted then?

Alas, practical implementations of quantum cryptography are still difficult, and often leaky. Vadim Makarov at the University of Waterloo, Canada, has demonstrated several hacks exploiting weaknesses that emerge when the theory is rolled out in the real world. Inefficient photon sources and detectors, or imperfections in optical fibres, mean that there are ways to siphon off some of the key's digits without being detected.

Researchers are working on fixing these flaws, but widespread use of quantum cryptography is still a long way off, which is why cryptographers are racing to make quantum-proof encryption (see main story).



THE WAITING GAME

Even if we got new quantum-computer-proof cryptography systems tomorrow (see main story), it is likely that many secrets are already compromised.

It can take up to 20 years to implement a new cryptosystem. So if a computer with the vastly inflated processing power required to crack current codes arrives in the next 20 years, no data encrypted with the old system can be considered truly confidential. All someone needs to do is store today's encrypted secrets and wait.

That's a headache for governments. A quantum computer able to break today's encryptions is likely to appear within the 30 years for which most states like to keep their secrets. And businesses are at risk too: many try to keep documents and records behind a veil for as long as possible.

According to a report issued by the European Union-funded research project PQCrypto, companies should be aware that information encrypted for safekeeping with our current best methods will be as easy to expose as those encrypted by the German Enigma code used in the second world war are today.

at Rambus in Sunnyvale, California, knows how hard it is to tick all the boxes. He has entered an algorithm called ThreeBears into the NIST competition, but his journey into post-quantum cryptography began three years ago when he created his own elliptic curve algorithm. Its security derived from incorporating a prime number that has what he terms a "curious relationship" to the so-called golden ratio, an irrational number that crops up all over the natural world. In cryptography, it is useful because numbers that interact with it take on values that are difficult to compute. Hence, he called the algorithm Goldilocks.

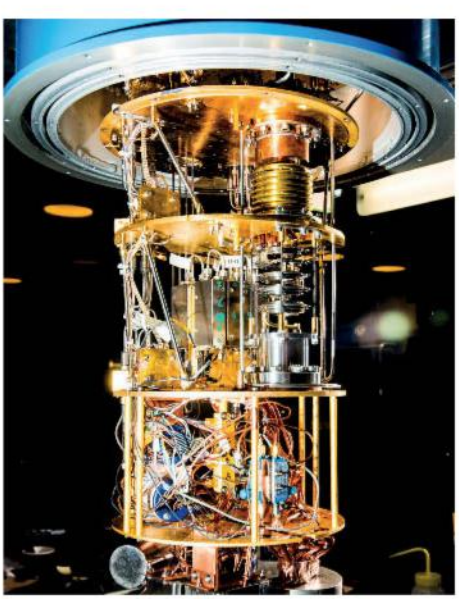
His new algorithm, on the other hand, is a lattice-based system. "ThreeBears uses a much bigger prime number with the same property, and it uses some of Goldilocks' code for the arithmetic," says Hamburg.

Among the other entries are algorithms with more macho names such as Titanium, Locker, Falcon and Lizard. In the end, though, the name doesn't matter. It is how the algorithms perform that will determine whether the months, years or, in some cases, decades of work were worth it.

Philippe Gaborit at the University of Limoges in France, for instance, has been working on post-quantum cryptography for 15 years. His name is on eight of the 82 NIST submissions. Not that he is complacent: he knows that, despite having so much skin in the game, his efforts may come to nothing as the entries are put through their paces. "The fact that the problems have been there for a long time brings confidence," says Gaborit, because no one has yet found a way for any computer to crack them. "But it is always possible that someone finds a new attack."

Hamburg, too, is wary of the unknowns that could scuttle ThreeBears. It is based on longer-established algorithms, all of which have also been submitted to NIST, but it's unclear which will perform best. "This version might have different security, for better or worse," he says.

Quantum computers are striking fear into security agencies across the world



ROGER KISBY/REDUX/EYEVINE

It won't be long before he finds out. This April, all the researchers who have entered an algorithm will meet in Fort Lauderdale, Florida, to pick over the carnage from their attempts at sabotage. The good news is that many of the flaws exposed so far aren't fatal. Relatively small tweaks can rehabilitate injured algorithms. So the meeting will be geared towards pointing out weaknesses and suggesting fixes.

Even if the algorithms emerge unscathed, however, there's no guarantee that any of them will be truly quantum-proof. Ultimately, there will always be an element of doubt. "We don't know there won't be a new quantum algorithm that works against quantum-resistant cryptography," Gaborit concedes. When we implemented RSA in 1976, he points out, no one could have foreseen Shor's algorithm emerging two decades later. "There is never 100 per cent security."

NIST's experts have a positive outlook, nonetheless. Chen is confident that they have the tools needed to create a secure future. "Assessing quantum-proof strength has been a very active research area in recent years," she says. It is now time to put that research to work.

To that end, NIST will select the strongest candidates and encourage everyone involved to sabotage them again. Moody reckons several of them look like they will survive scrutiny – although that might be wishful thinking arising from the widespread eagerness to get to grips with the problem. "We really do want to get something out of this," he says, "because we need to have replacements ready." ■

Michael Brooks is a *New Scientist* consultant and author of *The Quantum Astrologer's Handbook*

Director of evolution

Jennifer Doudna's discovery of the CRISPR gene-editing technique gives us unprecedented power over life itself. Now we must decide how to use it, she tells Michael Le Page

CARLOS CHAVARRIA/REDUX/EYEVINE

Jennifer Doudna is professor of chemistry, and of biochemistry and molecular biology at the University of California, Berkeley. Her 2017 book *A Crack in Creation: The new power to control evolution*, is published by The Bodley Head

"It was one of those moments of pure joy," says Jennifer Doudna. "The joy of suddenly understanding something."

In 2012, Doudna's team made one of the biggest discoveries in the history of biology: how to edit the DNA in living cells with relative ease. In essence, it gives humans the power to direct evolution.

It wasn't what the team had set out to do, but they realised immediately that CRISPR gene editing had immense potential. So did the rest of the world. Just six years on, it has already been used to help treat cancer and to alter the DNA of many plants and animals – including that of human embryos.

Doudna, who until then had worked on relatively obscure biochemical mysteries, suddenly found herself in a prominent position, with reporters phoning up asking for her opinion on the latest developments. "It makes me feel very humble," she says. "I'm this girl from rural Hawaii who took on this role. It's kind of bizarre."

Doudna's upbringing in Hawaii sparked her interest in biology. She was fascinated by the way plants and animals had evolved in an island setting. Her father, meanwhile, passed on a liking for puzzles. "I loved the idea of being able to have one's career be focused around figuring out how things work."

The discovery of CRISPR gene editing was the culmination of a working life spent uncovering the secrets of RNA. At Yale, her group worked out the three-dimensional structure of a key RNA enzyme, cracking a major scientific puzzle. Her group at the University of California, Berkeley, was interested in the CRISPR Cas9 protein because it is guided by RNA. No one understood how it worked until her team solved the mystery in 2012. Over the next few years, CRISPR took the scientific world by storm. By 2015, the first gene-edited monkeys had been born.

