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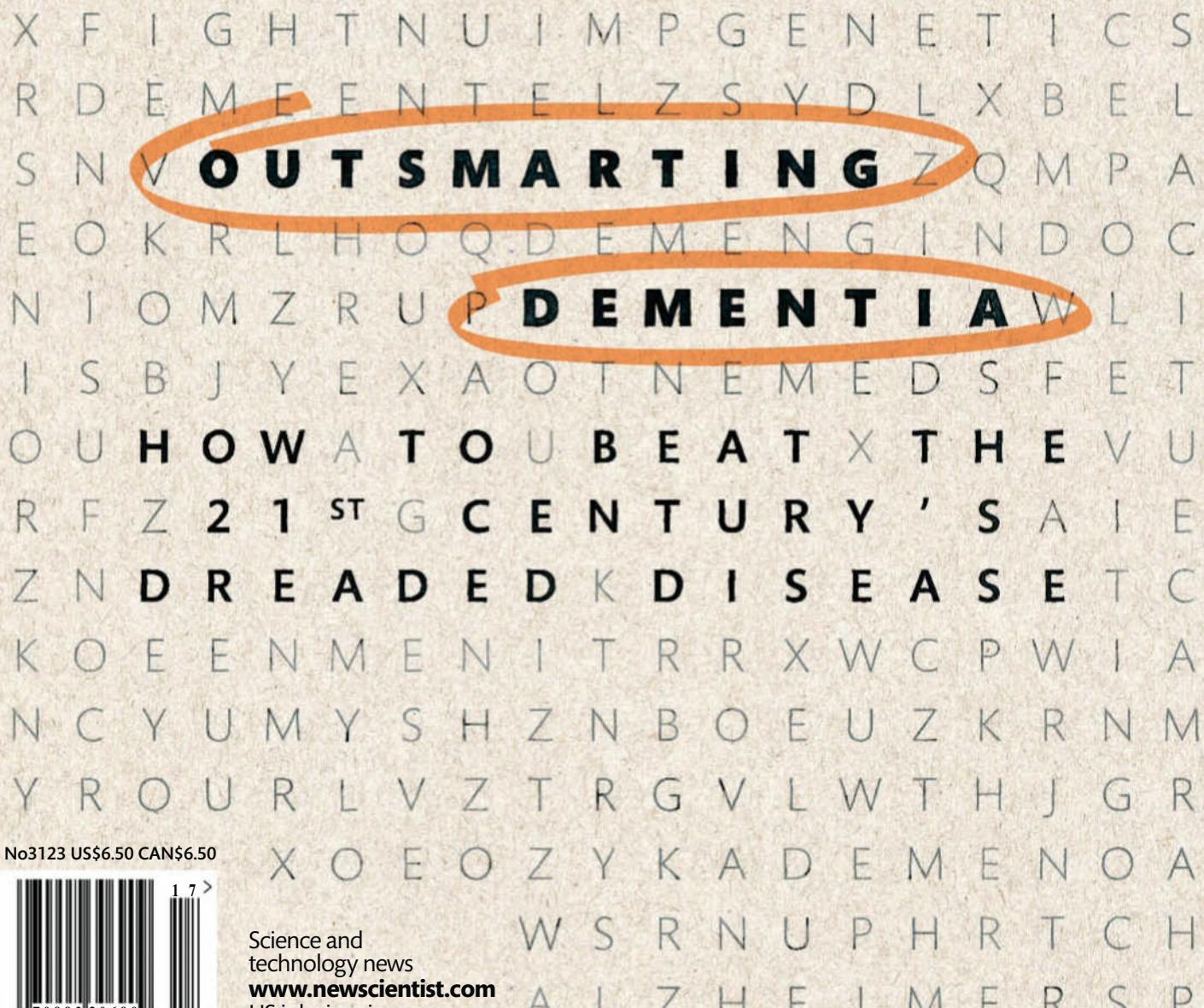
WEEKLY April 29-May 5, 2017

**PROTO SAPIENS**  
The chimp-like ancestor  
with a human brain

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Why it's so hard to  
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We've cracked the  
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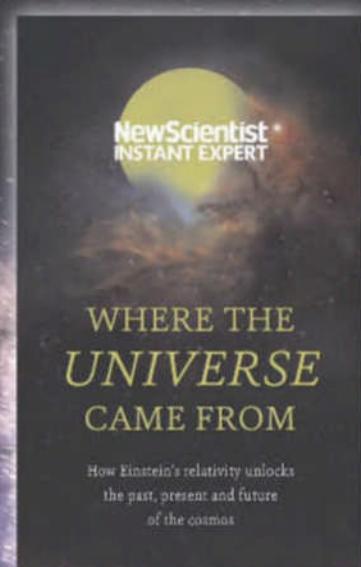
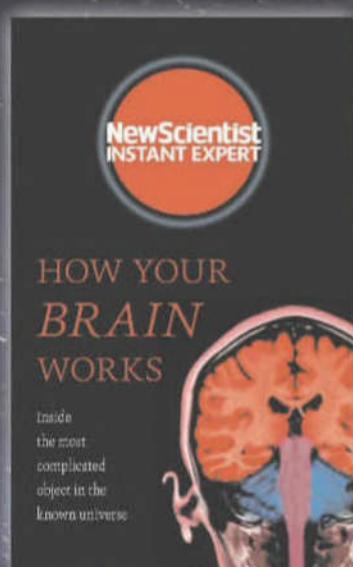
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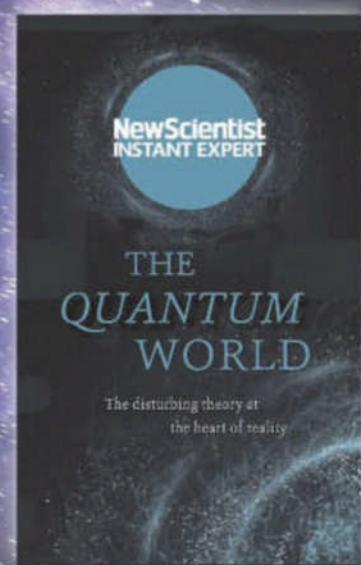
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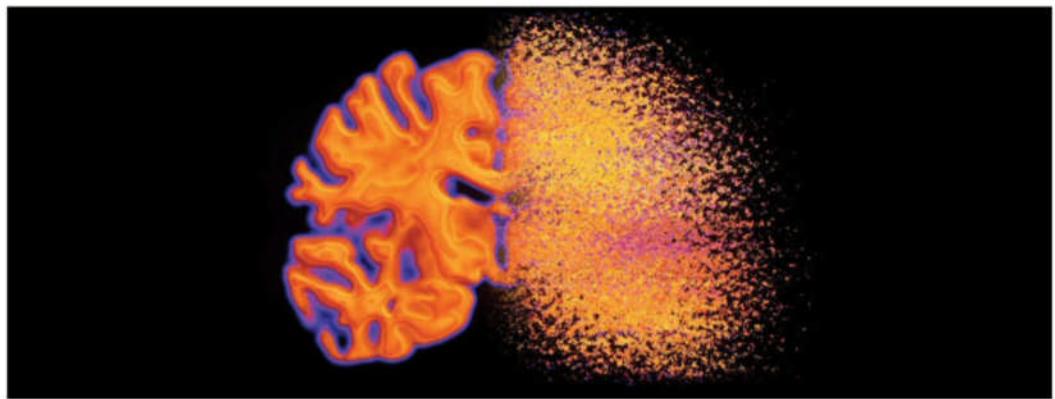
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ALFRED PASIEKA/SPL

# Prognosis uncertain

What does the Brexit election mean for dementia research?

TWO years is an awfully long time in politics. In April 2015 the UK was in the middle of a general election campaign that, by today's standards, felt very much like politics as usual. All the major parties published manifestos laying out their positions on the economy, the NHS, benefits, housing and so on. There were even some pledges on science.

One of the more eye-catching was the Conservatives' proposal to turn the UK into an international leader in dementia research. They promised to pump £300 million into basic science, create a separate fund for drug discovery and establish an international dementia institute.

The initiative was the pet project of the prime minister, David Cameron, who described dementia as "one of the greatest challenges of our lifetime". And with good reason (see page 28). Around 50 million people are living with dementia worldwide, and the number is expected to double in 20 years. Progress on treatments is painfully slow: in recent months several promising experimental drugs have crashed and burned in clinical trials.

Cameron unexpectedly won the election and, to his credit, set about making good on the promises. But then came the

Brexit vote. Cameron quit and the pledges of 2015 became irrelevant.

The UK now faces another general election. The manifestos have yet to be published but the danger is that – with Cameron gone and the task of extracting the UK from the EU subsuming all else – those admirable but costly commitments to dementia research will fall by the wayside.

That would be a serious setback for both UK and international research. Even though progress

### "Last week's March for Science proved that science activism is alive and well in the UK"

has been made in the past few years, the job is incomplete. Campaigners say that funding for basic dementia science needs to double again by 2025.

For now, the messages from the government are mixed. When Alzheimer's Research UK announced in January that Cameron would be its new president, a spokesperson for the prime minister Theresa May said: "We are committed to taking forward the plans that have been already set out for increased support for helping people with dementia and tackling this vital issue." Warm words, but well short

of explicit backing for the research element of the project.

On the plus side, only last week May's government announced further details of the promised Dementia Research Institute, which is being set up at University College London with £150 million of public money. But that merely honours an existing pledge.

More momentum could be lost if the Conservatives (and the other parties) don't explicitly recommit to research. Even if they do, challenges lie ahead. A "hard" Brexit might make it difficult to attract the overseas talent and international collaborations that are an important part of delivering world-class science.

The uncertainty over dementia research is a warning to the entire UK science base. The Conservatives look set to win at a canter in June, and may be tempted to write a manifesto short on policies to ensure their hands are not tied by inconvenient spending pledges when the work of Brexit kicks in.

Last week's March for Science proved that science activism is alive and well in the UK. But it must be the start of something bigger. Now is the time to crank up the pressure and make sure science does not vanish from a general election campaign that is anything but business as usual. ■



## A banner day for science

ARE we seeing the start of a broad new movement for scientifically minded people to rally around? On Saturday, tens of thousands of people attended the March for Science, whose main event took place in Washington DC. Satellite events stretched to 600 towns and cities around the world, with one in Antarctica.

Concerns have grown throughout Donald Trump's first 100 days as president that his administration is unconcerned with evidence, given the apparent dismissal of empiricism in favour of political expediency.

"My biggest worry is about the consequences to society if scientists are muzzled and intimidated, if science is defunded, if scientific institutions are undermined," Jane Lubchenco, former National Oceanic

and Atmospheric Administration president, told *New Scientist* in February. All of these have happened, with the administration demanding a list of climate scientists, proposing drastic funding cuts to basic science programmes, and gutting long-standing clean water protections.

The march coalesced out of grassroots online protests, and despite its perceived lack of a clear message, it could be a turning point for how scientists approach government.

"I hope professional scientists get a little less allergic to politics," says Caroline Flournoy, a medical imaging specialist who travelled from Virginia to join the Washington march. "There's this belief that if we remain sufficiently apolitical we'll stay above the fray."

Scientists aren't alone in worrying

judging by the attendance, which included many non-scientists and those participating in their first rally. "Science is important for everyone's lives," says Lauren Claeys, a secondary school student from New York state.

The Washington march was as much festival as protest. Bill Nye, Michael Mann and aspiring science students were among 55 speakers that addressed the crowd. Funk, soul and jazz music filled the time between speakers, and soul musician Questlove acted as master of ceremonies. "It's been frustrating to watch as certain forces in our society try to squelch science, or their refusal to believe in it or propose alternative realities and facts," he told the crowd.

The Trump administration hasn't issued a comment on the march.

## Europa alien hunt

A JOINT American-European trek to Europa could be the first to directly seek signs of alien life on Jupiter's moon.

Called the Joint Europa Mission, the plan was unveiled on 24 April at the annual European Geosciences Union meeting in Vienna. The proposal would involve NASA and the European Space Agency joining forces to execute the mission, which could launch in the mid-2020s.

Europa is thought to be a potential cauldron for life because an ocean where it could evolve is believed to sit beneath its icy surface. The mission would include a lander spending 35 days on the moon's surface to sample

**"Europa is thought to be a potential cauldron for life because an ocean sits beneath its icy surface"**

and screen material for traces of life; an orbiter spending three months taking measurements to unravel the basic structure of the planet; and the orbiter crashing into the moon, gathering data on Europa's tenuous atmosphere on the way down.

The plan builds on previous NASA proposals to explore Europa, but it is the first to specifically look for life and put a lander on the surface.

## Big health data

GOOGLE probably knows plenty about you already – and the company is poised to learn a whole lot more about some of us.

Last week, its health spin-off Verily launched Project Baseline, to collect reams of health data from 10,000 US-based volunteers. By looking at genes and microbiomes, and monitoring sleep, physical activity and general well-being over four years, the team behind the project hopes to find clues that might

**60 SECONDS**

predict the onset of diseases such as cancer.

Verily's chief medical officer Jessica Mega says the company is developing molecular, sensory and software tech that will organise all these different kinds of health data, "many of which have never been combined for a single individual".

"It's fascinating," says Kári Stefánsson, who leads deCODE Genetics, a company sequencing the genomes of people in Iceland. But Stefánsson says 10,000 people is too few. "Given the size and financial scope of Google, this is a small study."

**UK failing on seas**

THE UK government is dragging its heels over setting up protected marine areas near its coast, members of parliament have said.

Despite a 2015 pledge to set up a network of marine conservation zones to protect coastal and underwater habitats, only 50 of 127 recommended sites have been designated.

A report by the parliamentary Environmental Audit Committee hits out at "unacceptable" delays in creating the network. The government has "moved the goalposts" by setting unreasonably high standards of evidence for designating protected areas, the report says.

"The government needs to put firm plans in place to stop further degradation of our vulnerable ecological systems before they are destroyed forever," says Mary Creagh, who is chair of the committee.

"We don't just want 'paper parks,'" says Joan Edwards of The Wildlife Trusts. "These special places at sea must be managed and the most damaging activities must be banned straight away."

The government should consider investing in aerial and marine drones to deter illegal fishing in the protected areas, the report says.

**Socialise virtually**

WE WILL soon be meeting our friends in personalised virtual worlds, according to Facebook.

Last week, at its F8 Developer Conference in San Jose, California, the social network launched a VR app that lets you chat in a 3D virtual environment.

Facebook Spaces allows you to customise a cartoon avatar based on one of your Facebook photos to represent you in the virtual world. You can invite several people into this space at the same time and chat as you usually would, using Oculus Touch controllers to

animate your avatar's arms.

The VR app also draws on your Facebook content. You can overlay 360-degree images or videos from your Facebook feed onto the virtual space to plunge you and

**"You can overlay 360-degree videos from your Facebook feed for a customised environment"**

your friends into a customised environment, and flick through 2D photos with them.

Friends without an Oculus Rift VR system can take part via video chat on Facebook Messenger.

**Marijuana easing clinical pain?**

GROWING evidence that medical marijuana really does help relieve some conditions is leading to hopes that it may assist in curbing the US opioid addiction epidemic.

In the US, 28 states have legalised medical marijuana in some form. Conditions sometimes treated with cannabis include pain, depression, nausea, psychosis and seizures.

Now, an analysis of data from 2007 to 2014 has shown that states with legalised medical marijuana spent less than others on prescriptions for those five conditions through Medicaid, a scheme for people on low incomes.

The study couldn't prove that medical marijuana caused this difference. But no difference was

found in prescriptions for conditions unlikely to be treated with cannabis.

This might also be good news for efforts to cut the US opioid epidemic, which is seeing record numbers of deaths from prescription painkillers and illegal opioids. Some studies have found that the availability of medical marijuana is linked to fewer opioid overdose deaths.

David Bradford at the University of Georgia calculated that if all states allowed medical marijuana, the total Medicaid savings in 2014 could have been about \$1 billion (*Health Affairs*, doi.org/b6bc).

However, this pushes the costs on to patients as health insurance doesn't cover medical marijuana, says Bradford.



Reducing prescriptions

**Facts not fakes**

Wikipedia co-founder Jimmy Wales is launching Wikitribune, a news site with articles written by professional journalists and volunteers. Intended as an antidote to fake news, the site will have no adverts and will be free to read, with journalists' wages funded by donations.

**Neural connections**

A stage of brain development has been recreated in a dish - something never observed in real time before. Nerve cells derived from stem cells were seen migrating and forming functional neural circuits resembling those in the cerebral cortex (*Nature*, DOI: 10.1038/nature22330).

**Meet Steve the aurora**

Amateur astronomy group Alberta Aurora Chasers has discovered a new feature in the Northern Lights - and named it Steve. Photos of the mysterious purple streak were posted on their Facebook page. Home astronomers analysed Steve and found it is a common occurrence that just hadn't been noticed before.

**UK's first coal-free day**

The UK had its first full coal-free day since the industrial revolution on 21 April, according to the National Grid. It added that this is a sign of things to come, as coal gets squeezed out of electricity generation by sources such as gas, nuclear, wind and solar. The UK's last coal power station is expected to close in 2025.

**Holiday heart**

A study of beer drinkers at the 2015 Oktoberfest in Munich, Germany, has found that drinking alcohol is linked to a higher risk of developing abnormal heart rhythms. It suggests that heavy alcohol consumption over a short period could be to blame for "holiday heart syndrome", in which people with no history of heart problems develop cardiac arrhythmias (*European Heart Journal*, doi.org/b6bz).

# Early human was small but smart

Mysterious *Homo naledi*'s diminutive brain shows similarities to ours

Colin Barras

IT'S not the size of your brain, it's how you organise it. The most recently discovered species of early human had a skull only slightly larger than a chimp's, but its brain looked surprisingly like our own – particularly in an area with links to language.

This backs suggestions that these mysterious early humans showed advanced behaviours, such as teamwork and burial, even though we still don't know exactly when they lived.

In 2013, news broke of an extraordinary discovery in a chamber deep inside a South African cave. A team led by Lee Berger at the University of the Witwatersrand in Johannesburg had found thousands of ancient human fossils – the largest cache of its kind ever found in Africa.

The first scientific reports were published in 2015. The bones belonged to a never-before-seen early human, which was named *Homo naledi*. It had a peculiar mix of anatomical features, which is part of what makes it hard to tell when the species lived. Berger is expected to publish its age next month, but he told media this week that the best guess is between 200,000 and 300,000 years old, around the time modern humans were also emerging in Africa.

But what really set tongues wagging was the suggestion by Berger's team that *H. naledi* had deliberately disposed of its dead in this deep, dark cave full of remains. Such an endeavour probably required emotional sophistication, not to mention teamwork, but *H. naledi*'s skull was less than half the size of our own. Could its tiny brain have powered such advanced behaviour?

Berger's team thinks it could.

Using pieces of fossil skull, the group has now produced casts of parts of *H. naledi*'s small brain. What excites the team most is a region on the side of *H. naledi*'s frontal lobe called Brodmann area 45, which in modern humans has links to speech production. In this part of our brains, the pattern of ridges and troughs is very different from that seen in chimps. *H. naledi* seems to have had our pattern, even though as an adult its BA45 was not much larger than that of a chimpanzee.

"You look at the *naledi* cast and you think: 'Holy crap, this is just a

tiny human,'" says team member John Hawks at the University of Wisconsin-Madison.

"I would think the implication is that [*H. naledi*] was moving strongly towards enhanced communication," Shawn Hurst of Indiana University in Bloomington, another team member, told a meeting of the American Association of Physical Anthropologists in New Orleans,

**"You look at the *Homo naledi* skull cast and you think: 'Holy crap, this is just a tiny human'"**

Louisiana, last week.

Hurst says there is also evidence for a general expansion of the bottom surface of the frontal lobes – a region associated with higher emotions like empathy. Together, these observations might help to explain why groups of the small-brained hominin could have become interested in careful disposal of their dead, and how they could work together to transport bodies through the narrow and pitch-black cave that led to the burial chamber.

Dean Falk at Florida State University in Tallahassee has looked at the *H. naledi* brain casts and discussed them with Hurst. "We agreed on most of the interpretations," she says – but not on the presence of a modern BA45. "This is just my initial reaction, but to me the general shape of the region looks ape-like," says Falk.

"My first reaction was the same," Hurst says. But hours of comparing the *H. naledi* brain cast with those of other hominins and apes convinced his team it was configured more like modern human brains. When the research is published, Falk and others will be better able to assess the claim.

"In our field, there is this dispute about whether the important thing in human brains is their size or the way they are organised," says Hawks. *H. naledi* seems to suggest organisation is the key.

Simon Neubauer at the Max Planck Institute for Evolutionary Anthropology in Germany says the work supports the idea that brains changed configuration before enlarging. But he says *H. naledi*'s young geological age makes the findings less relevant for understanding the origin of modern human brains, which would have already been around. ■



CAMERA PRESS/PA/JOHN HAWKS/UNIVERSITY OF WISCONSIN-MADISON

*Homo naledi* fossils reveal its biology

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## Koalas' deadly chlamydia cured with a jab

A SINGLE dose of vaccine could halt the chlamydia epidemic wiping out Australia's koalas. It may even pave the way for a human vaccine. In trials, the vaccine has been shown to slow the rate of new infections and treat koalas in the early stages of the disease.

A third of Australia's koalas have been lost over the last two decades, largely due to chlamydia, which now affects between 50 and 100 per cent of wild populations. The sexually transmitted disease causes painful urinary tract inflammation, infertility and blindness.

Chlamydia in koalas is triggered by *Chlamydia pecorum*, a bacterium they may have contracted from livestock originating in Europe. A similar species, *Chlamydia trachomatis*, causes chlamydia in humans.

Unlike in us, antibiotics only work for koalas in the early stages, don't prevent reinfection, and must be given daily for at least 30 days in captivity. Moreover, some infected koalas show no symptoms and are overlooked for treatment while they continue to spread the disease.

Peter Timms at the University of the Sunshine Coast in Queensland, and his team may have a solution. Their new vaccine uses fragments of *C. pecorum* to train koala immune systems to fight chlamydia. The team tested the vaccine on 21 free-ranging koalas in Queensland's Moreton Bay region: six of them had early-stage chlamydia, while the others were healthy. After six months none of the chlamydia-free koalas had become infected, even though half the koalas in their habitat were carrying the disease. In addition, all six that started out with chlamydia were cleared of it.

Kenneth Beagley at the Queensland University of Technology, who co-developed the koala vaccine, is now using the same principles to develop a human version containing fragments of *C. trachomatis* bacteria instead. Alice Klein ■



Anybody out there?

## Why we might never detect alien signals

THE most ambitious search so far for extraterrestrial intelligence has released its first data – and there are no aliens yet. The lack of success could be explained by the result of a new approach to calculating the likelihood of detecting alien signals. This calculation suggests we might never make contact, even if extraterrestrial life is common.

The search for extraterrestrial intelligence (SETI) has been active for decades. Breakthrough Listen aims to be the largest, most comprehensive search ever. The \$100 million initiative uses three of the world's most sensitive telescopes to look for alien signals from the 1 million closest stars to Earth and the 100 closest galaxies.

"It's like finding a needle in a haystack," says Seth Shostak at the SETI Institute in California. "But we don't know how many needles are there."

Breakthrough Listen team members have analysed the light from 692 stars so far. They have

found 11 potential alien signals, none of which remained promising after further analysis.

"It's the beginning of a very exciting time," says Avi Loeb at Harvard University. "But while it's exciting, it's still very risky. We could find nothing."

That's exactly what an assessment by Claudio Grimaldi at the Swiss Federal Institute of

**"It's the beginning of a very exciting time. But while it's exciting, it's still very risky. We could find nothing"**

Technology in Lausanne predicts.

Most methods for calculating the likelihood of detecting alien signals start with an expected number of sources. Instead, Grimaldi started with what volume of the galaxy could be reached by alien signals, a value that requires fewer assumptions about the nature and abundance of extraterrestrial life.

Grimaldi assumed that signals

from an extraterrestrial emitter might get weaker or be blocked as they travel, so they would only cover a certain volume of space. It's relatively simple to calculate the probability that Earth is within that space and so able to detect the signal. "Not all signals can be visible at the same time – only those that intersect with the Earth," says Grimaldi.

He found that even if half of our galaxy was full of alien noise, the average number of signals that we would be able to detect from Earth is less than one (*Scientific Reports*, doi.org/b562).

This implies that, even if there are lots of aliens out there, we might never be able to hear from them. But some researchers take umbrage: Grimaldi's method still requires you to plug in numbers for how far alien signals could be detectable and how long they last – neither of which is known.

"You have to make some assumptions about what the aliens are doing in all these calculations, unfortunately, and the data set that we have with alien activity is fairly sparse," says Shostak. Our only example of intelligent life is on Earth, and there's little reason to expect that ET resembles us.

But, says Loeb, extraterrestrial signals should be no harder to find than other astronomical events.

"The question of whether you can detect a signal has nothing to do with whether it's artificial or natural, and astronomers routinely detect lots of kinds of signals," he says.

"In SETI, theory is great, but observation is the gold standard," says Douglas Vakoch, president of METI International, which aims to send messages to extraterrestrial intelligence. It's not difficult to think up a different signal that we would be able to detect, he says.

For example, if there were alien life at the TRAPPIST-1 planets, just 40 light years away, they wouldn't need particularly advanced technology to contact us. It seems implausible that we would miss their call. Leah Crane ■



Empty stomach, sharper mind?

## How fasting may be good for the brain

Clare Wilson

COULD fasting boost your brainpower? A stomach hormone that stimulates appetite seems to promote the growth of new brain cells and protect them from the effects of ageing – and may explain why some people say that fasting makes them feel sharper.

Ghrelin is known as the hunger hormone, as it is made by the stomach when it gets empty. If we go a few hours without food its levels rise in our blood.

But there is also evidence that ghrelin can enhance cognition. Animals fed reduced-calorie diets have better mental abilities. Injecting ghrelin into mice improves their performance in learning and memory tests, and seems to boost the number of connections in their brains.

Now Jeffrey Davies at Swansea University, UK, and his team have found further evidence that ghrelin can stimulate brain cells to divide and multiply, a process called neurogenesis. When they added the hormone to mouse brain cells grown in a dish, it

switched on a gene known to trigger neurogenesis.

If the same happens in animals, this could be how ghrelin affects memory, says Davies, whose work was presented at the British Neuroscience Association conference this month.

Young brain cells are thought to enhance the ability to form new memories. This is because they are more excitable, so are

### **"This suggests ghrelin or similar chemicals could be used as a treatment for Parkinson's dementia"**

more likely to be activated by new environments. "These neurons will fire more easily than old neurons, and they set in play a new memory," says Davies.

The work may have implications for treating neurodegenerative conditions. Previous research has found that ghrelin can help protect animals from developing a form of Parkinson's disease.

In further experiments, Davies's team has now found that ghrelin protects brain cells in a

dish from dying when they are encouraged to mimic the effects of Parkinson's disease. And Davies's colleague Amanda Hornsby has found that, in a study of 28 volunteers, people with Parkinson's dementia – cognitive impairment caused by Parkinson's disease – have lower levels of ghrelin in their blood.

This suggests that ghrelin, or chemicals that act the same way, could help treat Parkinson's dementia, says Hornsby.

Going on a permanent diet of about 25 per cent fewer calories than the daily recommended amount has several benefits to human health, such as better control of blood sugar levels. Some who try it also say it improves their cognitive abilities, although this is controversial – some studies have suggested it impairs mental abilities.

Some people are now turning to intermittent fasting. It's likely, for example, that diets where people eat normally for five days a week but stick to about 500 calories twice a week raise ghrelin levels.

But Nicolas Kunath of the Technical University of Munich, Germany, says new brain cells can take a few days or weeks to start working, so people shouldn't expect fasting to produce immediate effects on brainpower in this way. ■

## Plastic-loving grubs could eat up our rubbish

CATERPILLARS might hold the key to our growing problem of plastic waste. While removing caterpillars from beehives, researchers in Spain have chanced upon one type that seems to have a taste for the stuff.

The team found that a hundred caterpillars of the *Galleria mellonella* moth can riddle a bag with holes in under an hour, or consume 92 milligrams of plastic in half a day – just over 3 per cent of a supermarket shopping bag. That's fast, considering it takes at least 100 years for a bag to decompose naturally, says team member Federica Bertocchini at the Institute of Biomedicine and Biotechnology of Cantabria.

To make sure the caterpillars were digesting rather than just biting the plastic, the team ground some of them up to make a paste and spread a thin layer on a polyethylene film. Within 14 hours and after some reapplications, the paste had broken down 13 per cent of the plastic. There were also traces of ethylene glycol, a sign of polyethylene breakdown.

"Our study is the first scientific work to show that this species eats plastic, with the chemical depolymerisation of polyethylene," says Bertocchini. This ability might be down to enzymes produced by gut microbes.

Wei-Min Wu at Stanford University, who has studied various plastic-eating species, says the results are exciting. But he notes that the paste acts much faster than anything seen in polyethylene-degrading bacteria isolated so far, suggesting there is an unknown mechanism at work.

Bertocchini is hoping that a single enzyme is what is breaking down the plastic. "If this is the case, I can picture a scenario in the future where we can isolate it, produce it on a large scale and use that to biodegrade plastics." She has founded a biotech company with one of her co-researchers, but they don't yet have the funds to test the idea. Lef Apostolakis ■

## Infrared flare-ups reveal new events in stars' lives

SOME things that go bump in the night can only be seen with heat vision. SPRITEs, a new class of astronomical explosion, may be showing us never-before-seen phases in the lives and deaths of stars.

SPRITEs, short for “eSpecially Red Intermediate-luminosity Transient Events”, are undetectable in visible light. They were spotted only when Mansi Kasliwal at the California Institute of Technology in Pasadena and her team began monitoring 190 nearby galaxies with the infrared Spitzer space telescope in 2014.

In the first year, there were 14 odd flashes brighter than novae but fainter than supernovae. Strangely, these events were invisible to optical observatories like the Hubble or Keck telescopes.

“The question is, what the heck did we just find?” Kasliwal says. There could be more than one answer to that.

The event we know the most about is called 14ajc. Its source appears to be a glowing cloud of warm molecular hydrogen, in the spiral galaxy Messier 83.

This might be what a star-forming nebula looks like after

two young stars, each of about 10 solar masses, brush past each other or collide. That interaction would set off a shock wave through nearby interstellar gas, heating the nebula to produce the infrared glow (*The Astrophysical Journal*, doi.org/b56t).

But many of the SPRITEs have brightened and then faded more quickly than 14ajc. “I do believe that other events are not the same beast, because they just look different,” Kasliwal says.

Another possible source of SPRITEs could be failed supernovae, says Stan Woosley of the University of California, Santa Cruz. In these events, a massive star collapses on to its hardened core, but there is no shock wave

reverberating outwards and tearing the star apart, as in a supernova. Instead, the core crumples into a black hole and the explosion fizzles, leaving only a small outburst at the star’s outer layers.

It may take some time to differentiate between all the options, given that there are just a few observations with the Spitzer telescope. “They have found something interesting, but the available data is so sparse that it is difficult to come up with great hypotheses,” says Chris Kochanek at the Ohio State University in Columbus.

That’s something Kasliwal hopes to address. “How do we make this into an industry, from a cottage industry?” she says.

Since Kasliwal started looking in 2014, Spitzer has uncovered a total of 59 SPRITEs. Kasliwal has shared data about the most interesting ones online in real time, and is organising a workshop in September to study them further. She is also working on a new infrared detector to look for more. The James Webb Space Telescope should also help find answers when it launches in 2018.

“The observers are way ahead of us theorists,” Woosley says. “They are discovering things much faster than we can model or explain them.” Joshua Sokol ■



“What the heck did we just find?”

## Zika may have led to fewer babies in Rio

BRAZIL’S Zika outbreak may have prompted a drop in the number of live births in Rio de Janeiro in late 2016.

Between October 2015 and January 2016, roughly 4000 babies were born in Brazil with microcephaly – abnormally small heads, a condition linked to infection with the Zika virus during pregnancy. In June, the World Health Organization recommended that women in affected areas delay getting pregnant to avoid the risk of

having babies with birth defects. Last month, Marcia Castro at Harvard University presented evidence that this warning didn’t have a widespread impact on birth rates in Brazil last year. But new figures from Rio de Janeiro’s Municipal Health Secretariat suggest the birth rate may have declined in the city during the second half of 2016.

Castro cautions that the records aren’t yet complete, nor are they official figures. However, Margaret Armstrong at the Getulio Vargas Foundation in Rio and her team believe the figures indicate that the birth rate was below average during the period in question.

There may have been several thousand fewer babies than usual, says Armstrong. “It was more pronounced than I was expecting.” She and her team think the decline in live births could be as high as 15 per cent (*bioRxiv*, doi.org/b55p).

A difference between national birth rates and local rates in Rio could be due to the Zika outbreak being particularly pronounced in the city, says Karin Nielsen at the University of California, Los Angeles.

**“Zika can cross the placenta, and any virus that can do this may damage a fetus and cause miscarriage”**

Family planning decisions may be one factor in the decline in birth rate, but miscarriages could also be to blame. Nielsen and her colleagues have shown that, in a small sample of 125 infected pregnant women, Zika infection in the first trimester was linked to a 10 to 15 per cent increase in the likelihood of miscarriage.

Armstrong’s team thinks Zika may also cause very early miscarriages before a woman even knows she is pregnant. Nielsen says this hypothesis is plausible. Zika can cross the placenta, and any virus that can do this has the potential to damage a fetus and cause miscarriage, she says. Chris Baraniuk ■



ZEPHYR/SPL

Picking up brain signals

## Zapping the brain can boost memory

Lefteris Apostolakis

STRUGGLING to remember something? An electrical jolt deep in the brain might help – if it is given at the right time.

To discover the effect of electrical stimulation on memory, Michael Kahana and colleagues at the University of Pennsylvania turned to 150 volunteers who had previously had electrodes implanted in their brains to help control severe epilepsy. These electrodes can record the brain's electrical signals, giving the team a window into each person's neural processes. They can also deliver electricity to the brain.