It was around then that Doudna began to have tsunami dreams. Tsunamis mean more to Doudna than most: the small town where she grew up, Hilo, was hit by a massive one in her parents' lifetime, so she was aware of the threat from an early age.

In the dreams, the tsunami was CRISPR, spreading beyond control. "I began to feel a bit like Doctor Frankenstein. Had I created a monster?" she wrote in her 2017 book on the subject. That was when she decided she needed to be part of the debate.

No longer incurable

Since then, Doudna has arranged conferences, given talks around the world, advised policy-makers and answered every kind of query from the public to raise awareness of CRISPR's potential.

And that potential is huge. CRISPR is being turned into an extremely powerful toolset for disabling genes, repairing faulty genes or turning genes on or off. As Doudna points out, that means every genetic disease could be transformed into a potentially treatable condition.

But there are dangers, too. Take gene drives – bits of DNA that copy themselves to ensure they get passed to all offspring, not just half as with ordinary gene variants. There are many natural gene drives, but until CRISPR, no one had created an effective artificial one. Now several teams are testing them in fruit flies, mosquitoes and mice. The risks are great. For instance, if a gene drive designed to wipe out an invasive species – rabbits in New Zealand, say – escaped, it could drive that species to extinction.

The rewards could be great, too. "I think it is worth taking that risk," says Doudna. "Imagine if you really could use that method to remove a strain of mosquito that spreads malaria."

The ethical issue that has attracted by far the most headlines, though, is whether CRISPR

should be used to permanently alter the DNA of our children, and by extension all our descendants. That idea horrifies some, including one of the co-discoverers of CRISPR, Emmanuelle Charpentier. But not Doudna. "If the technology was shown to be safe and effective for doing things like correcting the cystic fibrosis mutation, I personally think that that's OK," she says.

We can already prevent almost all genetic diseases by screening the embryos of couples undergoing IVF, but this involves throwing away any with mutations. "Many people have shared with me that it's a very uncomfortable feeling to throw away embryos," Doudna says. "So for some it might feel like a better decision to instead correct a mutation."

What if we want to enhance children, rather than just prevent disease? "I have a problem with that," says Doudna. "Maybe I'm a fuddy-duddy." But her issue is a practical one. There are actually very few, if any, gene variants that we are 100 per cent certain would provide significant benefits. Take intelligence – it seems to be determined by hundreds of genes, each with a tiny effect. What's more, the same variant can have different effects in different people.

So there is no guarantee that children would be better off. "I'm not sure I'd be comfortable taking a risk with my child's life in that way." But we don't need an absolute ban on genetic enhancement, she says. We might get to the stage where we can be sure modification is beneficial.

One fear is that it could make society even more unequal. This is already a problem with access to healthcare in general, Doudna thinks, and the same will apply to genetic enhancement. "In principle one wants to be working towards using any technology to benefit the largest number of people," she says.

That might be the case if CRISPR can enhance the animals and plants we depend on. "I think the biggest impact is going to be in agriculture," says Doudna. Indeed, biologists have already used CRISPR to create everything from gluten-free wheat to low-fat pigs and goats that produce more cashmere wool.

"I began to feel a bit like Doctor Frankenstein. Had I created a monster?"

Will we all soon be eating gene-edited food? This depends partly on public perceptions – and many people haven't even heard of CRISPR or gene editing yet. "Many won't until it actually impacts them personally," Doudna says. And perception depends partly on where people get their information from. "We definitely have challenges with Hollywood and the way they portray gene editing." Doudna was talking to me before the trailers aired for *Rampage*, a movie in which "gene editing" turns ordinary animals into uncontrollable monsters, including a giant flying wolf.

Yet we really will be able to create extraordinary animals one day, says Doudna, including unicorns and winged lizards. Perhaps not flying wolves, though: animals will still have to obey the laws of physics.

By solving the puzzle of CRISPR, Doudna has created a far greater conundrum: how to use its immense power. It is something humanity is likely to wrestle with for centuries to come. But Doudna is upbeat. "I'm not worried. I feel excited," she says. ■

Michael Le Page is a reporter at *New Scientist*

Is science really the only game in town?

Scientists do themselves no favours when they try to lord it over philosophers, finds **Philip Ball**

Idealization and the Aims of Science by Angela Potochnik, University of Chicago Press

Science Unlimited? The challenges of scientism edited by Maarten Boudry and Massimo Pigliucci, University of Chicago Press

RICHARD FEYNMAN has been often quoted as saying that the philosophy of science is as useful to scientists as ornithology is to birds. It's not clear if he ever put it quite that way, but it rings true with what we know of Feynman. Certainly, the quote is usually wheeled out for purposes of disparagement.

Similarly, Stephen Hawking, in his 2010 book with Leonard Mlodinow, *The Grand Design*, declared that "philosophy is dead". Another prominent physics populariser, Lawrence Krauss, said that philosophy "has no impact on physics whatsoever… people in philosophy… have every right to feel threatened, because science progresses and philosophy doesn't". Biologist-turned-philosopher Massimo Pigliucci, co-editor of a book of essays, *Science Unlimited?*, quotes similar examples from Steven Weinberg and Neil deGrasse Tyson.

It's not worth lingering over what Pigliucci rightly calls the anti-intellectualism of these remarks, except to wonder where this antagonism masquerading as aloof mockery comes from. At least part of it is easily understood: physicists are doing very well by themselves, thank you, and resent outsiders telling them what's what.

But philosopher Angela Potochnik's ambitious book *Idealization and the Aims of Science* is an antidote to the view that the philosophy of science tries to pronounce grandly on

"Physicists are doing very well by themselves and resent outsiders telling them what's what"

what scientists ought to do. Even so, many might still resent her assertion that "science isn't after the truth". But she's right. While our picture of the universe is in some sense truer than it was in the Middle Ages, and science typically does work its way closer to some sort of truth, that isn't what scientists are trying to achieve.

What they want are useful, comprehensible, workable theories of the world. Understanding trumps truth: scientists will generally settle for a less accurate model if it is more cognitively transparent. They don't strive to map models perfectly onto reality. This doesn't seem so controversial. Even Hawking agrees, indulging in a bit of philosophy himself when he states: "There is no model-independent test of reality."

Potochnik's strength is in stressing the human dimension of the enterprise. Ultimately, scientists use simplified models because, as she says, our theories and models "are designed to facilitate human cognition and action". It's not a question of them being mere social constructions or fashion statements. She means we are looking for what works for us. Our theories must fit the human mind, although the universe need not. "Scientists' cognitive characteristics and interests," she writes, "can never influence what is true, but these can shape what generates understanding."

I'd like to think that the more thoughtful philosophy sceptics, like Weinberg, would have some sympathy with that.

There is no "scientific method", but there is a collection of tried-and-tested principles: try to use reason, compare theory against experiment, attempt to replicate results, that kind of thing. The precise emphases differ by discipline. Some depend more heavily on statistics. Some are necessarily empirical, with few theories. Some, like chemistry, are as much concerned with making as with understanding. At any rate, science doesn't do just one thing over and over again in different fields of enquiry. That, says Potochnik, is why there are also no clear boundaries between science and non-science.