First, the team recorded the brain signals of the volunteers while they learned items from a list, and then again as they later tried to recall those items. This signal data was then put through machine learning methods, enabling the team to predict if a person's efforts to commit something to memory would later prove successful, based on the state of their brain at the time.

The team next ran further recall tests, during which they delivered random jolts of electricity to the volunteers while they were trying to memorise test items. They compared the effects of jolting someone during two different brain states – the pattern of signals linked to being likely to later remember something, and

### **"Electrical stimulation at the right time gave significant enhancement of later recall"**

the pattern linked to being more likely to have a memory lapse.

They found that giving electrical stimulation when a person's brain signals suggested they would later forget the current item made that person on average 13 per cent more likely to recall it (*Current Biology*, doi.org/b529). "You get significant enhancement," says Kahana.

Timing was key, however. A jolt of electricity during a pattern of brain activity linked to later recall reduced a person's

likelihood of remembering an item by 18 per cent.

The study is the latest of many to probe the question of whether zaps of electricity can improve memory – until now, there have been conflicting results. "Electrical brain stimulation is controversial," says Inês Violante at Imperial College London. "The majority of studies have a very low number of participants. A study of this size is much more reliable."

Kahana is now working on a device that could tell when the brain would benefit from an induced memory boost. "You could build a technology that triggers stimulation at moments when you're predicted to have poor memory, thus enhancing the memory of an individual wearing such a device," says Kahana.

Such a device may be useful for people who have memory loss, but first we need to understand which parts of the brain benefit the most from this kind of stimulation.

While deep brain stimulation already helps people with severe epilepsy or Parkinson's disease, it's an extreme treatment that carries the risk of infection. Experimental approaches that stimulate the brain externally may be a more desirable option. ■

## Hobbit may be migrant kin of *Homo habilis*

THE origins of the mysterious, tiny *Homo floresiensis*, aka the hobbit, are up in the air once again. New research suggests it evolved from a hominin that was the first to ever venture out of Africa.

Remains of the extinct species were discovered on the island of Flores in Indonesia just over a decade ago. Some researchers think it is descended from the larger *Homo erectus*, others that it is simply a short member of our own species, *Homo sapiens*, and that the miniature skull may be the result of Down's syndrome.

Now, the most comprehensive analysis of the remains so far suggests a mystery ancestor that lived in Africa over 2 million years ago. Some members of this ancestral group remained there and evolved into *Homo habilis*, one of the first makers of stone tools. The others left Africa about 2 million years ago, before *H. erectus* did, and arrived in Flores at least 700,000 years ago (*Journal of Human Evolution*, doi.org/b55b).

"As this ancestor spread through South and South-East Asia and then finally on to Flores, it would have gradually changed, finally becoming *H. floresiensis*," says team member Colin Groves at the Australian National University in Canberra.

Previous research had focused only on the hobbit's skull and jaw characteristics, but Groves and his colleagues compared skull, jaw, teeth, arm, leg and shoulder fossils with those of other *Homo* species and more primitive ancestors. They found that *H. floresiensis* was far more closely related to *H. habilis* than to *H. erectus* or *H. sapiens*.

That suggests an ancient lineage and that it shared an ancestor with *H. habilis* – a finding reinforced by its more primitive, diminutive body type. The hobbit's ancestors probably died out across Asia when bigger, more complex species like *H. erectus* and *H. sapiens* emerged from Africa, Groves says. Alice Klein ■

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## FIELD NOTES River Severn, UK

# Out on eel patrol to find the poachers

Clare Wilson

IT'S a cold clear night and the River Severn is sparkling under a full moon. I'm on eel patrol - out with staff from the UK's Environment Agency on the watch for illegal fishing of the critically endangered European eel. This mysterious fish with a mind-boggling life cycle has crashed in numbers by 95 per cent in the past three decades.

European eels spend most of their lives lurking in muddy rivers. At about 10 years old, they swim thousands of kilometres to the Sargasso Sea in the western Atlantic Ocean. There they spawn - and die. Their tiny offspring then make the opposite journey. The Gulf Stream sweeps them to the mouths of European rivers and during the big spring tides the elvers, each about the size of an earthworm, come swarming up the waterways.

The Severn gets a large share because of its prime location facing the Atlantic Ocean and the huge funnel shape of its estuary. The eels once came in such numbers locals would catch them in pillowcases and hold elver-eating contests. Now elver fishing is only allowed on a few rivers and under strict rules: the "elvermen"

must use dip nets below a certain size. And they can sell elvers only to licensed dealers, who must then send 60 per cent for restocking less favoured rivers, with the rest going to aquafarms and restaurants across Europe.

Some say no eel fishing should be allowed, but Chris Bainger at the Environment Agency points out that the Severn gets more incoming elvers than it can support, and this way fishing helps restock other rivers.

But there is a black market, in which elvers are illegally exported to meet demand in China and Japan. Last month, a batch of 600,000 live elvers was found at London Heathrow Airport in a container headed for Hong Kong. That batch probably came from France, but the illegal trade goes on in the UK too, says Bainger.

Officers from the agency go out on patrol most nights in spring, especially when conditions are right for a large "bore", a tidal surge that races up the river. People have fought over the best spots for catching eels, known as "tumps", says Andy Black of the Environment Agency. "There's been guns - it's been like the Wild West."

Once Black has given a safety talk, we drive to our first tump. We meet



Tasty, but endangered

two elvermen who show their permits and nets without protest. As we wait for the bore, Black tells me the locals have become more law-abiding since patrols increased. Most appreciate the need to fish in a sustainable way, says Bainger. "They know it's in their own interest to toe the line."

The anticipation builds, but when the bore comes it is lower than predicted - the river only rises by a couple of metres or so - and each scoop of the nets comes up empty.

The next tump is by a noisy weir, where several elvermen are chatting companionably - no fighting tonight.

You can tell when the bore arrives as the rising water makes the weir go silent, as if someone turned off a tap.

This group have more luck, and they show me their catch, tipping elvers into my hands. Their translucent bodies wriggle, gleaming in the moonlight. They are strangely beautiful, more so given that no one knows how much longer they will call some rivers home.

By now it's gone midnight and I'm starting to shiver, so I don't complain when we head back to base. I may not have found any poachers tonight, but I still had a memorable encounter - and I've got an elver selfie to prove it. ■

## AI learns game thanks to English prompts

AN AI has learned to tackle one of the toughest Atari video games by taking instructions in plain English.

The system, developed by a team at Stanford University in California, learned to play *Montezuma's Revenge*, in which players scour an Aztec temple for treasure.

The game is challenging for an AI to learn because players have to make

several moves before earning any points. Most video-game-playing AIs use reinforcement learning to develop a strategy, relying on feedback like points to tell them when they are playing well.

To let their AI pick up game tactics quicker, the team gave their system a helping hand using natural language instructions, for example advising it to "climb up the ladder" or "get the key".

"Imagine teaching a kid to play tennis by handing them a racket and leaving them in front of a ball machine for 10 years. That's basically how we teach AI right now," says team

member Russell Kaplan. "It turns out kids learn a lot faster with a coach."

The group first trained the AI to associate instructions with screenshots of the same action being carried out in the game. They then let it practise playing the game with a list of instructions for each room in the game, rewarding it for completing commands and for advancing.

To show it was developing a general

**"Imagine teaching a kid tennis by leaving them with a ball machine. They learn faster with a coach"**

understanding of commands like "climb up the ladder", the team ran another experiment in which they removed training data for the second room. The system was still able to follow instructions there despite not having seen them before, says Kaplan, which suggests it is not just learning by rote ([arxiv.org/abs/1704.05539](http://arxiv.org/abs/1704.05539)).

Devendra Chaplot at Carnegie Mellon University in Pennsylvania says using natural language guidance is an interesting approach. "This is extremely useful as it provides a natural way for humans to guide AI systems," he says. Edd Gent ■

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# This rat survives with little oxygen

Michael Le Page

THE naked mole rat can cope fine with oxygen levels low enough to kill us. It can even go 18 minutes with no oxygen at all.

To investigate how well these East African rodents tolerate low oxygen, a team of biologists put them in a chamber with just 5 per cent oxygen, less than a quarter the amount found in air. Such conditions kill mice within 15 minutes – and we wouldn't survive either.

But naked mole rats just carry on as normal. The first test was stopped after 5 hours when nothing happened, says Thomas Park at the University of Illinois at Chicago. "We were blown away."

Next, mole rats were put in pure nitrogen. Being without oxygen kills mice in about a minute. People pass out after a breath or two of pure nitrogen, and would probably die in under 10 minutes. But the mole rats survived for at least 18 minutes. They stopped breathing after a few minutes, but their hearts kept beating and they

revived as soon as they were returned to normal air. "They come back to life without any apparent problems," says team member Gary Lewin of the Max Delbrück Center for Molecular Medicine in Berlin, Germany.

Diving mammals such as

whales can hold their breath for over an hour. But between dives they breathe air at the surface and store oxygen in their tissues to help them survive.

Naked mole rats, by contrast, live in underground colonies of up to 300 animals where oxygen is likely to be limited. "They live in really challenging conditions," says Chris Faulkes of Queen Mary, University of London.

The tunnels that link colonies to the surface are narrow and can get blocked by heavy rain, he says.



Can last 18 minutes in pure nitrogen

ROLAND GÖCKEL/MDC

## LSD puts brain in state we've not seen before

PSYCHEDELIC drugs really do change the state of the brain, it seems, creating a different kind of consciousness.

"We see an increase in the diversity of signals from the brain," says Anil Seth at the University of Sussex, UK. "The brain is more complex in its activity."

Seth and his team discovered this by reanalysing data collected by researchers at Imperial College London. Robin Carhart-Harris and his colleagues had monitored

brain activity in 19 volunteers on ketamine, 15 who had taken LSD, and 14 under the influence of psilocybin, a compound in magic mushrooms. Carhart-Harris's team compared the magnetic fields produced by the volunteers' neurons when they took a drug and when they had a placebo.

"We took the activity data, cleaned it up then chopped it into 2-second chunks," says Seth, whose team worked with Carhart-Harris on the reanalysis. "For each chunk, we could calculate a measure of diversity."

We already know that brains in a state of wakefulness show more diverse patterns of activity than

sleeping brains. But Seth's team discovered that people who have taken psychedelic drugs display even more diversity – the highest level ever measured (*Scientific Reports*, doi.org/b53b).

Such diversity coincided with what volunteers described as "ego-dissolution" – a feeling that the boundaries between self and the world had become blurred. The degree of diversity was also linked to more vivid experiences.

There's mounting evidence that

**"Seeing things in a different way could give your outlook a jolt that existing antidepressants can't"**

What's more, the animals tend to huddle in nesting chambers. "They like to pile together in a big heap of naked mole rats," he says.

So how do they cope with the resulting lack of oxygen? Partly by minimising their need for it. Naked mole rats have a low metabolism and burn little energy heating their bodies, instead staying at the same temperature as their burrows – around 30°C.

They also go into a sort of suspended animation in zero oxygen. But the team found a clever metabolic trick that helps the mole rats survive, too.

Animal cells get their energy from "burning" glucose. When there is no oxygen, these cells must use far more glucose to get the same amount of energy, and the process produces lactic acid. High lactic acid levels can kill cells, so a feedback system soon kicks in to shut down the process, says team member Jane Reznick, also at the Max Delbrück Center.

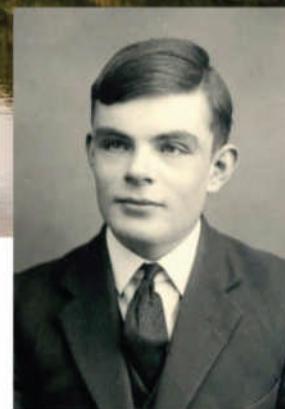
But if cells use the sugar fructose instead, they can bypass this system and keep producing energy. And that's exactly what naked mole rats do: they release fructose into their bloodstream when oxygen drops too low. The sugar is taken up by heart and brain cells to keep critical systems running (*Science*, doi.org/b53c). ■

psychedelic drugs may alleviate depression in ways that other treatments can't. Some benefits have already been seen with LSD, ketamine, psilocybin and ayahuasca. "I think there's an awful lot of potential here," says Seth. "If you suddenly see things in a different way, it could give your outlook a jolt that existing antidepressants can't because they work on the routine, wakeful state."

"These findings are intriguing," says David Mischoulon at Massachusetts General Hospital, Boston. "But we need to learn more about long-term safety, and be aware of complications that may arise from unsupervised use." Andy Coghlan ■

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## Perfect husbands? Robins indulge mate's food cravings

IT'S not just humans who have cravings during pregnancy. The females of one bird species also seem to hanker for certain foods when incubating eggs – and their partners pander to their dietary whims.

"For the first time, we tested whether and how males cater to the specific desires of their mates in the wild," says Rachael Shaw at Victoria University of Wellington, New Zealand. Shaw and her colleagues studied 16 pairs of New Zealand robins at the city's Zealandia nature sanctuary, offering incubating females mealworms and two types of insect larvae. Sometimes the male could see

what his partner ate, sometimes not.

The females generally preferred a food that they hadn't eaten recently. The males somehow knew what food the females wanted, even when they couldn't see what the researchers were feeding them, and brought those foods. This suggests that females can signal their current desires to their mates, enabling males to cater to them in the wild (*Scientific Reports*, doi.org/b5w6).

This is important for monogamous species such as New Zealand robins, in which food sharing is vital to help the female offset the energetic costs of reproduction. The male's ability to provide his mate with the food she wants could be an important factor in determining the success of a pair, as well as influencing whether they stay together, says Shaw.

## Drones monitor bat calls on the fly

BAT-DETECTING drones could discover what the animals get up to when flying beyond the reach of land-based monitors.

Drone-builder Tom Moore and bat enthusiast Tom August have developed two aerial drones and one remote-controlled boat equipped with ultrasonic detectors to listen for bat calls.

In the pair's latest tests last month, one of their aerial drones,

a quadcopter, successfully followed a predetermined course and picked up simulated bat calls.

Moore says one challenge is detecting bat calls over the noise of the drones' propellers. They overcame this by dangling the detector underneath the drone.

The drones the duo have been experimenting with can hear the bats from around 20 metres away, so they aren't thought to pose any

danger to the animals. The drones could be useful for environmental surveys.

Little is known about what bats get up to high in the air, says ecologist Kate Jones at University College London. "We're monitoring on the ground and thinking that's representative of the entire air column – but I don't think that's true," she says. Using drones could give a more detailed picture of how bats move around at higher altitudes, says Jones.

## Hairy bacteria erupt after eruption

GONE today, hair tomorrow. Soon after an underwater volcano erupted and wiped out all nearby life forms, hardy bacteria moved in and covered the sea floor in a huge mat of hair-like filaments.

These strange colonies were seen on an expedition to Tagoro volcano, near the Canary Islands, in 2014, two years after an eruption reshaped 9 square kilometres of the seabed.

"Something very strange appeared to us: a very nice picturesque coverage of very long white filaments, which were very unusual," says Roberto Danovaro of Marche Polytechnic University in Ancona, Italy, whose team made the discovery using robotic subs. "It was the first time we had seen something like that."

It's not clear where these bacteria come from – it could be from the sea column above (*Nature Ecology & Evolution*, DOI: 10.1038/s41559-017-0144).

## Lasers cool three-atom molecule

CALL it the big chill. Lasers have brought a three-atom molecule to within a thousandth of a kelvin of absolute zero for the first time.

Physicists have long been cooling atoms with lasers, zapping them to slow their vibrations. The trick relies on matching the laser energy to the gap between two of the atom's energy levels – which is much harder with molecules as their energies are more complex.

Now Ivan Kozyryev and his team at the MIT-Harvard Center for Ultracold Atoms have finally managed the feat with strontium monohydroxide molecules (*Physical Review Letters*, DOI: 10.1103/PhysRevLett.118.173201). Such cooling could form the basis of future molecular quantum computers, Kozyryev says.

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## Super-Earth might be best yet for life

THERE'S another "Earth-like" world in our galaxy, and this one could let us probe its atmosphere for signs of life.

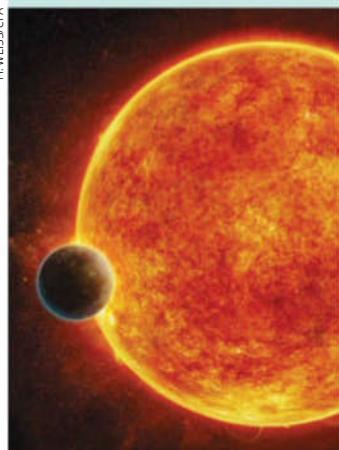
Last week, Jason Dittmann at the Harvard Smithsonian Center for Astrophysics and his colleagues announced the discovery of LHS 1140b, circling the faint dwarf star LHS 1140 in the constellation Cetus. It lies in its star's habitable zone - where temperatures are mild enough for liquid water.

The new planet is a super-Earth - more massive than our world but puny relative to a gas giant. Although it is 1.4 times the size of Earth, its mass is seven times that of our planet, implying a dense world made of rock with an iron core.

Its star emits less radiation than many other red dwarfs, making LHS 1140b more likely to have kept its atmosphere. Astronomers estimate the planet to be at least 5 billion years old - about the same age as Earth, and old enough for life to have evolved.

Dittman and his colleagues made the discovery using the MEarth-South telescope array in Cerro Tololo, Chile, detecting telltale dips in light as the planet passed in front of its star (*Nature*, doi.org/b55f).

Future telescopes could observe that starlight filtering through the planet's atmosphere to check it for biosignatures.



## Mars's rocky companions may be a wrecked mini-planet

MARS has an asteroid entourage, with several so-called Trojans trailing in its wake. Now it seems a cadre of these travelling companions all had a violent beginning: as the innards of mini-planets, eviscerated in a collision.

Trojans are distinct from the asteroids found in the asteroid belt. They follow in the same orbits as planets, at a position that remains fixed relative to their planet, in gravitational sweet spots known as Lagrange points.

True Trojans come from

material present when the planets formed, says Apostolos Christou at the Armagh Observatory in the UK. "The Trojans are really a relic from the early life of the solar system."

In 2013, he went looking for Mars Trojans and found a group accompanying one nicknamed Eureka, which brought the total up to nine. Eureka's companions all seemed to occupy the same area in Mars's orbital path, strongly suggesting they came from one object.

Previous research showed

Eureka is rich the mineral olivine, which forms in the mantles of large rocky bodies but is rare in asteroids. This implies Eureka was once part of a bigger object, maybe a planet, that has long since been destroyed.

Christou studied the sunlight that two other Mars Trojans reflected and found they contain olivine too. This suggests they also came from mantle material, meaning they could be debris from a mini-planet that died in a collision - or pieces shaved off of Mars itself (*MNRAS*, doi.org/b53h).

## Sociable crayfish get drunk easily

A MORE sociable life could make booze work faster. When crayfish are put in water containing alcohol, those that have spent the preceding week alone take longer to show signs of alcohol exposure - such as tail flips - than those that have had company.

To investigate this, Jens Herberholz at the University of Maryland and his colleagues implanted tiny electrodes in the neurons that drive tail-flip behaviour. Exposure to alcohol lowered the intensity of the electrical signal needed to trigger a tail flip. And crayfish that had had company required a lower intensity to spark a tail flip than did loners (*Journal of Experimental Biology*, doi.org/b528).

"This clearly shows a socially induced change in their reaction to alcohol," says Herberholz. The social environment seems to affect the receptors on nerve cells that respond to neurotransmitters like serotonin, which in turn changes how alcohol affects nerves.

A similar system could be at work in humans, Herberholz says: people who are socially isolated may have to drink more to achieve the same level of intoxication.



EDELmann/SCIENCE PHOTO LIBRARY

## Cord blood rejuvenates old brains

IS YOUR brain getting sluggish with age? A protein in umbilical cord blood may help restore its youthful vigour.

Joseph Castellano at Stanford University in California and his colleagues collected blood from humans at different life stages. They then injected the liquid plasma component into mice that were around 50 years old in human terms.

The most dramatic effects were when mice received plasma from babies' umbilical cord. They became faster learners, showed better recall, and displayed enhanced activity in the hippocampus - the brain region

responsible for learning and memory.

The team found that cord plasma has elevated levels of a protein called TIMP2. Injecting old mice with TIMP2 also boosted hippocampal activity and improved maze navigation (*Nature*, doi.org/b522).

How TIMP2 improves cognition is unclear, but it may inhibit some proteins known to be involved in Alzheimer's disease. In theory, TIMP2 would make a better treatment for age-related cognitive decline than cord plasma because it can be synthesised in a lab, avoiding the need for donors, says Castellano.

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BEST CONSUMER SHOW

# The toss of a coin

Bitcoin is at a crossroads. One route could see it rival Paypal, the other could see it slip into obscurity, says **Timothy Revell**

FOR the better part of a decade, bitcoin has been touted as the currency of the future, but for most people it has remained just that – a future not current currency. Technical problems have stymied its mainstream adoption.

But now, an elegant fix to one of bitcoin's most intractable problems could clear the way, potentially making bitcoin as easy to use as the debit card in your wallet today.

If, that is, bitcoin's decentralised network of users agree that this is a good idea. The community is at war with itself: some want it to remain a niche currency, used only for sending money across borders or for purchasing items on the dark web. "There are some very outspoken people in bitcoin's core development team that are stopping progress – it's crazy," says Olivier Janssens, a bitcoin investor.

So why are we at this crossroads, and will it lead to a bitcoin we use to pay rent and buy coffee – or will it seal the cryptocurrency in permanent obscurity?

## Gathering momentum

Despite a bumpy road, bitcoin's continued rise in value and users indicates its potential to become a viable mainstream alternative to traditional currencies



When bitcoin was introduced in 2008, it promised to become something you could use to buy whatever you wanted, without the need for banks (see "What's so great about bitcoin?", right).

Nearly 10 years later, bitcoin is the world's largest digital currency. Its value and number

**"There is a war on between people who want bitcoin to go mainstream and those who want it to stay niche"**

of users have risen (see graph, below), as has the average number of transactions.

But recently, the currency has become a little stuck. In its earliest days, bitcoin transactions were free and would take about 10 minutes to process. Now, people are paying more than \$1 per transaction on average to the miners who both create bitcoin and process transactions on the network, and can wait hours or days for transactions to be confirmed.

This delay is down to the rise in users. The bitcoin network can support at most seven transactions per second. Compare that with Paypal, which can do 100 per second on average – or Visa, which routinely does about 4000, and could do much more if pressed.

If bitcoin is to compete, it needs to lower fees and be faster. Few would pay \$1 to use bitcoins to buy their morning cup of coffee, and that number would drop to none if you had to wait a day for the payment to clear.

Bitcoin has long been in need of an upgrade, but deciding the best way to do that is difficult. By definition, the bitcoin network is under no centralised control. So any decision to make big changes requires a consensus among its users. And at the moment, that seems a long way off.

The controversy is over whether to change the software that is now struggling to cope with bitcoin's increasing popularity. It all comes down to a simple line of code in the bitcoin network software that sets the maximum block size – representing the number of transactions allowed over roughly 10 minutes – to 1 megabyte. Throw any more transactions at the network than that, and they have to either wait or pay a higher fee to get bumped up the queue.

There seems to be an obvious solution: why not just lift the 1-megabyte limit? In 2015, a group of developers led by Mike Hearn, who had left his job at Google to become a bitcoin developer, tried to do just that. Hearn created a new version of the software running the bitcoin network that changed the limit to 8 megabytes.

The update sparked a furore. One problem was that the new



REUTERS/David Gray

software wasn't backwards-compatible, so once activated, anyone running the old system would essentially be kicked off the network.

There were more fundamental objections too. Many worried that if the blocksize increased, users would need more computing power and faster internet speeds to be part of the network. Some people feared that this could lead to greater centralisation because only the most powerful mining groups could remain active.

## Price crash

By 2016, it was clear that Hearn's attempt to increase the 1-megabyte limit had failed. As a result, he sold his bitcoins and ceased his involvement with the currency. Two days later, bitcoin's value had dropped by nearly 15 per cent.

How to increase block size continued to be a problem



Time to ring the changes

without a solution. So when a possibly elegant workaround was publicised, many took notice.

Segregated Witness, or segwit, is a suite of technical improvements to the bitcoin network that allows users to have their cake and eat it: it provides a way to effectively increase the 1-megabyte limit without actually changing it.

The trick is that segwit removes some of the data included with each transaction and stores it elsewhere. This reorganisation quadruples the limit size. And yet, it is backwards-compatible. Users will still be able to run older versions of the bitcoin software. And you won't need to quadruple your processing power to join the bitcoin club.

Since being released in October last year, segwit has been slowly growing in popularity, and now has about 30 per cent support on the bitcoin network – compare that with the 15 per cent at which

Hearn's 8-megabyte solution peaked. If support can hit 95 per cent and stay there for two weeks, segwit will be activated.

That may seem a long way off, but there could be a dark horse in the mix. Another digital currency called litecoin is on the cusp of a segwit rollout.

Litecoin's software is almost identical to bitcoin's, but the currency's total value of about \$500 million is around a 40th of bitcoin's. If segwit performs well on litecoin, "bitcoin users will take note", says Ghassan Karamé at NEC Research Laboratories in Heidelberg, Germany. In other words, if the upgrade works for litecoin, it could cause support on bitcoin to rapidly head for the required 95 per cent.

If segwit makes it easier for more people to use cryptocurrencies, it will help bring them into the mainstream. Among its improvements, segwit

also clears the path for inclusion of a system called the Lightning Network. This allows any regularly occurring transactions – for example, your daily bus fare – to be batched as a monthly bill instead of being confirmed singly.

That would reduce fees because they wouldn't need to be paid for every transaction, just the total. Advocates say this could turn bitcoin into an everyday currency, opening up the possibility of easy-to-use bitcoin debit cards, turning bitcoin into a credible competitor for the likes of Visa and Paypal, able to process millions to billions of transactions per second.

But first the stalemate needs to be resolved. "Right now, bitcoin is at an impasse," says Janssens. "If things don't change soon, bitcoin will start to lose its importance."

Oddly enough, that may be exactly what some members of the network would prefer. Some people are already making a lot of money, and going mainstream could lose them their edge.

One group that benefits disproportionately from the current setup is the miners who create bitcoins. Mining is more profitable when members of the bitcoin network must pay fees for transactions – more fees translate to more bitcoin rewards for processing transactions. "If the users say that retail isn't the way to go, other digital currencies can

### "The new technology opens up the possibility of easy-to-use bitcoin debit cards that compete with Visa"

spring up to do that job instead," says Andreas Antonopoulos, host of the Let's Talk Bitcoin podcast.

However, if segwit leads litecoin to success as a retail currency, it might edge out bitcoin. Either way, litecoin's decision on whether to adopt segwit could end up determining the future of bitcoin. And perhaps the future of cryptocurrency is not bitcoin at all. ■

## WHAT'S SO GREAT ABOUT BITCOIN?

Bitcoin is popular because it's free from the control of banks or governments.

"Anyone can send money to anyone else in the world with a transaction fee of less than a dollar," says Andreas Antonopoulos, who hosts the Let's Talk Bitcoin podcast. Anyone can – but not everyone does (see main article).

Digital currencies like bitcoin exist solely as records stored on computers around the world. That might seem strange, but few traditional currencies are actually linked to physical commodities like gold any more. For example, most US dollars exist only as digital records held by banks.

Why do you trust that these digital 0s and 1s have value? Because governments back them, and other third parties like banks and payment processors like Visa vouch for the transactions.

But governments can devalue a currency by printing extra money. And the 2008 recession showed that banks don't always operate with their customers' best interests at heart.

Proponents of digital currencies say they replace these intermediaries with code. The only thing you need to spend digital currency is knowledge of a secret number associated with an online wallet that no one else needs to vouch for.

To check whether a bitcoin transaction is legitimate doesn't require a central bank. Instead, it is done by a decentralised network of computers that anyone can join. The system is underpinned by the same mathematics that powers encryption, making it incredibly hard to deceive or control without infeasible amounts of computing power. "The system is built to resist hostile takeover," says Antonopoulos.

It's not surprising then that since its conception in 2008, bitcoin has gone from being a plaything of hackers to a multibillion-dollar juggernaut. Every day, there are hundreds of thousands of bitcoin transactions, with people sending money around the world with no centralised oversight or government control.

# New theory, old problem

The dominant idea that life online is the primary driver of deepening partisan attitudes may need a reboot, says **Lara Williams**

THE internet is habitually invoked as the prime facilitator of today's political polarisation. The hermetic echo chambers of Twitter, Facebook and YouTube, the idea goes, are increasing division and entrenchment of the sort seen in the Brexit and Trump campaigns.

Users subscribe to feeds, pages and channels offering news that closely represents their world view, proponents say, along with misinformation about those who disagree with them, sealing them off from alternative discourse.

But there's a problem with this idea. A working paper published by the US National Bureau of Economic Research found that polarisation had increased most in the over-75s, those least likely to use the internet. It seems the reductive "online echo chamber" maxim isn't that helpful; social media and the internet is, at heart, participatory, requiring at least



the veneer of a conversation.

That paper's focus is the US, but it is reasonable to assume the findings will be similar in the UK. As to why polarisation grew faster in the over-75s than the young, nobody quite knows.

The authors don't dismiss internet effects. They speculate that divisions fuelled online may radiate out to older groups who don't use social media, or indirectly cause polarisation offline through selection of political candidates, for example, or by disrupting traditional media.

One of the economists behind the work has also said polarisation in over-75s could be down to "non-digital media" that need not be accountable and don't necessitate dialogue – not even an echo.

There are, of course, other possible explanations for their pace of entrenchment. Chief among them is that the politics of

## Human flood

It's not just coastal populations who will be caught up in sea level rise, says **Jeff Goodell**

IT IS an obvious truth that rising seas will displace a lot of people. Recent studies indicate that nearly 190 million are directly at risk, and that in more extreme scenarios in excess of 1 billion would be in jeopardy. Where will they go? What impact will they have on the places they flee to?

Mathew Hauer at the University

of Georgia has taken a stab at answering such questions. Looking at the US, he drew on studies identifying 13 million people likely to be displaced if seas rise 1.8 metres by 2100.

Hauer reasoned they are likely to follow the paths of earlier migrants, and used historical data to predict where they would head.

His most compelling and thought-provoking finding is that rising seas are not just a problem for coastal elites with beach houses and waterfront condos. Every state in the US will be affected, either by residents fleeing or by those seeking refuge.

Nine states will see population falls, with Florida the biggest hit, losing more than 2.5 million residents. Texas is the biggest gainer, with 1.5 million arrivals. Among cities, the key losers are

**"Migration could happen in an orderly fashion, giving officials time to adapt. But it might not"**

Miami (down 2.5 million) and New Orleans (500,000). The biggest gainers are Austin, Orlando and Atlanta, each with 250,000 or more new residents.

In a perfect world, a population surge could be a boon. But as Hauer points out, many cities that would swell – Phoenix, Las Vegas, Atlanta – already have water and growth-management issues.

Migration could happen in an orderly fashion, giving officials time to adapt. But it might not. It's not hard to imagine a flood-driven version of *The Grapes of Wrath*.

The implications are darker for countries such as Bangladesh where sea level rise threatens

nostalgia have been on the march for some time. The culmination was the Trump campaign, predicated on a rose-tinted view of the past. His administration assuages the anxieties of those most wary of progress: the old.

In the UK, where a surprise June general election was announced last week, we saw the Brexit campaign capitalise on the same reverence of how things used to be. A breakdown of polls showed support for Brexit among over-65s was 60 per cent – the highest of any demographic. Likewise for Trump: a majority of voters aged 65 and over backed him.

If progress feels alienating and hostile, the fetishised past becomes a cosy place to become entrenched. Its familiarity can be potent. This denotes a psychological phenomenon in which people prefer things they know well. If this also manifests in media consumption and voting choice, the digging in of heels becomes more pronounced, and the offline bubble is sealed.

Those hoping to undo Brexit in June's poll shouldn't pin hopes on key older voters who backed Leave or try to tweet them into a change of heart. ■

Lara Williams is a writer based in Manchester, UK

chaos, poisoning farmlands and polluting drinking water supplies. The ties between mass migration and political conflict are evident.

Hauer's study is just a first pass at getting to grips with all this. It suggests that even the US is very unprepared for what is to come.

The bigger picture is that as rising seas eat away at the world's coastlines, it's going to affect everyone. You can build all the walls you want, but in the end, we are all in this together. ■

Jeff Goodell is author of *The Water Will Come: Rising seas, sinking cities, and the remaking of the civilized world*, out in October (Little, Brown)

## INSIGHT Facebook



It can be hard to stop watching

# AI can't stop violent video going viral

**Chelsea Whyte**

LAST week, a man chose 74-year-old Robert Godwin Sr at random on a street in Cleveland, Ohio, shot him, and uploaded the video to Facebook. Sadly, this is only the latest nefarious use of social video. As increasingly easy-to-use video applications have lowered the barrier to entry, we have seen it spread from beheadings by Islamic State, to gang rapes and suicides.

This latest horror has unleashed a wave of criticism for Facebook. What responsibility should the company bear for preventing these kinds of videos? It's easy to demand fixes from the platforms that host them, but this elides some uncomfortable truths about who else is to blame.

To be sure, Facebook has not covered itself in glory. Its initial response to the video tellingly referred to it as "content". It was reportedly at least 2 hours before the video was taken down.

Emerging research suggests violent footage could lead to more violence. "People who are otherwise mentally distressed could get the idea that [this] would be something they would

want to do," says Sherry Towers at Arizona State University, who has found a relationship between how widely a gruesome act gets shared and the likelihood of copycat violence.

Most of the solutions being demanded of Facebook are technical. For example, people point to the 3-second delays used by live broadcasters to avoid the unexpected. Some call for better algorithms to flag and remove content before it is shared; or AI to censor videos before they can even enter the network.