Which brings us to the topic under examination in *Science Unlimited?*: the concept of scientism. None of the authors of these essays define the word identically, but it might be crudely expressed as the sin of science exceeding its proper bounds and making hubristic claims to be the sole source of reliable knowledge.

Several philosophers are here laid end to end to consider the matter – and no, they don't reach a conclusion. The views range from the proposal that scientism should be reclaimed from being a term of abuse to become a badge of honour, to dismissing it as an

HILL STREET STUDIOS/L PAUL VERHAGE/GETTY

Big picture: science looks for understanding, not truth

empty insult and to agreeing that it is real and troubling.

To argue the case, you need to decide if science has any limits at all, and if it does, what they are and what (if any) reliable sources of knowledge lie beyond. The usual suspects here – philosophy, religion and morality – are dissected by several of the authors. Some scientists, such as Richard Dawkins, seem to feel that when philosophers are reasoning in ways that are at least logically falsifiable, they are just doing science anyway. Steven Pinker has even claimed "rational thinkers" like David Hume and Thomas Hobbes as honorary scientists. It is rather as if they are saying, "Science is thinking that I like."

Morality, though, is often seen as a branch of philosophy that scientific methods can't adjudicate. Yet some, such as Sam Harris, author of *The Moral Landscape*, have ambitions to turn it into a hard science, claiming that disciplines such as neuroscience can supply objectively correct answers to moral issues.

"There's still no good answer to Hume's insistence you can't derive an 'ought' from an 'is' "

That endeavour has often been held up as a classic example of scientism, but it is probably more useful just to call it wrong-headed. There is still no good answer to Hume's insistence that you can't derive an "ought" from an "is", and Harris relies on an assumption that is irreducibly philosophical: that the right course is the one that most enhances human happiness. We might be able to use neuroscience, game theory and evolutionary psychology to understand why people respond as they do to the infamous trolley problem or games involving punishment, but we can no more prescribe absolutely what they should do than we can prescribe who they should love. Parts of philosophy indeed deal with concepts (such as love, life and identity) that lack a rigorous scientific definition, but which seem indispensable to human existence.

And so, religion. Some of those here defending science against cries of "scientism!" from religious believers pick off easy (if justifiable) targets: woolly rhetoric about ineffable deities, say, or outright anti-science fundamentalism. And religion as an oppressive, mind-washing ideology should be attacked like any other. But arguments about "proving" or "disproving" the existence of God as cosmic designer are tedious now and irrelevant to the social aspects of how religion is typically practised.

I have seen enough breakdown of reason when New Atheists work themselves up about religion to conclude that everyone loses from attempts to argue away this particular pocket of non-rational belief that can manifest in the minds of sober, intelligent and humane folk. We all have such pockets; not all of them are God-shaped. Get over it.

Co-editor Maarten Boudry is probably right to assert that "if a factual question is answerable at all, it can be answered using methods… that are at least continuous with science". But there are questions important and meaningful to humans that can't be expressed in well-posed scientific terms. As physicist Taner Edis writes: "We often have other intellectual purposes besides investigation and explanation."

Science Unlimited? offers an entertaining and stimulating gallery of views. Everyone will draw their own conclusions from it, precisely because, while there are wrong answers to the questions it poses, there is no single right one. Sometimes science is like that too. ■

Philip Ball is a science writer. His forthcoming book is *Beyond Weird,* published by Bodley Head

Showing and telling

Cultural clash makes for a fascinating new show, finds **Liz Else**

Deconstructing Patterns, Francis Crick Institute, London, to 1 December

AS EUROPE'S premier biomedical enterprise, there is a lot riding on how far the UK's multi-million-pound Crick Institute can push the frontiers. Less obviously but equally importantly, there is also a lot riding on how well it handles its engagement with the public, through lectures, exhibitions and sci-art collaborations.

Crick's first approach to the latter is Deconstructing Patterns, a show where commissioned artists worked closely with the institute's researchers to explore patterns at the microscopic level. Perhaps wisely, the exhibition is framed as a conversation between art and science. In the right hands, this leads to good art – literally in the case of artist Helen Pynor.

She has made an astonishing film – *Development of the Visual Circuit of Drosophila melanogaster in Three Acts: Larvae l; Pupae l; Pupae ll* – of some very special hands (pictured bottom right). They belong to Iris Salecker, head of the Crick's visual circuit assembly laboratory. They are eloquent, talking science in an excitingly kinaesthetic way as they describe the complex series of events during the development of the brain circuits responsible for vision in the fruit fly.

According to Salecker, research is "only just starting" to get to grips with the fly's eye, part of the challenge posed by pioneering neuroscientist Santiago Ramón y Cajal when he said: "The complexity of the insect retina is something stupendous, disconcerting and without precedents in other animals."

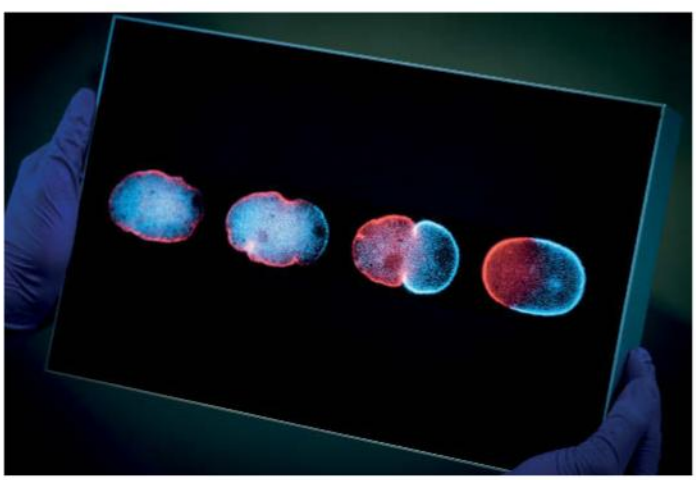
Pynor and Salecker formed a close bond while the artist was embedded in the lab. Watching Salecker talk, Pynor was struck by the power and precision of her hands filling important gaps in the language of "describing" what is an essentially 3D process.

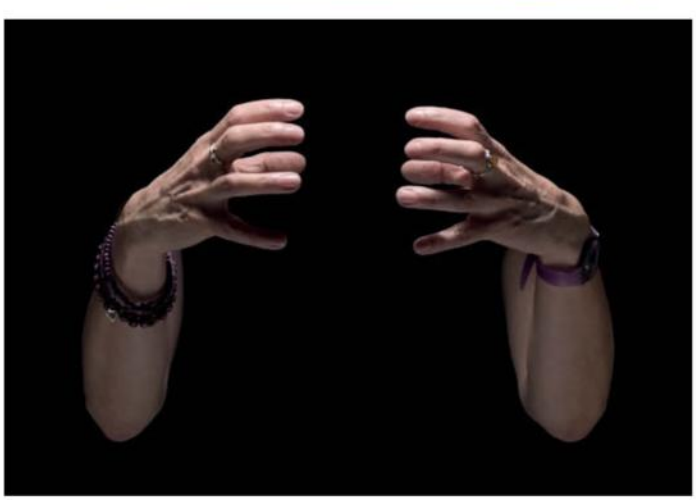
Pynor's second commission, *Random precision_Countless intimate acts*, also draws on that experience. To help her grasp the spatial complexities, she built 3D wax models of the fly's optic nerve, photographed them, added filament-like structures to suggest neural connections as well as idealised clouds, and encased the result in acrylic. It is hung high, just the right tone for a complex, sculptural work.

Another commission, *A New Music: Making Sense of the Noise,* a sound installation by Chu-Li Shewring and Sarah Howe, also intrigues even if the components don't entirely disappear in the making. Standing in white pods hung from the ceiling, we are on a journey. There is an assortment of watery noises, white noise, voices repeating the letters A, T, C, G (the DNA bases and the stuff of life) or chatting about the search for patterns from simple code.

Sound artist Shewring wanted to explore noise and how we find understanding – or in the case of the genome, a pattern – as a way to interpret what we see or hear. Howe's poem *A New Music* is woven into the mix, from which, somehow, sense emerges. Among its memorable lines, she evokes a "biological Bletchley" and "archaeologists of cancer… searching for the point a mangled chromosome went wrong".

A nematode worm inspires a film; hands "describing" fly vision





BOTTOM: HELEN PYNOR, IRIS SALECKER. BEN GILBERT, 2017 TOP: FIONA HANSON

"What emerges are the very different, pervasive effects of immersion in each other's culture"

At the other end of the show, the kids are less reverent but clearly alright. A group of them called KaleiKo made a movie, drawing on the help of Nate Goehring. He is head of Crick's polarity and patterning networks lab, which studies nematodes.

The result, *Selection*, is a surreal tale about a worker who breaks out of work's machine-like conformity to find a better fate. It is KaleiKo's response to Goehring's briefing about uniformity, breaking symmetry and cell fate – the process by which a cell takes on an identity or function. And it is fun.

But what really emerges from the show are the very different, pervasive effects of immersion in each other's culture. And that can only be a good thing. ■

Cultivate children's curiosity with AQUILA!

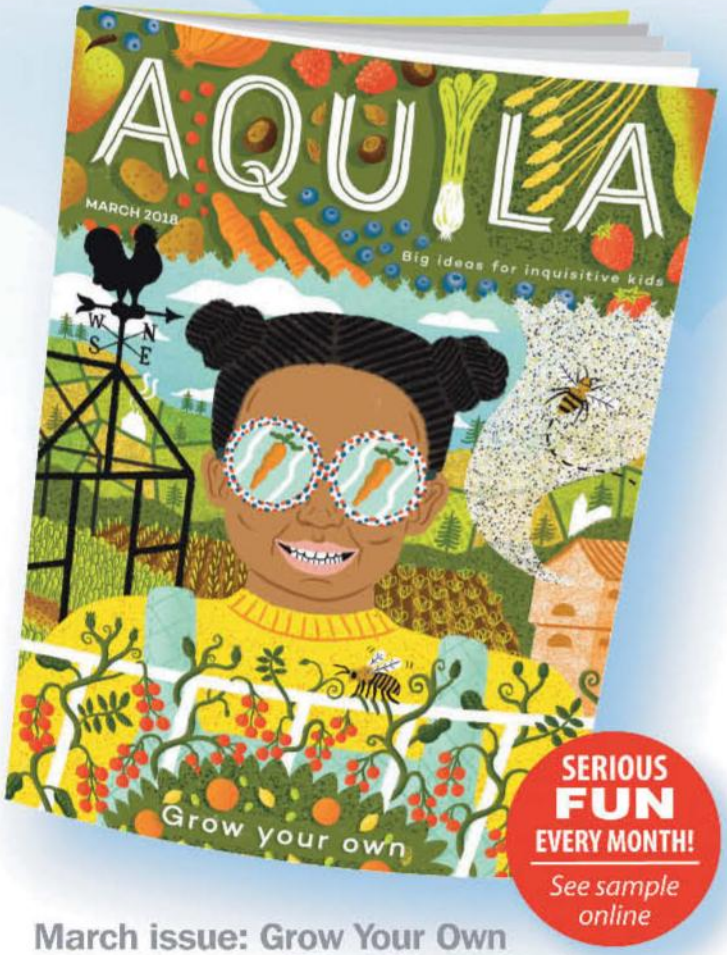
*From **The Story of Humankind** to **Supervolcanoes**, this highly-regarded publication has a great line-up of articles you will probably want to read yourself.*

Ideal for lively 8–12 year-olds, **AQUILA** is an advanced and philosophical magazine that introduces young readers to a thought-provoking mix of **Science**, **Arts** and **General Knowledge**.

AQUILA is not like any magazine you will find on the newsstand; it is more like a special club for inquisitive kids who will soon discover a community of other youngsters just like them. With a new topic every month each issue is jam-packed with challenge and fun; readers can explore concepts beyond the range of the school classroom and build strong foundations for their future education.

Coming-up in AQUILA: Pop Art, Zoologist Safari, The Story of Humankind, The Vikings, Detectives and Charles Dickens.

AQUILA Gift Subscriptions include a **Welcome Pack and your gift message**. Visit our website or call 01323 431313, 9am–4pm weekdays.



SERIOUS FUN EVERY MONTH!
See sample online

March issue: Grow Your Own

Is that a **Honey Bee or a Wasp?** This month **AQUILA** gets the kids out in the garden to prepare for a **veritable vegetable feast** come the summertime. They can find out about the **Dig for Victory** campaign of **WWII** and try some **'baked bean botany'**. PLUS: meet an intrepid plant hunter from **Kew Gardens' Millennium Seed Bank** and make some **carrot ice cream:** YUM… this month's issue of **AQUILA** is the Bee's Knees!

- ✔ **Perfect Birthday Gift for 8–12 year-olds**
- ✔ **Challenging Puzzles & Experiments**
- ✔ **Teachers & Parents love AQUILA!**

Find out more:

www.AQUILA.co.uk

University of Strathclyde Glasgow

Centre for Doctoral Training in Medical Devices (4 year studentships) for Engineers and Physical Scientists

Doctor of Engineering in Medical Devices (EngD)

We are currently recruiting graduates in Engineering or the Physical Sciences for September 2018 who have obtained, or expect to obtain, a first or upper second class honours degree to join the Medical Devices Centre for Doctoral Training at the University of Strathclyde which is funded by the EPSRC. The centre is designed to allow graduates to carry out research relevant to problems in healthcare that can be addressed through new medical devices or related technologies. The students of the centre have the opportunity to work with medical companies and NHS and other clinical groups in state of the art research projects. The projects carried out in the centre have a high degree of relevance to the clinicians, patients and medical companies who are the end users of such research.

Graduates accepted for the centre who are UK citizens will receive a four-year studentship covering living expenses and fees. EU citizens who have been resident in the UK for 3 years or more are also eligible for the full studentship. Fees only support is available for other EU citizens.