Leaving aside the fact that right now, asking for AI to police 1.86 billion

**"Asking for AI to police 1.86 billion Facebook profiles is like asking for a magic spell"**

Facebook profiles is the equivalent of asking for a magic spell, do we want all violent video to be pre-emptively culled by an algorithm? Last year, video of a man being fatally shot by a police officer while reaching for his ID in his car set off protests in the US. When it bears witness to police violence or to the effects of chemical

warfare, video can raise awareness and hold those in power accountable.

So at whose discretion do some violent videos stay, while others go? AI is certainly not capable of making fine distinctions yet; Facebook's process is still unable to reliably differentiate between photos of breastfeeding mothers and pornography. And this is an easy task compared with deciphering intent.

Whatever sophisticated algorithms we develop in the future, the question of censorship might depend more on human nature than on technological possibility. "The reason media stories about mass killings or things like this murder are so popular is that the public has a desire to read about it," says Towers. Even after Facebook removed the video, the footage circulated on other platforms. In one of those posts, the video had 1.6 million views.

Facebook's explanation for the delay in removing the footage was that it took that long to be reported by users.

Eventually, Facebook will need to take responsibility for its content, and the way to do that is by paying more human employees to take on that role, instead of offloading the problem onto as-yet-notional AI or the unpaid volunteers it counts on to police each others' accounts.

It's not letting the company off the hook to say Facebook is only part of the problem. We bear some of the blame for circulating the videos, and there's no app for that. ■

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## APERTURE





## Weevil, away!

IN THE lush rainforest of east Tanzania, a pink weevil prepares for take-off.

Wildlife photographer Paul Bertner came across the insect resting on a leaf while walking through Udzungwa National Park at night. He was able to capture the moment it spread its wings and launched into the darkness.

Udzungwa is part of the Eastern Arc Mountains, which span Tanzania and Kenya in east Africa. Because of its remote location, the rainforest here hasn't attracted the same attention as its counterparts in central Africa, like the Congo rainforest, and so remains largely untouched.

Its isolation also means that Udzungwa is home to plants and animals that have evolved in unique ways. Thousands of species here are found nowhere else, and Udzungwa is commonly referred to as Africa's Galapagos Islands.

Bertner's brief encounter with the pink weevil was a "moment of calm in a stormy voyage," he says. During a six-month trip through the forests of Congo, Tanzania, Rwanda and Madagascar in 2014, he had to navigate his way between militia groups, facing aggressive guards and harsh weather. "I spent Christmas on a bus that slipped off the road eight times in 8 hours on a mud road that had been destroyed by the rains," he says.

Nevertheless, it was worth it to be able to photograph the hidden world of Udzungwa, Bertner says. "I am just happy to be in pristine nature and to simply observe." Alice Klein

### Photographer

Paul Bertner

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# DEFYING DEMENTIA

We can fight back against the 21st-century scourge, finds Kayt Sukel

WHEN you have dementia, the thought processes and memories you once took for granted can shift and vanish, even as you reach for them. It can be like going to fetch something from a familiar cupboard, but "you open the cupboard and there's nothing there," says Sube Banerjee, director of the Centre for Dementia Studies at the University of Brighton, UK. "You know it should be there but it's not." If that sounds scary, think about the prospect of not being able to recognise your own partner or child. It's not without reason that dementia is the disease people over 60 fear the most.

More than a third of people in the UK have a family member or friend with dementia, and it's a similar story elsewhere in the developed world. Globally, 1 in 20 people over 60 lives with the condition. And thanks to our longer lifespans, those numbers are expected to soar.

The figures are alarming, as are the stories of people who have experienced dementia. But these testimonies help us understand it. And knowledge is power. Dementia is not an inescapable result of ageing, and we are making inroads against it. There may not yet be a cure, but we can do things to help keep it at bay, and hold it in check once it's struck. Read on to find out how we can wrest back control.

ANGUS GREIG



# WHAT CAUSES DEMENTIA?

**D**EMENTIA isn't inevitable. The human brain can stay sharp well past 100 years of life. Yes, getting older slows us down: parts of the brain associated with memory and executive function shrink, myelin sheaths around our neurons start to erode, slowing down signalling, and arteries narrow diminishing blood supply. But those things mainly affect speed: when healthy older people are given extra time to perform cognitive tasks, the results are on par with younger folks.

In contrast, dementia alters the cognitive playing field. As well as affecting memory, it causes issues with understanding or expressing oneself in language, problems with sensory perception, and disturbances in executive function that can undermine day-to-day independence.

Dementia also isn't just one thing. "People sometimes use dementia and Alzheimer's disease interchangeably. But that isn't correct," says John Haaga, director of Behavioral and Social Research at the US National Institute on Aging, (see "The different kinds of dementia", page 31).

Genes play an important part in many kinds of dementia. If you have a parent or sibling with it, you are more likely to develop it yourself. More than 20 different gene variants are now known to influence susceptibility, (see "Should you test your genes?", page 32).

The various conditions give rise to similar symptoms by different means. Vascular dementia, for instance, can result when cardiovascular disease or a stroke limits blood supply and damages brain tissue.

Alzheimer's disease, the most common cause of dementia, is characterised by a build-up of hard plaques of beta-amyloid protein between brain cells, and tangles of tau protein within them. The amyloid hypothesis, the leading idea for how these plaques drive cognitive decline, suggests that a build-up of plaques causes inflammation in the brain, which spurs development of tau, which disables and then kills brain cells, resulting in memory loss, confusion and other symptoms.

This hypothesis is supported by research in families with early-onset Alzheimer's, which strikes before age 65; many have gene variants that interfere with the ability to clear amyloid. That is also the mechanism by which a certain variant of the *APOE* gene that codes for apolipoprotein E – a protein that binds to and affects the clearing of beta-amyloid – can increase risk of Alzheimer's.

Yet, despite the dominance of the amyloid hypothesis, the absolute cause of Alzheimer's is far from being agreed on. To begin with, autopsies reveal that many people die with a significant amount of amyloid in their brain without ever showing dementia-like symptoms. And promising amyloid-clearing drugs have failed spectacularly in clinical trials involving people with advanced disease, (see "Will we find a cure?", page 33).

Still, most researchers in the field remain convinced that beta-amyloid is central to the Alzheimer's tale, even if it doesn't tell the whole story, says Laurie Ryan, programme director for Alzheimer's disease clinical trials at the US National Institute on Aging. There is also evidence that it may be a kind of "diabetes of the brain", Ryan says, where the ability to use glucose, our brain's essential fuel, is impaired. With a condition as complicated as Alzheimer's, as with other forms of dementia, many different factors probably contribute.

## 3 out of 4

people in the UK don't realise they can reduce their risk of dementia

SOURCE: ALZHEIMER'S RESEARCH UK

# WHY IS ALZHEIMER'S ON THE RISE?

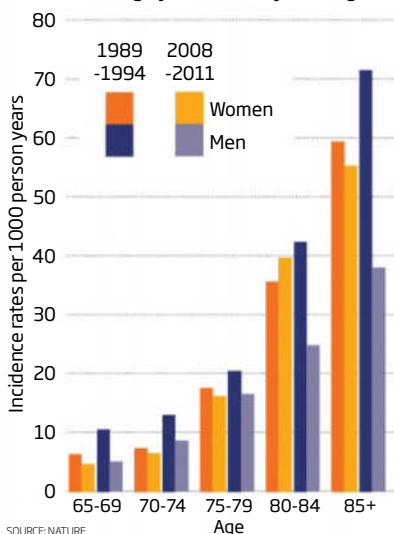
**A**LZHEIMER'S disease strikes after our reproductive years, so the established thinking is that there has been no evolutionary pressure to weed it out, and its prevalence has risen simply because we are living longer.

Things might not be that simple. The "grandmother hypothesis" has it that helping raise your grandchildren boosts the chances your genes will be passed on. So any gene that lets you do this by fending off Alzheimer's provides an evolutionary edge.

Previous research suggested such genes offer protection by enhancing the hormone oestrogen's anti-inflammatory activity in the brain. Now Molly Fox of the University of California, Los Angeles, has some evidence to support the idea. Her team calculated lifetime oestrogen exposure for 81 women over 70 by looking at onset of puberty, pregnancies, age at menopause and other factors. Each extra month with oestrogen was associated with a 0.5 per cent decrease in Alzheimer's risk. That suggests changing exposure to the hormone - due to having fewer children, among other things - may be linked to the rise in Alzheimer's.

## BEATING BACK DEMENTIA

In the UK, improvements in education and heart health may have helped reduce dementia rates, although women remain more vulnerable - largely because they live longer



# WHAT CAN YOU DO TO AVOID DEMENTIA?

**T**HE number of people affected by dementia may be rising, but most specialists say that's largely because more of us are living longer. Between the late 1980s and 2011, the proportion of people over 65 with dementia actually dropped by 20 per cent in England and Wales. Between 2000 and 2012, dementia rates in that age group dropped by 24 per cent in the US. Similar declines have been reported in other developed countries.

There are two driving factors, says Kenneth Langa at the Michigan Center on the Demography of Aging, who tracked the US trend: a rise in educational attainment and better control of cardiovascular issues.

After the second world war, there was an increase in schooling that averaged out to about an extra year of education across the US population. Research suggests that people with more education, or those who have done things like learn a new language or learn to play a musical instrument, may be resilient to symptoms of dementia.

That doesn't mean they escape the ravages of vascular dementia or plaques of Alzheimer's, but they may cope better with the damage. "By challenging your brain during education, you create a more fit brain that can compensate for problems that you have as you age," Langa says.

Increased cognitive reserve is thought to help in two ways: boosting the brain's ability to work around damaged areas, and promoting more efficient processing. That might also explain why people with more education seem to decline so rapidly: it's not that Alzheimer's comes on suddenly, it's that by the time symptoms manifest the disease may already be quite advanced.

As for cardiovascular risk factors, while the prevalence of conditions such as high blood pressure and diabetes has risen over the years, there has also been an increase in treatments that can limit their damage.

But poorer countries haven't seen such advances. And despite improvements in wealthier nations, the absolute number of dementia cases will probably continue to climb – the decline in prevalence isn't steep enough to make up for the rising tide of ageing baby boomers, says John Haaga at



the US National Institute on Aging. "People are living longer – and that's great. We're also living with our wits intact for much longer," Haaga says. "But we can't deny that we have a much larger population of ageing persons to contend with in the future." What's more, there is not a significant educational attainment difference between 65-year-olds and 25-year-olds today, and metabolic diseases like diabetes are on the rise. That means gains we've made may not continue apace.

It is also important to acknowledge that much of dementia risk is down to genetics, about 70 per cent in the case of Alzheimer's disease, says Jonathan Schott of the Dementia Research Centre at University College London. Too often he sees patients lamenting that they didn't do enough, but sometimes there is only so much you can do. "We know that some people have strong genetic risk factors that can predispose them to some forms of dementia whether

**20%** of dementia cases around the world could be avoided with improvements in public health

SOURCE: WORLD HEALTH ORGANIZATION



they live a healthy lifestyle or not," he says.

Still, if 30 per cent or more of dementia risk is down to lifestyle and environmental factors, there is an opportunity to make a difference. Maintaining social connections, keeping a healthy diet, exercising regularly, practising good sleep habits and pursuing intellectual challenges may all delay or lessen symptoms of dementia later in life. "Walk, talk and read," says Langa. And do it now. "These changes have the most effect when they are started earlier in life."

Physical activity may be most critical. Regular exercise not only addresses risk factors such as weight and cardiovascular health, but it increases the creation of brain cells, connections between neurons, and production of nerve growth factors and neurotransmitters, says Arthur Kramer at University of Illinois at Urbana-Champaign.

You don't have to run ultra-marathons to reap the benefits. Just an hour-long walk a few times a week can make a difference.

ANGUS GREG

# WHAT ARE THE WARNING SIGNS?

**W**HEN it comes to memory, all of us get a bit creakier as we age. It's common to forget the specific word you were searching for, miss the occasional appointment or misplace your car keys. "It happens to all of us," says Sube Banerjee at the University of Brighton, UK.

So when might a memory issue be more than just a little extra creakiness? Because so many things can cause dementia, symptoms and severity can vary greatly, making it difficult to catch the earliest warnings. But common signs include problems with short-term memory, abstract thinking, the ability to focus, visual perception and communication.

There's no reason to be alarmed if you do have the odd "senior" moment. For one thing, people of all ages have differences in memory, says Joseph Masdeu, director of the Nantz National Alzheimer Center at Houston Methodist Hospital in Texas. And as well as slowing down, certain skills shift as we get older. "Multitasking, the ability to deploy attention to multiple things at the same time, becomes more difficult," says Jason Brandt, director of medical psychology at Johns Hopkins University in Baltimore, Maryland.

One warning sign might be the inability to summon a memory even when

prompted. With normal ageing, it might take you longer to remember, says Brandt, but at early stages of Alzheimer's, having more time won't help because "the information has degraded". When these types of shifts happen, or memory or cognitive problems begin to interfere with daily life, it's time to consult a doctor.

Healthcare professionals have tools to help catch problems early. To assess patients over 60, most use some version of the mini-mental state exam, which asks simple questions about time and place and is designed to measure cognitive impairment. Doctors may also test working memory by asking people to count backwards from 100 in 7s or remember three unrelated items after a period of time. If you score poorly on these kinds of tests, you should expect to be referred for further testing.

For people who want personalised feedback from home, Brandt and his team developed an online tool. It includes a series of memory tests, as well as a questionnaire about different risk factors for dementia. "This enables people to do something in the privacy of their home," he says. If there is something worrying, it directs you to follow it up with your doctor. The test can be found at [alzcast.org](http://alzcast.org).

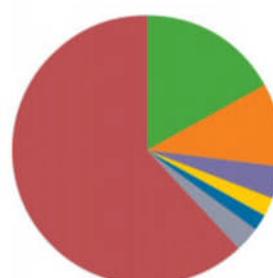
## THE DIFFERENT KINDS OF DEMENTIA

Dementia is not one thing. There are several routes to similar symptoms

**ALZHEIMER'S 62%**  
Causes problems with memory, language and reasoning. 5% of cases start before age 65

**VASCULAR DEMENTIA 17%**  
Impaired judgement, difficulty with motor skills and balance.  
Heart disease and strokes increase its likelihood

**MIXED DEMENTIA 10%**  
Several types of dementia contribute to symptoms. Most common in people over 85



**OTHER 3%**  
Conditions such as Creutzfeld-Jacob disease; depression; multiple sclerosis

**DEMENTIA WITH LEWY BODIES 4%**  
Caused by Lewy body proteins. Symptoms can include hallucinations, disordered sleep

**FRONTOTEMPORAL DEMENTIA 2%**  
Personality changes and language problems. Most common onset between the ages of 45 and 60

**PARKINSON'S DISEASE 2%**  
Can give rise to dementia symptoms as the condition progresses

# HOW BEST TO CARE FOR SOMEONE WITH DEMENTIA?



PLANPICTURE/MASKOT

HERE are a few drugs to treat the confusion caused by dementia. Some can, for a limited time, help improve memory. But there aren't yet drugs that offer a cure. Dementia treatment is more about finding the right way to care for a person whose mental faculties are declining. Because it varies so much from person to person, there is no "best practice" plan.

Dementia is often thought of as a disorder of memory. But to slow its progression, it may be best to focus on factors that are simply due to ageing – trouble with vision, for instance. "What we do depends on what the most annoying symptoms are," says June Andrews, a specialist in dementia care and author of *Dementia: What you need to know*. Simple things like improving the lighting, clearly labelling drawers, avoiding patterned floor surfaces and wallpapers or making sure

someone has access to large-print books and reading glasses, can make a big difference to how rapidly symptoms progress.

"There is not a lot we can do about the pathology," says Andrews, "but there are masses we can do to reduce the symptoms. And it is the symptoms that are dementia."

To stay well with dementia you need to avoid stress, stay hydrated, exercise, be distracted with interesting things, keep pain under control, avoid constipation and sleep well – among other things, says Andrews. The more you can attend to these needs, the longer someone will be able to maintain a higher quality of life.

There are some new strategies being developed – care homes that focus on helping people better engage with their environment and look after themselves, for instance. But there is no definitive research to

show one care type is better than another, says Sube Banerjee at the University of Brighton, UK.

People often live for a decade or more after a dementia diagnosis, and their needs will be different at different stages. Three key aspects have been shown to improve outcomes. First is increased awareness and understanding of the disorder from the public and medical professionals. Second, diagnosis as early as possible so people can take part in planning their future while they have the capacity to do so. And third is quality of care and support from family.

Part of that is ensuring that the caregivers look after themselves too, says Banerjee.

Family can be critical to whether a patient will do well, he adds. "There are little miracles happening every day where family members help put the focus on what patients can do rather than what they can't."

## SHOULD YOU TEST YOUR GENES?

WITH about two dozen genes accounting for 70 per cent of your Alzheimer's risk – the only kind of dementia we can do genetic tests for – taking a test may seem like a simple choice. But with no cure in sight, what can you do with the results?

Having the *APOE4* gene variant, for instance, only means you have a higher risk of Alzheimer's, not that you will get it. Genes associated with early-onset Alzheimer's, such as certain mutations of *APP*, *PSEN1* and *PSEN2*, are more definitive. But even those with a family history of the disease struggle with whether to get tested. Carol Jennings

knew she had a 50 per cent chance of having the faulty *APP* gene, but didn't want the test. With no cure, what was the point?