Additional information can be found on our website at:
http://www.strath.ac.uk

Applications can be made online at **http://pgr.strath.ac.uk**

For further information please contact: **Carol McInnes**
Biomedical Engineering, University of Strathclyde, Glasgow G4 0NW
Telephone: **0141 548 3781** Email: **carol.b.mcinnes@strath.ac.uk**

THE QUEEN'S COLLEGE, OXFORD

ELECTION OF PROVOST

The Governing Body of The Queen's College, Oxford, seeks to elect a new Provost with effect from 1 October 2019. The Provost will offer inspiring and engaging leadership to this outstanding academic community, and will represent the College both within Oxford University and the public domain.

Ideal candidates will be women or men of academic or professional distinction who have a strong commitment to – and enthusiasm for – teaching, research, and the values of academic excellence. They will have a considerable reputation for achievement in their chosen field, and a wide range of interests that will allow them to speak to diverse groups of people.

Information about The Queen's College, and further particulars about the appointment and the application procedure, can be found on the College's website **https://www.queens.ox.ac.uk/provost**, or obtained from Dr Curly Moloney at *Moloney Search* (**tqc@moloneysearch.com**), the College's advisors in this process.

Applications should be sent electronically to **Provostship2019@queens.ox.ac.uk**, and should include:

a) A curriculum vitae,
b) A concise statement explaining the candidate's reasons for applying, and how the candidate believes he or she matches the qualities that the College requires.

The closing date for applications is **16th March 2018**.

The Queen's College is committed to diversity and equality and is an equal opportunities employer.

MOLONEY SEARCH

Find your perfect candidate with our

CV DATABASE

- Search **over 62,500 STEM professionals**
- Sophisticated Boolean search so you can **query the exact criteria** you're looking for
- **Quickly scan** through the results, view their **actual CV** and pick your ideal candidate

For more information please contact us on **020 7611 1204**
or email at **nssales@newscientist.com**

recruiters.newscientist.com

NewScientist | Jobs

National School of Healthcare Science

NHS Health Education England

Higher Specialist Scientist Training Programme

Advancing your clinical and scientific skills for patient and public benefit

Salary: Locally determined by the employer to at least AfC Band 7

Through the Higher Specialist Scientist Training Programme (HSST) the NHS offers an exciting opportunity to train towards being eligible to apply for consultant clinical scientist posts.

This five-year full time programme has been developed jointly between the Modernising Scientific Careers team, Medical Royal Colleges and scientific professional bodies for clinical scientists and is equivalent to the standards of training undertaken by medical postgraduate trainees.

If you see yourself as a future leader in healthcare science, then apply to join this innovative programme which offers bespoke workplace based training supported by an underpinning doctorate-level academic course.

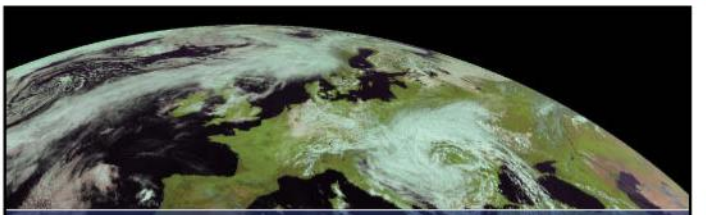
Health Education England local teams commissioned HSST training posts will be available in accredited training departments either as:

- **Direct entry** - new posts created specifically for the purpose of training and open to competition by application.
- **In service** - existing posts supported by employers. There are in service posts available in a range of specialisms within life sciences, physiological sciences and physical sciences. In service posts are not open to competition and only clinical scientists nominated by their employer who reach the standard for higher specialist scientific training are eligible to apply. If you are eligible you must apply to be considered for entry into HSST and undertake the appointment and benchmarking process.

To apply and for full information about the opportunities available and details of the qualifications and experience you need, please visit

http://www.nshcs.hee.nhs.uk/join-the-programme/nhs-higher-specialistscientific-training

Applications should open during March 2018.



Help us build our future and make a world of difference.

DARMSTADT, GERMANY

At EUMETSAT, we value new ideas from our colleagues and are focussed on innovation. Our satellite systems survey the atmosphere, ocean and climate 24 hours a day. Our data informs weather forecasts that protect lives and property, and to monitor the changing climate.

Once again we are looking for bright minds with the launch of our 2018 Early Careers Employment Programme (ECEP). Do you have what it takes?

We are looking for recent graduates to join us on our two year development scheme. In addition to our extensive technical training, we will improve your interpersonal skills and business acumen, supporting you with our network of mentors and coaches.

The posts we are going to fill for the ECEP are:

- Junior Communication and Network Engineer
- Junior Data Centre Engineer
- Junior Remote Sensing Scientist - Atmospheric Motion Vectors
- Junior Ground Stations and External Interfaces Engineer

With all of these roles you will work in a multi-cultural environment, based in Darmstadt, Germany, alongside colleagues and partners who are the best in their field.

EUMETSAT is committed to providing an equal opportunities work environment for men and women and is seeking to recruit nationals from its Member States.

The closing dates are early March, with interviews being held in April. The ECEP will start in September.

To learn more and apply online, please visit:
https://onlineapplication.eumetsat.int

EUMETSAT

EDITOR'S PICK

Confusion when you're pregnant and in pain

From Margaret O'Hara, Pregnancy Sickness Support, UK
Jessica Hamzelou says that drugs aren't routinely tested on pregnant women, as experimenting on their fetuses would be unethical (10 February, p 25). The problem here is that pregnant women still need, and do take, medicines. They are then effectively in a trial with one participant and no ethical approval, data collection or monitoring. Without proper trials, women are left with insufficient information to make decisions. Simply wishing away the health condition that necessitates the drugs isn't a solution.

The untreated condition is often not neutral for the fetus: commonly, the risk-benefit ratio for both woman and fetus firmly favours taking the drug. An example is the use of anti-emetics for extreme nausea and vomiting to prevent maternal malnutrition or termination of the pregnancy.

By failing to test drugs in pregnancy, medicine fails pregnant women and condemns them to some long-gone age before modern pharmaceuticals. This cannot be regarded as the ethical or moral high ground.

Science and politics don't inhabit separate worlds

From Paddy Shannon, Lancaster, UK
You are right that science doesn't exist in a political vacuum (3 February, p 5). Hence your justifiable forays into comment on political matters.

But why not follow the evidence to the ultimate question: has the capitalist system finally passed its sell-by date?

Commodity production for the private accumulation of wealth has revolutionised society, but it has also resulted in a world of staggering inequality where a billionaire can launch a car into space while billions don't have the basic means of living and billions more are chained to economic drudgery as modern-day wage-serfs. From climate change to oil wars, capitalism arguably represents a global tragedy of the commons that could threaten our collective survival. Is this really the best we can do as an intelligent species? Perhaps a better model exists, but if so we need to know what it is, how it could work and what we need to do to achieve it.

This debate must happen now and it needs to be impartial and evidence-based because politics doesn't exist in a scientific vacuum. The magazine that has the courage to combine the two and ask the biggest questions might make an epoch-defining difference.

There's enough partisan politics elsewhere

From Eric Hayes, Yokohama, Japan
Curtis Abraham accepts reports that US president Donald Trump referred to "shithole countries"

"Reverse causation? That's not going to run in court any day soon"

Johnson's Solicitors gives a lawerly response to the quantum idea of the future changing what happens now (17 February, p 28)

(27 January, p 22). The world is filled with partisan politics. I wanted to read objective science. Trump wanted to make up with Russia. The military-industrial complex and mainstream media vilify him, as they did all presidents who want to lessen tensions. Political factionalism has for me completely ruined the joy of reading *New Scientist* as a science magazine.

From Chris deSilva, Dianella, Western Australia

Abraham's position on cultural reality is illogical. He quotes Wade Davis saying that various cultures are "simply different ways of being and of thinking". He then condemns President Trump for his way of thinking and being. He cannot have it both ways. Being xenophobic and culturally chauvinistic is a model of reality.

What would a workable society look like?

From Helen Haran, St Albans, Hertfordshire, UK

Andy Coghlan reports that no society manages to live well without overusing natural resources (10 February, p 10). He misses the key that could unlock this conundrum: a reduction in world population, especially in rich countries. This is particularly important at a time when the US administration has cut its funding for family planning in developing countries. Population growth will not slow down unless contraception is made available to all who wish to have it.

From Bryn Glover, Kirkby Malzeard, North Yorkshire, UK

I have one small criticism of the reported work on living standards and ecological impact. Countries were apparently treated as homogeneous entities, but alongside the extreme wealth of some in the US there is much abject poverty. This is also true for South Africa, Australia and, increasingly, the UK. In terms of the "how many Earths does it take to support this lifestyle" index, pockets of US poverty rank below "one Earth". One relatively developed nation rated at a fraction below one Earth was Cuba – albeit before the end of the US trade embargo. Should it be our target for quality of life?

From Hillary Shaw, Newport, Shropshire, UK

Modern society does look unworkable: countries either overconsume or fail to meet well-being targets. But why can't people in developed nations be happy with less stuff? Those of us who lived in the UK in the 1960s weren't excessively poor. We had enough to eat, most housing was satisfactory and many people could afford cars, holidays and even some foreign travel.

Could we not have a two-day working week, with walks in the park rather than excess consumption? As Aldous Huxley put it: "A love of nature keeps no factories busy."

From Steve Pollaine, Occidental, California, US

Coghlan reports that most countries either have good, but unsustainable, lifestyles or poor, but sustainable, ones. However, there is an exception: Bhutan, which uses "gross national happiness" instead of "gross national product" to decide what projects to fund and to measure how well it is doing. It is the only carbon-negative nation. It doesn't have extreme poverty ›

or homelessness, and does have universal education and healthcare. Everyone we met there was happy and friendly.

The editor writes:

■ Sadly, the research we reported doesn't analyse Bhutan, possibly because of a lack of data.

Signs of collapse and limits to growth

From Bruce Denness, Whitwell, Isle of Wight, UK

Laura Spinney notes that, historically, collapsing societies lost complexity and "people lived shorter, unhealthier lives" (20 January, p 28). Your subtitle on Laudan Aron's piece about US health declared that "shorter lives and poorer health are becoming the new norm" there (p 24). Are we being invited to put two and two together?

From Ted Webber, Buderim, Queensland, Australia

Spinney's discussion of the crumbling of Western civilisation didn't mention the *Limits to Growth* studies since 1972. Updates include *Is Global Collapse Imminent?* from Graham Turner of the Melbourne Sustainable Society Institute in 2014. One point it made was that the concept of "peak oil" seemed to have been refuted as fracking in the US had produced a surplus that sharply reduced prices. But rising prices now indicate that this bonanza is already at an end.

When the economics of information went awry

From James Decandole, Toronto, Canada

Chris Baraniuk discusses failures of oversight related to content aimed at young people (27 January, p 20). In an aside, he identifies the root of the problem of internet content: "its creators get paid through ad revenue sharing". Why is it that the financing of the mass media of information and entertainment by means of advertising is taken for granted?

If consumers paid directly for these services, as we do for books, records and films, what kind of content would result? If they were financed by a dedicated tax administered by an independent local authority, as the Canadian public school system is, could we have a more socially desirable and responsible industry? After all, it is our money, handed over when we purchase goods and services, that the advertisers are using.

Something went wrong a century ago when commercial radio broadcasting adopted the revenue model invented by newspapers and magazines. We gave the advertisers control of the mass media of communication. Now the power of this sector of society exceeds that of the Catholic church when it was the established religion.

A simpler proposal on diabetes and migraines

From Theresa Jones, Wolfenbüttel, Germany

Jessica Hamzelou draws attention to a Norwegian study that found that people being treated for diabetes turned out to be less likely to experience migraines (13 January, p 7). She reports researcher Ippazio Antonazzo proposing several possible explanations, including nerve damage caused by diabetes making it more difficult for a person to sense migraine pain, or some treatment normalising the activity of insulin, making migraines less likely.

I am a migraine sufferer. Many years ago, a scientific colleague and fellow sufferer advised me to take glucose as soon as the "aura" of an oncoming migraine is apparent. Over the years, I have followed her recommendation – with speedy results.

My daughter also successfully takes glucose when such symptoms arise. We consider that we get migraines because of low blood sugar.

It may be that many of the Norwegians with diabetes avoid migraine because they artificially maintain a constant and suitable blood glucose value. More research to examine this simpler explanation of the phenomenon might be interesting.