Only when symptoms began did she finally get tested. Now Jennings's two adult children, who may have the same mutation, face that difficult decision. One doesn't want the test; the other hopes the results can guide future plans.

It's understandable that genetic testing prompts mixed feelings. Today it is mostly useful for identifying candidates for clinical trials, and to help researchers understand the disease and potential treatments, says Laurie Ryan at the US National Institute on Aging. "It can't tell us anything like, 'If you have this variant, we need to do this to help you'."

# WHAT IS DEMENTIA LIKE?

**W**I TH so many different causes, each person's experience of dementia is bound to be unique. But specialists say the best way to understand what it is like for a loved one may simply be to ask. If they have mild to moderate dementia, they should be able to answer. What they say may surprise you.

**Stuart Jennings**, is the carer for his wife Carol (see "Should you test your genes?", left), who has advanced Alzheimer's. He is a chaplain at the University of Warwick, UK.

## What is it like seeing your wife develop dementia?

The best analogy I know is a sandcastle. Little by little bits trickle away. The decline is slow and relentless, but then periodically there are huge falls, and you realise you've lost something more – and for good.

## What did she say it was like for her?

She didn't want to talk about that, she was pragmatic, she talked about what she wanted. "Please keep me clean," she said. "If you're struggling, please get me into a good home." And the most important thing: "Please make sure that my brain is donated."

Now I too have signed up to donate my brain for research – as a healthy control. It's probably the most powerful expression of our love for each other, that we'll beat this awful illness, even in death. It's an act of defiance.

**Lorraine Brown**, worked as a mental health nurse for 24 years. She has early-onset Alzheimer's, which was diagnosed in 2014. She serves as an ambassador for the Alzheimer's Society in the UK.

## Before you were diagnosed, were there signs?

I used to do a lot of bluffing. If I couldn't recall people's names, I'd try to catch their eye, or deliberately go and stand near them to ask a question.

The symptoms really go unnoticed for up to 10 to 15 years. And in that time, I was slowly changing. I know we all change, but I was losing my personality, myself.

## When did you know something was wrong?

One day I went to a patient's house in a very familiar area, a stone's throw from the hospital where I worked. When I came out, it was as if somebody had placed me in a different town. When I looked around, I couldn't recognise the buildings, the road markers, any of that. It had all gone.

# £12.9 billion

could be saved annually in the UK by 2050 if we can delay the average onset of dementia by two years

SOURCE: ALZHEIMER'S RESEARCH UK

# WILL WE FIND A CURE?

**N**EWS headlines seem to announce promising new treatments for dementia each month. But while many drugs have helped prevent or reverse dementia-like pathology in animal models, they have so far failed to do so in human clinical trials.

With Alzheimer's, many drugs have focused on clearing excess beta-amyloid from the brain. But several clinical trials have been cancelled because of lacklustre performance.

In fact, the medications barely stood a chance of helping the people they were tested on, says Joseph Masdeu at Houston Methodist Hospital in Texas. "The drugs were not given until the participants already had cognitive problems. The damage was already done." But if given to people when they are unimpaired, many researchers are confident drugs could make a difference.

Both beta-amyloid and tau proteins can be seen in brain scans decades before there are cognitive issues (see "What causes dementia?", page 29). That offers a window for intervention.

But which individuals should be targeted for these kinds of measures? An area of intense research is to identify definitive signs of dementia in the body. Finding an equivalent of cholesterol, a biomarker that, although imperfect, helps doctors understand who is at risk of heart disease, would be a game-changer. It would allow doctors to screen patients early for potential disease – and decide who would benefit

from different preventive approaches, says Kenneth Langa at the Michigan Center on the Demography of Aging.

The lack of progress isn't for lack of trying. There are studies of families and groups with early-onset Alzheimer's, the largest of which is known as the Colombia cohort. Teams are feverishly hunting for genetic and environmental factors that affect dementia risk. There are analyses of long-term studies like that tracking a group born in the UK in 1946. There are trials involving people with the *APOE4* gene variant, known to increase risk of late-onset Alzheimer's – particularly in women. And there are efforts to use neuroimaging to identify amyloid build-up ever earlier.

Teams are investigating ways to treat inflammation that may cause dementia's cognitive symptoms after amyloid build-up as well, and focusing on agents that may offer neuroprotection or neuroregeneration.

"There are a lot of pieces to this puzzle," says Laurie Ryan at the National Institute on Aging. "It's likely there will be different treatments and interventions for different patients if we really want to affect change in the long term." Langa agrees. "The next 10 to 20 years will be very interesting," he says. "We can do more to get in there and intervene to decrease the risk and prevalence of dementia. We're doing the work." ■

Kayt Sukel is a writer based in Houston, Texas \*Additional reporting by Tiffany O'Callaghan

# Excess baggage

Insights into hoarding disorder reveal why we all can find it hard to throw things away, says Elizabeth Landau

**O**N 21 March 1947, police arrived at a home in New York's Harlem district, after a neighbour called convinced there was a dead body inside. Confronted by walls of newspapers and other junk, officers had difficulty getting in. One patrolman finally squeezed through a second floor window and found a warren of twisting passageways lined with bric-a-brac, some armed with booby traps. After scaling a mountain of junk he discovered the emaciated body of 65-year-old Homer Collyer. More than two weeks later, as the clean-up continued, the corpse of his brother Langley was unearthed some 3 metres from where Homer had died.

Amassing more than 150 tonnes of stuff, including 14 grand pianos, the Collyers became a notorious example of hoarding. But if the craze for decluttering tells us anything, it's that many of us find it difficult to throw things away. Despite the feeling of catharsis that dumping our junk can bring, our possessions often outgrow our homes: around 10 per cent of US families, for example, rent a unit in one of the country's nearly 53,000 self-storage facilities. And for up to one in 20 of us, hoarding is a diagnosable psychological disorder (see "Do you have a hoarding problem?", page 36).

But you needn't be sleeping on newspapers or wading through piles of clothes to have experienced the pain of letting go. Why can it hurt so much to get rid of stuff you will never need again? Researchers investigating what's going on inside the minds of people with hoarding disorder have uncovered some intriguing paradoxes. Their findings can also help those of us who would like to better understand our motives for amassing clutter – or identify strategies to get rid of it.

It's tempting to think of hoarding as a modern problem – a regrettable by-product of consumerist culture. In fact, it has ancient

roots. Many animals stockpile food to prepare for harsh winters or guard against theft by other animals. Likewise, our prehistoric hunter-gatherer ancestors benefited from hiding supplies so that wild animals and other bands of early humans wouldn't get to them. Archaeologists have uncovered such stashes dating back almost 10,000 years, containing food, jewellery and more. "I suspect that any culture where there's a large number of relatively inexpensive, easily accessible things will have a significant hoarding problem," says Randy Frost at Smith College in Northampton, Massachusetts.

Reality TV may have brought hoarding to public attention recently, but it's almost 25 years since Frost helped pioneer research in the field when he placed an advertisement in a newspaper calling for chronic savers and pack rats. We now know that between 2 and 6 per cent of people grapple with hoarding disorder. Most are diagnosed in middle age, and there is some evidence that the tendency to hoard increases as we age. However, hoarding behaviours are thought to begin quite early, even in adolescence. "Often, we finally see people in treatment when they're 50 [or so], but they've been hoarding for decades,

TOM WATSON/NY DAILY NEWS VIA GETTY IMAGES



Few can rival the notorious Collyer brothers when it comes to clutter



OLIVIER CULMANN/TENDANCE FLOU



and that means that they have a huge volume of stuff and the problem is severe," said Jessica Grisham from the University of New South Wales in Sydney, Australia.

Until recently, hoarding disorder was seen as part of obsessive compulsive disorder. But there are key differences. People with OCD go through their daily lives haunted by negative thoughts, which influence their behaviour. Hoarding, by contrast, includes positive emotions. "In addition to the anxiety and distress people feel when throwing things away, there's also this kind of addictive element, a pleasurable side of hoarding that you don't see in OCD," says Grisham. "People who hoard often like their stuff, they feel pleasure, joy and happiness and love toward their possessions." The growing realisation that this is not the same as OCD meant that in 2013, hoarding got a separate classification in the Diagnostic and Statistical Manual of

***"Despite the clutter,  
they tend to have  
perfectionist qualities"***

Mental Disorders, the standard guidebook for mental health professionals.

Brain studies reinforce the idea that hoarding involves a distinct pattern of thinking. Only small studies have been done so far, but there is clear evidence that people with hoarding problems show different kinds of brain activation during decision-making tasks compared with individuals with OCD and those without either condition. In particular, regions of the brain responsible for understanding how important something is relative to something else "get turned all the way up" in people with hoarding problems, says David Tolin at the Institute of Living, a psychiatric hospital in Hartford, Connecticut. "The brain is not functioning in a way that is conducive to making rapid, intuitive decisions, and instead the person has to think really hard about everything."

Tolin and his colleagues used fMRI to explore what happens inside the brains of people with hoarding disorder when asked to decide whether to keep or discard their own letters and papers and others that did not belong to them. The team found excess activity in key frontal lobe areas involved in decision-making, such as those related to assigning values and making value judgements – but only when volunteers were making decisions about their own stuff. We may all have this problem to some extent. Since the 1980s,



NATALIA CALVOCRESI/MILLENIUM IMAGES/UK

behavioural economists have been exploring the so-called endowment effect – the tendency to assign a higher value to things that belong to us than to those that do not. Even if you have only just acquired an object, the pain of losing it increases as a result of possessing it.

The problems of people with hoarding disorder extend beyond decisions about their own possessions, though. Last year, Christina Hough and colleagues at the University of California, San Francisco, asked people with hoarding disorder to carry out general cognitive and decision-making tasks, and found overactivity in some of the brain regions implicated in Tolin's work.

## Creative thinking

This group also showed increased activity in visual regions of the brain compared with other people. This fits with the idea that people who are inclined to hoard process information in a more complex way. Instead of organising their possessions efficiently, by category, they may keep track of objects visually and spatially. "Many of them seem to have a mental map of the pile in the middle of the room and can tell you, roughly, where things are in it," says Frost. They also tend to pay attention to unusual details in objects, seeing beauty where others see mundaneness. A person with hoarding disorder might think of 10 different things to do with an old soda can, and use that to justify keeping it. "[They] do seem like very intelligent, very creative people," says Tolin. "But a strength can eventually become a weakness."

Hough's team found something else intriguing, too. Brain activity indicated that people with hoarding disorder are highly aware of their potential to make a bad

decision, even when it doesn't really matter. This fits with the idea that, in spite of their disorganised clutter, they tend to have perfectionist qualities. They might intend to read all their magazines from cover to cover before getting rid of them, for example, or they might be hampered by their desire to dispose of objects in the best way possible.

Although each person with a hoarding problem is unique, there are certain patterns of thinking that clinicians often see. People who hoard often maintain that it's better to

## DO YOU HAVE A HOARDING PROBLEM?

Few people's lives are free from clutter but when hoarding becomes pathological there are telltale signs. Here's what to look out for:

- Keeping things that are broken or lack monetary value.
- Difficulty categorising or organising possessions.
- Severe anxiety when attempting to discard items.
- Indecision about what to keep and where to put things.
- Extreme attachment to items and suspicion of others touching them.
- Clutter that interferes with relationships and daily living.

## MOST WANTED

Commonly hoarded items include:

- Newspapers/magazines
- Plastic bags
- Photographs
- Household appliances
- Food
- Clothing

People who hoard may form a mental map of their possessions

save items that could be useful in the future than to dispose of them. Many talk about a sense of responsibility towards their things, wanting to make sure that they get properly recycled or donated or used to their fullest extent. They may keep things simply because they find them attractive. However, often they develop emotional attachments to objects, seeing them as mementos and even imbuing them with person-like qualities.

These ways of thinking are not unique to hoarding disorder. "We all save things because we're sentimentally attached, or we think they could be useful, or we think they are pretty. It's just that someone with hoarding problems will carry that to an extreme," says long-time hoarding researcher Gail Steketee of Boston University. Grisham agrees: "The kinds of beliefs of people with hoarding problems are similar to the ones everyone endorses, just at a much higher level, about many more things."

It's still not clear why some people develop a hoarding problem, but we do know that it tends to run in families, and there has been some evidence of genetic associations. "We think that you don't inherit hoarding per se. You inherit something that makes you vulnerable to having a hoarding problem," says Steketee.

So, what should you do if you think this applies to a family member or friend? "Don't argue about hoarding, ever. You will lose," says Tolin. Indeed, it can make things worse: when criticised, people who hoard often get defensive and become even more entrenched in their habits. Instead, encourage them to seek professional help. Cognitive behavioural treatments lasting several months can have "reasonably good results", says Tolin. They work by instilling strategies for managing the condition. But they cannot cure it.

For anyone trying to address a hoarding problem, Tolin, Steketee and Frost have some advice in their book *Buried in Treasures: Help for compulsive acquiring, saving, and hoarding*. First you should examine your values and motivations for bringing objects into our homes. Then you should come up with rules about what you allow yourself to acquire. Organising your possessions in systematic ways will also help. But letting go of things will be a struggle. "It involves dealing with the beliefs you hold and the emotions you experience," says Steketee. That's not easy, but you can change. "It takes time. It's like a muscle that you build." ■

Elizabeth Landau is a writer based in Pasadena, California. Follow her on Twitter at @lizlandau



# Unbreakable

Master the strongest atomic bond and we can do some amazing things, says James Mitchell Crow

MOST people do their best to avoid the manchineel tree. Even sheltering under it during a rain shower could give you a nasty surprise. Its sap is toxic and water-soluble, so any drips bouncing off the trunk and on to your skin will yield blisters. And don't even think about eating its small round fruit – in central America, where it grows, it is sometimes known as the “little apple of death”.

Phil Baran isn't like most people. For him, the toxin the tree secretes, called phorbol, is an intriguing curiosity. It exemplifies the elaborate chemical structures and interesting effects that naturally produced molecules can have. Give phorbol a few tweaks and it morphs from a toxin into a potential anticancer agent. Other natural products might be the basis of the next great pill, perfume, plastic or pigment.

To study them we must first make and manipulate these natural products in the lab. And that's where synthetic chemists such as Baran run up against a gnarly problem. Natural chemicals put up a barrier in the form of a particular atomic bond, one that crops in all of them and is incredibly tough to break. Until now, that is: Baran and a few others think they have a way to break the unbreakable and usher in a new era of chemical alchemy.

Synthetic chemistry is all about breaking old bonds and making new ones: it is responsible for most of the human-made stuff we see around us. And the bonds we most want to make are between one carbon atom and another. That's because carbon chemistry is the molecular language of living things, and so it is also the language medicines must understand.

To bond carbon to something, you must first remove one of the atoms already ➤

INSADCO PHOTOGRAPHY / ALAMY STOCK PHOTO

## NATURAL WONDERS

Chemicals produced by plants and animals are the basis of many successful drugs

### MORPHINE

This painkiller is found in a number of plants, including poppies. It was isolated in the early 19th century and first used during the American civil war.

### ASPIRIN

It has been used to treat pain and inflammation for thousands of years, but in pill form only since 1899. The active ingredient comes from the leaves of the willow tree.

### PACLITAXEL

This compound was isolated from the Pacific yew tree and approved to treat a range of cancers in 1993. Achieving the first chemical synthesis took 12 years.

### ARTEMISININ

Part of a combination of drugs now used to treat malaria, artemisinin was isolated from the sweet wormwood herb by Tu Youyou, who shared a 2015 Nobel prize for the discovery.

Poppies still provide the raw material for morphine production



PETER PITSCHENZEW/GETTY

attached to it. Chances are that it will be a hydrogen atom. Ever since carbon was forged within the first stars, it has been pairing up with hydrogen, the most abundant element in the universe. Wherever you find carbon in the natural world, it will probably be nestled inside a hydrogen blanket.

Take crude oil, our favourite raw material for making drugs and much more. It is based almost exclusively on carbon and hydrogen. The clue is in the name we use for many of its ingredients: hydrocarbons. Their long chains of atoms can be chopped into smaller, workable fragments using an industrial process called catalytic cracking, which involves heating them up beyond 500°C. But this can't break carbon-hydrogen bonds in the controlled way needed for useful chemistry.

### Molecular rubble

The problem is that hydrogen, once attached, is supremely difficult to dislodge. Chemical bonds are often the result of two atoms sharing a pair of electrons, and because hydrogen is the smallest atom, it gets particularly close to carbon and forms a particularly strong bond.

"If you look in a textbook, you'll find it's a very thin chapter on CH bonds because there's very little chemistry that can be done on them," says Huw Davies, a chemist at Emory College in Atlanta, Georgia. Until recently, one of the few strategies we had for breaking CH bonds was combustion, which leaves molecular rubble that's no good for making anything.