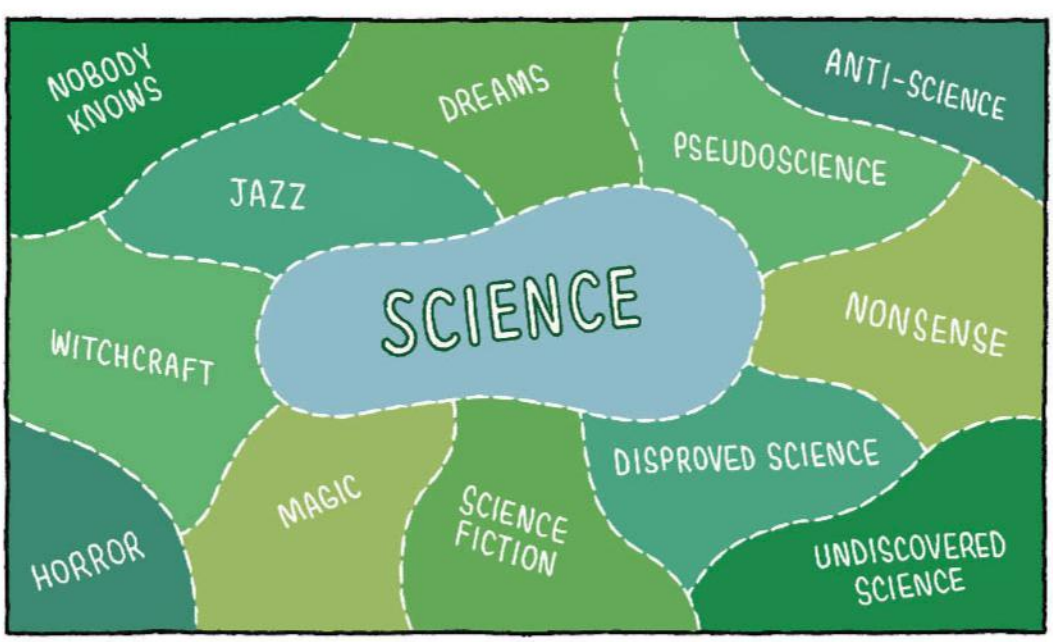
Meta-humblebrags, for better or worse

From Marilyn Lott, Front Royal, Virginia, US

Alice Klein reports a study finding that humblebrags really are the worst (20 January, p 14). Those who would downplay their achievements should rather be guided by an ancient proverb: "Toot not your own bassoon, and the same shall not be tooted."

In keeping with this advice, when I had a letter published in *Rolling Stone*, I promptly tooted it all over my Facebook page, just to make sure my nearest and dearest knew how clever I am.

TOM GAULD



Letters should be sent to:
Letters to the Editor, New Scientist, 25 Bedford Street, London, WC2E 9ES
Email: letters@newscientist.com

Include your full postal address and telephone number, and a reference (issue, page number, title) to articles. We reserve the right to edit letters. New Scientist Ltd reserves the right to use any submissions sent to the letters column of *New Scientist* magazine, in any other format.

OLD SCIENTIST

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

JEWEL SAMAD/AFP/GETTY

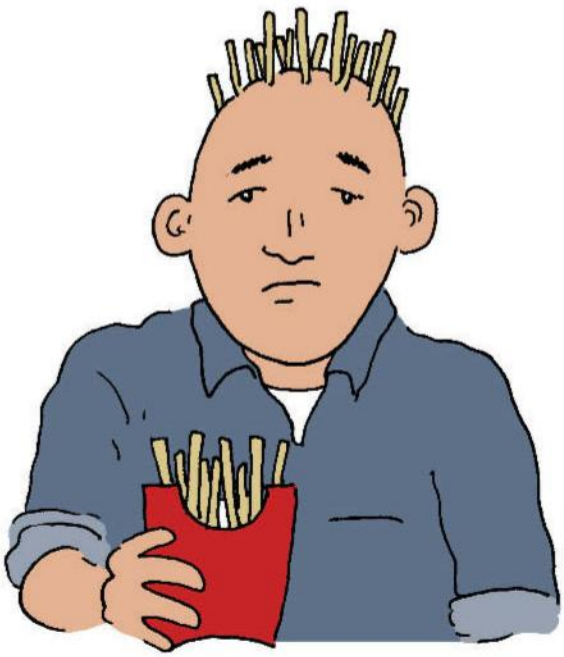
THE computer age dawned before this magazine launched, but *New Scientist* has been around for long enough to capture the machines' ever-accelerating evolution and their infiltration of our daily lives.

Back in 1963 they were big and slow, but already replacing humans at mundane tasks. We reported that February that British Railways was using a Ferranti Pegasus 2 to compile its Eastern Region timetable, and that the Eastern Region had to rearrange its headquarters to fit the beast in. We recognised the start of an inexorable process of speeding up tasks while cutting the need for people to do them, a challenge the world is still grappling with. In our 7 March issue, our editorial proclaimed the advent of "king computer", lamenting how machines were running things as diverse as US Navy missile systems, coal-mining strategy and government policy.

By 1975, having entrenched themselves in big national enterprises, computers were starting to take control of individual citizens' business. Our 6 March issue reported that the UK government was halfway through computerising 20 million drivers' records, and it did not escape us that the machines would make it ever harder to evade the authorities' gaze. "The most astonishing thing about the driver licensing operation," we noted, "is that a group of civil servants was able to evolve a quasi-national identifier without consultation with representatives of the public." The computers still needed a large building to accommodate them, however, not to mention almost 7900 workers to do what the machines still could not.

Twenty years on and the world had changed again, with a headline in our 5 March 2005 issue proclaiming that "A cellphone is the only gadget you need". It could do everything: "games machine, emailer, camera, or news browser". That was prescient. Whether pocket computers have led to more/fewer or better/worse jobs for humans, however, is open to argument. **Mick O'Hare** ■

To delve more into the *New Scientist* archives, go to **newscientist.com/article-type/old-scientist/**



PAUL MCDEVITT

JAPANESE researchers who showed that one of the chemicals in fried potatoes could help grow hair follicles have asked people to stop eating French fries as a cure for baldness.

The team developed a new technique that allowed them to culture large numbers of hair follicle germs – a precursor of follicles – in the lab. These were transplanted into mice, where they produced new hair.

The process uses a chemical called dimethylpolysiloxane, which is also added to oil in deep fat fryers to reduce splatter. The news sent hordes of smooth-pated men scurrying to fast-food joints to devour French fries.

Exasperated lead researcher Junji Fukuda told Reuters: "No matter how many fried potatoes you eat, you'll never grow more hair. That's a total misunderstanding that's gone viral."

IS THIS the best thing since sliced bread? Lasers can now tattoo graphene circuits directly on to any material with a suitable carbon content, such as paper, cardboard, clothing – and toast. The tattoos can act as batteries, sensors and RFID chips, allowing companies to better manage inventory or detect microbes responsible for food spoilage.

If it seems as if the latest smart gadget has a shelf life comparable to the contents of your bread bin, perhaps in future the two will become one. Pity the parents who have banned mobile phones at the dinner table, only to find junior tweeting from a bread roll.

LOVE in a time of cholera? A 300-year-old sex manual is going under the hammer at Hansons Auctioneers near Derby, UK. First published in 1684, *Aristotle's Masterpiece,* or *The Secrets of Generation* contains advice on a whole range of relationship and reproductive matters.

Inside, there are warnings about the esoteric effects of apparently innocuous things: too much salty and spicy food can promote early puberty in girls, for example. And children of "monstrous shape or habit", we are told, are the result of sudden frights, extraordinary passion or their mother's strange imagination.

The guidebook also has much to say about marriage: old men who take on young wives, it warns, are likely to find themselves "wedded to an early grave" by their exertions. There's less insight for those courting in the age of Tinder, but if your dinner date orders the sparrow and parsnips, he just might be worried about maintaining his performance later.

HUMANS will react pretty well to news of alien life. Michael Varnum at Arizona State University examined news stories such as the suspected fossil Martian microbes found in a meteorite in 1996, and the not-so alien megastructure orbiting Tabby's star, and found coverage was generally positive in tone.

A subsequent poll, where 500 people wrote down their reactions to the hypothetical discovery of alien microbes, also prompted mostly positive views.

Of course, stumbling upon extraterrestrial microbes in Martian rocks is a far cry from an alien armada turning up on our planetary doorstep. Indeed, evidence of late suggests that we seem much less welcoming to aliens arriving from less far afield.