There is a more subtle option. Under normal circumstances, breaking a bond means shifting its two electrons to one of the atoms, while the other gets nothing. This creates two electronically charged fragments. But there is a fundamentally different sort of split where each atom gets one electron, generating uncharged fragments called radicals. In the case of the CH bond, you can do this by adding chlorine gas and shining particular frequencies of light on the chlorine. It will then rip away the hydrogen along with one of its electrons, leaving a carbon radical. This is then primed to react to form a fresh bond. The trouble is, radicals are flighty critters that will react quickly with almost anything. Chemical chaos is the result.

That leaves chemists in an sticky situation. It's a bit like plotting a route across a sprawling city without being able to make any right turns. Whole blocks of the metropolis seem impossible to reach unless you execute an

Nature's way with chemistry can take years to emulate in the lab



elaborate series of left turns to loop around to the waypoint a single right turn would have got you to. Not being able to manipulate CH bonds is, for chemists, akin to not being able to steer one way.

It means making a natural product in the lab is a lengthy task. A typical synthesis of phorbol, that toxin from the manchineel tree, takes 52 separate reactions. Each might take a day or so, with another day on top of that to purify the desired compounds from the reaction broth. Add in dead-end attempts, and perfecting the synthesis can take years.

That said, chemists have got extremely good at the turning-left-type reactions that break carbon's bonds with atoms like nitrogen, oxygen, chlorine, sulphur and more. Since the 1970s, they have developed various metal catalysts that act like matchmakers. These will grab first one carbon and then another, snapping off the bonds to other atoms in the process and bringing the two carbons smoothly together, creating a new bond. These "cross-coupling" reactions have paved the way to many of the natural-product-inspired drugs in use today (see "Natural wonders", above left). No wonder they won the 2010 Nobel prize in chemistry.

Cross-couplings are, however, far from perfect. One niggle is that the catalysts will only do their grabbing if the carbon is first



VLADIMIR BULGAR/SCIENCE PHOTO LIBRARY/GETTY

modified with something like a boron or zinc atom – not usually difficult, but another time-consuming step.

Baran, at the Scripps Institute in La Jolla, California, has little patience with these meanders. He advocates a concept called ideal synthesis. “All it says is that you should do things in the laziest way possible,” he says. This involves “right turn” chemistry, if you will, and eschewing any unnecessary reactions like adding those boron and zinc atoms. Instead, Baran is taking aim at “native groups” of atoms that are already commonplace. His hit list includes arrangements of carbon and oxygen atoms called carboxylic acids, carbon-carbon double bonds – and the CH bond.

One way to dismantle them is to turn them into those supposedly skittish radicals. But rather than adopt the old approach of using chlorine, in 2014 Baran designed an iron-based catalyst that would grab a carbon-carbon double bond and generate a free radical at exclusively that position. That radical can then react with a different carbon atom to form a new single bond, with no elaborate pre-activation required.

Baran and others have made similar progress using carboxylic acids. And his eye for the ideal is paying dividends: last year he brought phorbol synthesis down from 52 steps to just 19.

But although double bonds and carboxylic acids are common, they have nothing on the ubiquitous CH bond. Until we crack that, we can’t say the right turn reactions are nailed.

Nice, then, that serious progress is being made here too, including off the back of an accidental discovery by David MacMillan at Princeton University. He had been working on a reaction triggered by high-energy ultraviolet light, and designed to form a different type of

## “The idea of ideal synthesis is to do chemistry in the laziest way possible”

bond. It worked, but its cost, complexity and safety considerations around powerful UV lamps meant it wasn’t practical.

So he asked a member of his team to find an alternative. The researcher happened to talk to a friend working on catalysts used to capture sunlight for artificial photosynthesis systems. When the researcher gave them a go in his own reaction, it worked almost immediately using low-energy light.

Although chemists have worked on these “photoredox” catalysts for decades, MacMillan’s group was the first to show that their ability to both donate and receive single electrons – most catalysts can only do one or

the other – makes them perfect for powering the breaking and making of carbon bonds via radical chemistry. They soon had one catalyst working in a reaction that rips away single electrons from CH bonds, generating carbon radicals that can then be coupled to another carbon of their choice.

“Photoredox is very exciting; it leads to unusual ways of putting molecules together,” says Davies. Pharmaceutical companies are already considering how to adopt these catalysts in their drug discovery and manufacturing, says MacMillan. Merck, for example, has developed a custom photoredox reactor that uses blue LEDs and is shaped to maximise the uptake of the light. “We have reactions that are done now in 1 or 2 seconds. It’s wild,” says MacMillan.

Yet conquering the CH bond is a double-edged sword. The feat is useful because they are everywhere, but that ubiquity is also problematic. It’s all very well gaining the power to slice the bond open. But molecules with more than five or six carbon atoms – which is to say nearly all medicinally interesting natural products – can easily have 10 CH bonds. How to sever the correct one?

MacMillan has a plan on this front too. His catalysts can discern the dance of electrons around CH bonds, a dance that differs narrowly depending on the arrangement and type of the other atoms the carbon is connected to. He hopes to create versions of his catalysts that act selectively.

Davies’s lab has demonstrated an impressive example how this could work. Davies took a molecule of pentane, a simple compound consisting of five carbon atoms linked in a chain and covered with hydrogen atoms. Chemically, there’s virtually nothing to distinguish any one of its CH bonds from another. Yet by synthesising and screening a series of catalysts, the team found one that breaks only the CH bonds of the second carbon in the chain with 95 per cent selectivity. “Pentane was a showcase challenge,” Davies says. Now he is moving to try the same trick on molecules that are useful waypoints en route to natural products.

None of this, of course, will replace the classic left hand chemical reactions like cross-couplings. The challenge is to come up with equally powerful right hand reactions, so that we can turn both ways. “I hope,” says Baran, “that some of the reactions we develop end up being as good as the old ones.” ■

James Mitchell Crow is a science journalist based in Melbourne, Australia

# Fish extinctions? Not if I can kelp it

After decades of pillaging the seas on commercial fishing boats, **Bren Smith** had an epiphany. Now he wants to restore balance to the oceans with 3D ocean farming

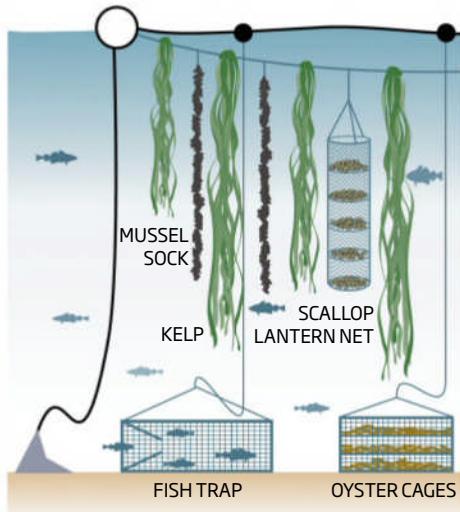
**You have pioneered the idea of farming within the ocean's water column. What inspired you?**  
I'm not a scientist, I'm not an engineer, I'm not an oceanographer – I'm just a regular guy who grew up in a small fishing village and dropped out of high school. After more than 30 years travelling the world catching all kinds of fish, I couldn't deny the damage commercial fishing causes. I decided to learn to work with the ocean, not against it.

**What did you do in response to seeing this damage from commercial fishing?**

First, I went from ocean fishing to ocean farming: for seven years or so, I grew oysters on my coastal farm. But when the storm surges of hurricanes Sandy and Irene hit, my farms were completely wiped out. I realised I had to rethink

**Vertical thinking**

By utilising the entire water column, 3D ocean farms can produce a lot in a small area



my farm design. That's when I developed the 3D ocean farming model, which involves more flexible infrastructure that's better able to withstand storms and less expensive to replace if it does get ruined.

**What is 3D ocean farming, exactly?**

It's farming that utilises the whole coastal water column, from top to bottom, so a lot is produced in a relatively small area. Thimble Island Ocean Farm, my original farm in Connecticut, goes down to 6 metres, but the 3D ocean farming model can work in anything from 3 to about 25 metres of water. Seaweed, particularly sugar kelp, and mussels are grown on ropes hanging in the water above oyster and clam cages (see diagram, left). One acre of sea can produce between 10 and 30 tonnes of sea vegetables and 250,000 shellfish every five months. We catch a few fish, too. Nutritionally, ocean plants like seaweeds are just as healthy and often healthier than land-grown foods. And bivalves are a source of lean protein that grows quickly.

**What is so good about farming in water?**

First off, you don't have to fight gravity, so all you need is cheap but strong underwater infrastructure. An ocean farm is easily tended from a boat and doesn't require the expensive inputs needed by most aquaculture and land-based farms. Crucially, we don't have to feed or water "crops" once we seed them. Being in coastal waters means they often benefit from the nutrient-rich run-off from fertilised land farms. And the farms are visually low impact, with just some buoys visible above the water.

**You call your farms "restorative". Why?**

Kelp is among the world's fastest growing plants, so it could absorb large quantities of carbon from the atmosphere, making it

**PROFILE**

Bren Smith is executive director of non-profit organisation GreenWave and owner of Thimble Island Ocean Farm, Connecticut



the perfect crop for helping to mitigate climate change. And each oyster can filter 50 gallons of water a day. Many aquatic ecosystems suffer from excessive nitrogen, mostly from fertiliser from industrial farms. Shellfish pull that nitrogen out of the water. And we're not catching many fish, so vertical farms become artificial reefs, havens for hundreds of species. Finally, the farms are strong yet flexible, helping to protect the coastline from storm surges.

**Is your 3D system catching on?**

I created the non-profit organisation GreenWave a year-and-a-half ago. Since then, we have helped 12 farmers adopt the model in the north-east US. These are not franchises; we simply help them set up and offer ongoing support. We have another 25 farms in the pipeline, and in the next five years we will have helped create as many as 100 farms in the region. They are cheap to set up, and that's the key to replication while everything else in



RON GAUTREAU/GREENWAVE

the world is getting more expensive. Right now, we have interest in every coastal state and 20 countries.

#### You paint a very positive picture. What problems does ocean farming face?

Oceans are a commons: anyone can boat and swim in them, and people can dive around our kelp forests, which are also a great place for recreational fishing because they're such rich ecosystems. But you can imagine a scenario in which there are many poorly placed farms – it could become a battle for sea space. We've already experienced the not-in-my-back-yard effect, a little pushback from locals wary of coastal farms.

But really the downside is climate change, and how to stay ahead of the curve. Will I be able to grow sugar kelp 10 years from now? Warming seas have already wiped out natural kelp forests in some tropical parts of the world, so climate is a real threat. If we don't do the science now to determine which species will

survive in evolving climatic conditions, things will change, we won't know how to adapt and everything I've done could be for naught.

And then there's another question: how will we get American consumers to embrace kelp?

#### Do you think it will be possible to make eating kelp mainstream?

Such things take time, but we can't continue eating fish – our last wild, staple food – at its current rate. Climate change is altering ocean habitats by warming seawater, and the increased carbon in the oceans is making the water more acidic, so many fish stocks are falling. Couple that with overfishing and we could be looking at entire populations being wiped out. As Jacques Cousteau said, "We must plant the sea... using the sea as farmers

**"One acre can yield 30 tonnes of vegetables and 250,000 shellfish in five months"**

instead of hunters. That is what civilisation is all about – farming replacing hunting."

My goal is to rearrange the seafood plate, moving sea vegetables and bivalves to the centre and fish to the edge as something to be savoured occasionally. Fish should be a treat. There are thousands of edible ocean plants and hundreds of shellfish species to explore.

**What will push people in the right direction?** This year, GreenWave won the Sustainia award in Denmark. At the ceremony in Copenhagen, I got to eat incredible food prepared by René Redzepi, a chef with two Michelin stars. The 20-course meal was almost completely made up of shellfish and seaweeds. It's up to chefs to make ocean-farmed foods delicious, that's what will drive people's dietary acceptance of sea plants and animals. We do climate farming; they need to do climate cuisine. Perhaps we can make kelp the new kale. ■

Interview by Erica Cirino

# Seeing is not perceiving

Context dictates what your eyes take in, says **Anil Ananthaswamy**

*Deviate: The science of seeing differently* by Beau Lotto, Weidenfeld & Nicolson

**DEVIATE**  
THE SCIENCE  
OF SEEING  
DIFFERENTLY  
INTRODUCED AND READ BY  
**BEAU LOTTO**

"THE doubt-driven ride this book will take you on is going to physically change your brain," claims Beau Lotto early in *Deviate*. He wants to change our brains by making us reassess the reality we perceive.

The book draws on his research at University College London, where he studies perception, and his work at the Lab of Misfits at London's Science Museum – an exhibition creating experiences designed to alter how and what our brains perceive.

To this end, *Deviate* plays with the book's design: some words get larger fonts (making the page look like a word cloud), and occasionally pages are upside down, or columns of text run diagonally across. The intent is to shake up our very experience of reading.

The idea that our perceptions don't mirror objective, external reality is not new. People with neuropsychological conditions provide stark evidence that we can perceive things that really aren't there. The question is whether everyday perception is also questionable.

*Deviate* takes sides, aiming to convince that normal perception is also suspect. As Lotto says, "We're all like Alice all the time...except that we didn't have to drop through the rabbit hole. We're already deep inside it." And he tries myriad ways to show us that. There's the delicious story of Goethe's ill-advised odyssey



PASCAL ALMAYER/TENDANCE FLUVE

to undermine Newton's theory of light with his own theory of colour. Goethe got it wrong because "like most of us, he took for granted that he saw reality".

Then there's Michel Eugène Chevreul, a French chemist who showed why the colours of the tapestries displayed in the Paris showrooms of the 1820s ("rich burgundies, grassy greens, sun-kissed golds") looked so different in the homes of customers. The perception of a colour has to do with the colours surrounding it – reality is constructed in the mind.

That's the key idea: perception is the outcome of the brain trying to make predictions, based on experiences and assumptions that are either hardwired (over evolutionary time) or that accumulate during individual lifetimes. If we have to change ourselves, for whatever reason, then "the first challenge is to

accept everything you do is a reflex grounded in your assumptions", writes Lotto.

He reveals how to see things differently, with some tantalising insights. For instance, if your perceptions are the result of what your brain has experienced and the meanings attributed to these experiences, one way to change your future perceptions is to use the power of thought and imagination to rewire those associated meanings.

Unfortunately, the book rarely gets stuck in for long. So in the section on changing our past to influence our future, he writes: "Governments – especially totalitarian ones – and their spin doctors understand the power of re-meaning history". But in

**When it comes to colour, reality really is constructed in the mind**

two paragraphs, he has moved on to big data.

*Deviate* can wander into pop psychology, as when Lotto talks about how living purposeful, creative lives means having to embrace uncertainty. He even dispenses relationship advice: "Waking... with another needs to be like seeing a sunrise."

In the end, *Deviate* can't quite make up its mind if it's about the neuroscience of perception or helping us change our lives using neuroscience. The tension is best illustrated when Lotto discusses how hard it was to apply his neuroscientific knowledge to make sense of an illness causing him neurological problems: "You know too much and nothing." ■

**"One way to change future perceptions is to rewire the meanings associated with past experiences"**

Anil Ananthaswamy is a consultant for New Scientist

# Taking a brush to nature

**Matthew Cobb** on an epic experiment to domesticate foxes

**How to Tame a Fox (and Build a Dog): Visionary scientists and a Siberian tale of jump-started evolution** by Lee Alan Dugatkin and Lyudmila Trut, University of Chicago Press



NEARLY 60 years ago, Russian scientist Dmitri Belyaev began a remarkable experiment that still runs to this day. His aim was to selectively breed wild silver foxes to see if it was possible to bring about a similar transformation to the one that turned wolves into dogs. *How To Tame A Fox*, co-authored by US biologist Lee Dugatkin and by Belyaev's long-term collaborator, Lyudmila Trut, is a charming account of this study, which has intrigued behavioural geneticists and evolutionary biologists for decades.

Begun in secret at the tail end of Trofim Lysenko's devastating rule over Soviet genetics, Belyaev's study was expected to take a long time to produce significant results, if it ever did. Although foxes had been bred in captivity for their fur since the end of the 19th century, they remained as bitey and cross as they had been all those decades earlier.

Under Belyaev's leadership, Trut and her co-workers used standardised tests to identify the least aggressive animals, and then mated them together. Within three years, the foxes began to accept humans and breed slightly earlier in the year. After four years, one cub, Ember, wagged

his tail when Trut approached the cage. After eight generations, curly tails appeared. A few years later, some foxes began to breed more than once a year.

These findings were significant. In *On the Origin of Species*, Charles Darwin wrote that in virtually every domesticated mammal species, certain characteristics often appeared alongside tameness: floppy ears, star-shaped forehead markings, multiple breeding periods and reduced, often curly tails. (Camels are an obvious exception, but they are so bad-tempered that they are arguably not tame at all.)

Belyaev became convinced that this revealed something about the genes involved in domestication. He put forward the rather vague

notion that domestication involves a period of "destabilising selection", affecting the hormonal control of development. Dugatkin and Trut recast this idea in terms of gene regulation, but it isn't clear what extra insight into domestication this gives.

When Belyaev began the study, DNA's role as the hereditary material in animals was only suspected. Now, whole genomes can be compared and scientists can study where and when genes are expressed. As well as a story of scientific determination, *How to Tame a Fox* is therefore also

**"Certain characteristics appear with tameness: floppy ears, forehead markings and curly tails"**

a striking description of how much science has progressed.