Will first contact be followed by calls to build a space wall – and make the aliens pay for it?

WATCH out for low-flying deer. An elk has collided with a helicopter carrying two wildlife researchers studying mortality rates among migrant elk. The pair had been pursuing the animals in the mountains east of Salt Lake City to fit them with tracking collars, according to the Associated Press.

The pilot had descended to around 3 metres from the ground to let a researcher jump out and capture the elk, when the animal leapt into the tail rotor, sending the helicopter crashing to the ground. After clambering from the wreckage with minor injuries, the researchers presumably updated their elk mortality records with: "1 x death by helicopter".

HAVING read about the Australian electromagnetic radiation cleanser that looks suspiciously like a lump of plastic (3 February), Rob Holmes writes to say: "It occurred to me that Feedback's fruitloopery drawer must be bulging."

He wonders if we have considered tapping this gold mine of profitable ideas to ensure a comfortable retirement for ourselves. Rob, we must admit, the temptation is ever-present (surely someone can sell us a crystal pendant for that).

Thankfully though, we already have a way of converting fruitloopery into a steady income, without running foul of trading standards. And with the sheer volume supplied by readers, we won't be retiring any time soon.

YOU may recall Adrian Wilkins writing to Feedback to report on the perilous bathing experience offered by adverts for "super heated" swimming pools (27 February 2016).

He finds himself flirting with danger again while walking alongside the River Avon at Hanham near Bristol, where a sign attached high up a tree warns ominously against straying from the path: "Keep out. Unquantifiable hazards."

"Is technology getting ahead of itself?" asks Dave Rogerson. "I tried to get a black coffee today from an automated machine in a well-known chain of pubs and it refused – because it was out of milk"

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

Pale rider

Driverless cars are already in existence. Would riderless motorbikes be a possibility?

■ Riderless motorbikes might be problematic. A motorbike is very stable travelling in a straight line at speed because of the gyroscopic effect of the rotating wheels. But to change direction, a rider has to lean into the bend to balance the force of turning. Initiating a turn involves briefly "countersteering": steering in the opposite direction to achieve the lean. The rider will increase or decrease this countersteer to maintain the lean appropriate for the arc, the speed and road camber, while dealing with such things as potholes and crosswinds.

Turning at low speeds also requires a completely different skill set because the bike is much less stable and much more likely to fall over when travelling slowly. Any passenger must lean appropriately and a rider needs to know when to put a foot down to stop the bike toppling over. In addition, motorbikes cannot reverse, so parking requires careful planning.

A computer might struggle with all of these variables. However, the main reason why riderless motorbikes are unlikely to succeed is that most motorcyclists in affluent countries ride because it is far more challenging and enjoyable than driving.

Hopefully, driverless cars will reduce what are known as SMIDSY – "sorry mate, I didn't see you" – collisions with motorbikes, which are a common cause of serious injury and death.
Geoff Sharpe
Lazonby, Cumbria, UK

And one reader asks a question of his own – Ed

■ Aren't there more important transport issues to consider here? Trams are faced with much simpler choices, so can a driverless tram be built?
Michael Bell
Newcastle upon Tyne, UK

Dead of night

How do green plants cope with 24 hours of darkness for long periods? Does this affect oxygen production, and in turn cause any problems for local wildlife?

■ During the Arctic winter, for example in December in Lapland, there are 24 hours of almost darkness. Santa and Rudolph tolerate it, and so do the vast areas of conifers that grow there, up to 70° north, well above the Arctic circle. During this period, trees can't photosynthesise, so they produce no oxygen. However, this dark spell coincides with a cold period. The average December temperature in Lapland is about -10°C (or -25°C for coniferous forests at similar latitudes in Yukon, Canada, and Siberia, Russia).

At such low temperatures, all metabolic processes grind to a virtual standstill. This includes respiration, the main activity that might otherwise have caused the trees to use up atmospheric oxygen. Like hibernating bears, the forests become dormant – almost "dead wood".

In temperate regions, in comparison, deciduous trees such as the oak and ash effectively enter a period of self-imposed darkness in winter. With their leaves having fallen, they might as well be in 24-hour darkness as they can't carry out any photosynthesis.

They do continue to respire at low levels, especially in their roots, fuelled by reserves such as the starch manufactured the previous summer. But when this is happening in the northern winter, it is offset by deciduous trees in the southern hemisphere photosynthesising during their summer. Any effect on local oxygen concentrations is negligible because winds ensure the global circulation of our shared oxygen supplies. So don't worry!
Stephen Fry
University of Edinburgh, UK

■ A lack of oxygen isn't of immediate importance where this element can be freely exchanged with the atmosphere. The main exception is under water because oxygen is so poorly soluble that it must be continually supplemented by photosynthesis and convection if active animals are to function.

Where banks of plants such as water hyacinths or water lilies prevent the wind from circulating oxygenated water and block out light, inhibiting photosynthesis at lower levels, the water beneath the plants deteriorates into a smelly dead zone. Fish die if they cannot escape and mosquitoes flourish on the rotting material.
Jon Richfield
Somerset West, South Africa

This week's questions

TAKING A BOW
Recent strange weather conditions have led to a number of extraordinarily bright local rainbows. They contain extra colours inside the usual violet. There are as many as three additional bands: a narrow one of orange-yellow, a wider one the vivid green of nocellara olives and a narrow one of purple. These extra bands occupy about a third of the width of the rainbow itself. What am I seeing?
Bryn Glover
Ripon, North Yorkshire, UK

CLEAN CUT
Every so often, my adopted cat brings home geckos in two pieces, namely the still-moving tail and the rest of the body (also still moving). But there is never any obvious blood. Why?
Jo Dunn
Cape Town, South Africa

We pay £25 for every answer published in New Scientist. To answer a question or ask a new one please email lastword@newscientist.com. Questions should be scientific enquiries about everyday phenomena, and both questions and answers should be concise. We reserve the right to edit items for clarity and style. Please include a postal address, daytime telephone number and email address.

You can also send questions and answers to The Last Word, New Scientist, 25 Bedford Street, London, WC2E 9ES.

New Scientist Ltd retains total editorial control over the published content and reserves all rights to reuse question and answer material that has been submitted by readers in any medium or in any format and at any time in the future. All unanswered questions and previous questions and answers are at newscientist.com/lastword/

KUGA

TOGETHER WE GO FURTHER

MOVING YOUR FLEET FORWARD

P11D	BIK	CO_2	COMBINED MPG
£35,840-£22,340	33%-25%	173-115g/km	37.7-64.2

Official fuel consumption figures in mpg (l/100km) for the Ford Kuga range: urban 30.1-58.9 (9.4-4.8), extra urban 44.8-67.3 (6.3-4.2), combined 37.7-64.2 (7.5-4.4). Official CO_2 emissions 173-115g/km.

The mpg figures quoted are sourced from official EU-regulated test results (EU Directive and Regulation 692/2008), are provided for comparability purposes and may not reflect your actual driving experience.