Yet while the social context is informative and Trut's memories are often heart-warming, I wanted more science. There are repeated references to how cute, loyal, irresistible and rambunctious the tame foxes are, but not one set of data showing the speed with which selection had an effect.

Only five pages are given over to summarising the molecular genetic data from the past decade or so, to no very great conclusion. The group has recently identified 335 genes that show differences in their activity in tame and control foxes, some of which affect hormone levels. But there's little evidence that these same genes were involved in wolf domestication.

For the moment, the persistent reappearance of the same suite of characteristics in various domesticated species remains a mystery. The most likely explanation, as Belyaev suggested, is that they are all focused on prolonging infancy, leading to changes in hormones and behaviour. Strikingly, these changes aren't seen in the line of aggressive foxes that Belyaev astutely set up in parallel to the domestication study. Those foxes are simply very, very cross.

After about 20 generations, the tamed foxes became truly like dogs: loyal and unbearably cute. It is now possible to adopt a tame fox – the substantial fee goes towards supporting the research project. After reading *How to Tame a Fox* I am very tempted, but my cats would object. ■

Silver foxes have been tamed, but it's unclear how the process works



ARTYOM GEODAKYAN/TASS VIA GETTY IMAGES

Matthew Cobb is a zoologist at the University of Manchester, UK

# Reinventing the world

Alternative economies are coming of age, finds **Paul Mason**

*Another Economy is Possible: Culture and economy in a time of crisis* by Manuel Castells, Polity



IMAGINE a motorway whose builders reach an unexpected cliff. They can stop, or carry on building, driving supports into the seabed.

Since the 2008 financial crash, the world economy has expanded over such supports: cheap or free money, created by central banks, together with cost-free insurance policies extended by states to banks, and, by proxy, to anybody who can afford them.

But, as Bank of England boss Mark Carney put it, are we building a bridge between crises or a pier to nowhere? Do efforts to keep the old economic model going lead anywhere other than permanent stagnation?

The remarkable thing about mainstream economics is that, having come up with an excellent metaphor, it cannot face up to it. For any central bank, state or corporation to even contemplate perpetual stagnation (or, what amounts to the same thing, to admit that the present model of capitalism is broken) would be to instantly invalidate share prices, exchange rates and asset values.

Thinking about alternatives has therefore been left to heterodox economists and social scientists, now contributing to Manuel Castells's *Another Economy is Possible*. Since the 1990s, the network has been Castells's guiding concept: in *The Rise of the*

*Network Society*, he documented the fragmentation of hierarchies in economic and social life.

With the outbreak of networked protest, Castells turned to the dynamics of such movements and the small-scale economic change they created. Four years after the crash, in *Aftermath* he and his collaborators looked at Catalonia's unemployed and working poor under austerity, finding the kind of cooperation and non-market interactions previously associated with hippie or anarchist lifestyles.

*Another Economy* sees Castells and co seeking a theory, a sort-of bestiary, of alternative economies. They explore the time banks which use time as a social currency; they map local exchange systems, globally; they document attempts to adopt the Italian "slow city" model.

Some see this sharing and collaboration as a basis for an alternative to market capitalism. But the writers begin from a different place. "Economy," insists

Castells, "is culture." A range of practices are "equally relevant... equally able to organize the way people produce, consume, exchange, innovate, invest... live".

Now there is more to study. By 2015, radical left parties in Spain had taken control of three cities, experimenting widely, including with basic income and transition town ideas. Barcelona, one of the

## "Do efforts to keep the old economic model going lead anywhere other than permanent stagnation?"

cities, set up the Barcelona Initiative for Technological Sovereignty. Key to BITS is both IT-driven direct democracy and attempts by city government to reclaim for its citizens the benefits generated by smart city tech, by, say, negotiating contracts stipulating open-source tech.

Castells explores the interplay between economic structures that started out as acts of survival and

resistance, and projects like BITS. He concludes that the regulatory attack on market capitalism and the small-scale experimentation sustain each other. However, the big challenges – scalability, replicability, legal defensibility – are not explored in depth.

Castells's book is ambitious, but shows how far we have to go beyond just mapping alternatives. Take the contribution of Sviatlana Hlebik, an economist at an Italian bank. Her survey of local lending and exchange schemes shows complementary currencies can help companies survive downturns in the business cycle. But the absence of a theoretical framework makes it hard to see how the dynamics of a local exchange scheme compete with and replace, rather than simply complement, existing economies.

In this book, that theory remains an aspiration. ■

Paul Mason is a writer and broadcaster on economics and social justice



Meltdown: Greece was a major casualty in 2008's economic crisis

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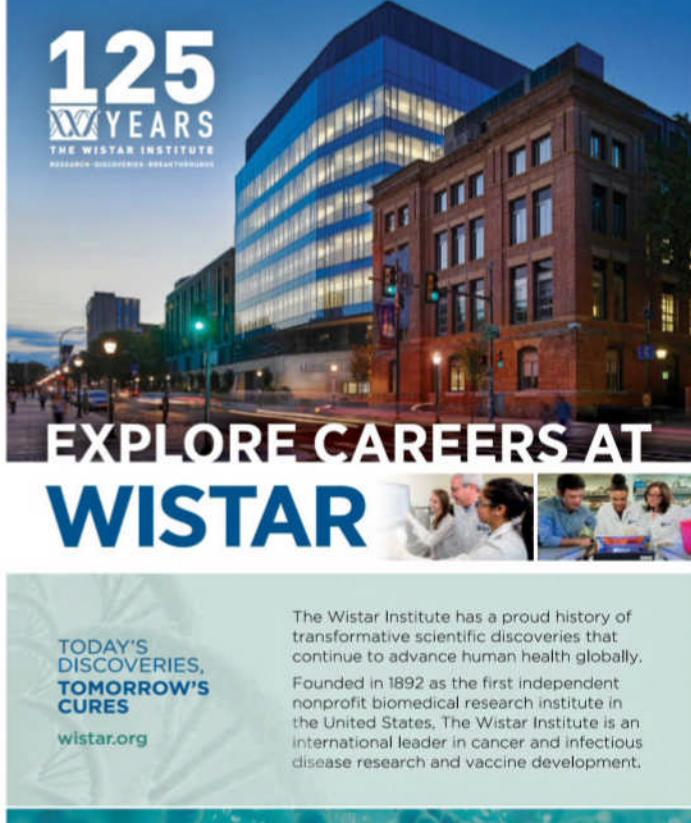
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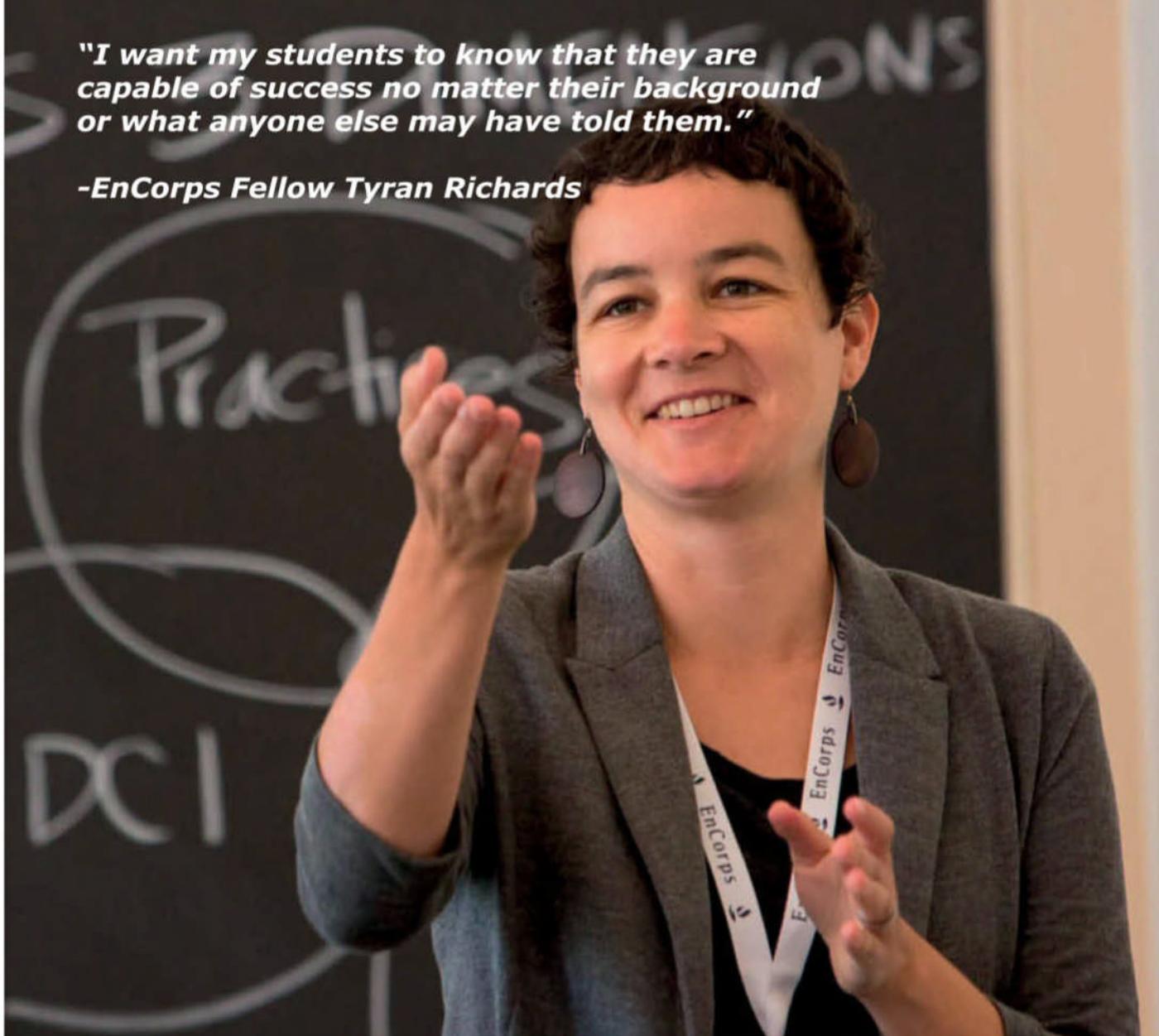
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CHICAGO

**EDITOR'S PICK****Knowledge is a falsifiable relationship**

*From Jim Packer, Macquarie Fields, New South Wales, Australia*

Attempts to define "knowledge" seem to make an impossible demand (1 April, p 32). Knowledge is the relation between knower and known. As a relational "thing", it has no qualities and can only be pinned down at the point of relation, whatever that is.

"Knowing something" is not a "state", "complex" or otherwise. Epistemology, the study of what it means to know, is ill-served by any idea of states, even when the state is honestly admitted to have a nature that extends beyond itself – whatever that can be taken to mean.

*From Peter Basford, Potters Bar, Hertfordshire, UK*

Surely knowledge is that which we believe hasn't been falsified after appropriate attempts. It isn't an absolute. Scientific theories are beliefs subjected to eternal obsessive falsification attempts. Even if falsified, a theory may remain useful within crude limits. For example, the time given by my watch could be falsified by an atomic clock, but I still "know" the time well enough using it.

**An uncertain universe based on information**

*From Ed Subitzky, New York, US*

Anil Ananthaswamy reports a suggestion that the basis of the universe is a type of information that isn't "about" anything (1 April, p 41). But if a piece of information isn't about anything, then presumably that piece of information cannot be said to be either true or false.

Could that be another way of saying that the basis of the universe is uncertainty?

**To know how animals know, ask how we do**

*From David Werdegar, Naperville, Illinois, US*

Michael Brooks asks whether animals know things (1 April, p 37). To answer this, one has to

understand how we know things.

For humans, knowledge is the conversion or abstraction of the world around us into an internal model we call language. What we know is determined by the language structure we are born into. As we are exposed to more parts of our world, we have to adapt or invent new words and relationships to comprehend the new reality.

Given how critical language is to knowing our world, how can animals conceptualise and successfully interact without it? How does a wolf pack or lion pride coordinate an attack on its prey?

I suggest that we need to redefine knowledge to encompass the mental constructs that exist and operate without language. Whatever these structures are, they allow animals to survive and thrive in their world space.

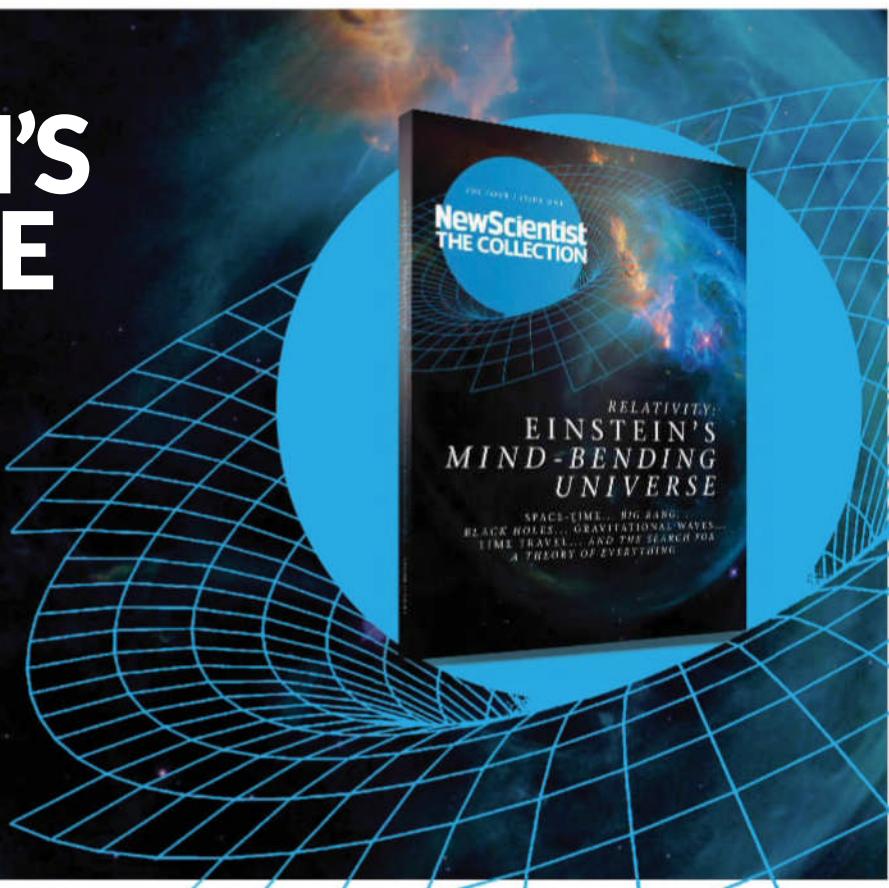
Understanding animal

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**NewScientist**



## "Must have more barnacle goose genes than is good for me"

Catherine responds to the news that a barnacle goose trains for its 3000km migration by getting fat (22 April, p 35)

non-language thought processes may help explain how solutions seem to appear to us from nowhere, or how a composer can "hear" an entire sonata in their head.

### Ownership and control of robotic production

*From Roger Denison,  
Huddersfield, West Yorkshire, UK*  
If large numbers of workers are made redundant by robots and AI, who will be able to afford the goods and services they produce?

To combat this, Sumit Paul-Choudhury discusses the idea of taxing robots or a basic minimum income (4 March, p 25). I would also suggest using the proceeds to pay for an increase in employment in the health service and other caring services that don't lend themselves well to full automation. Producers may not

like the idea, but without it, they will have a minimal market for their goods and services.

### Lobbyists pushed for antibiotics in animal feed

*From Gwyn Humphreys,  
Elland, West Yorkshire, UK*  
You say that "unlike the fossil fuel industry, drug firms haven't engaged in industrial-scale lobbying and the manufacture of denial" (8 April, p 5). But in the late 1960s and early 70s this is exactly what happened to allow the continued addition of antibiotics to animal feed.

That practice may have been far more damaging in breeding antibiotic resistance in pathogens than human misuse of the drugs. In 1969, the UK government published the Swann report, recommending restrictions, and there was a similar move at the US

Food and Drug Administration. Leading researchers at the time supported this initiative.

There was a major push back from several government and political figures with farming constituencies, however, and much scientific evidence was ignored. Use of antibiotics in animal feed continued for decades thereafter.

I suggest that industry lobbying and profit have been major drivers for the misuse of antibiotics over the past five decades and the crisis facing their use in human health today.

### Breastfeeding shouldn't be a dogma

*From Ilka Flegel,  
Kapellendorf, Germany*  
Many thanks to Clare Wilson for her article on the "Fed is Best" campaign (18 March, p 25). I felt

very relieved after reading it – apparently for the last five years I have been feeling guilty for not being able to breastfeed our sons.

I gave birth to twins in a "baby friendly" hospital. As one of my breasts produced less milk than the other, we weighed the kids before and after breastfeeding, so as not to give one an advantage in life from more of that magic stuff that would make him intelligent, slim, a non-smoker and so on.

I needed two people to help me manage the procedure, including topping up the twins with formula. Each feeding round took about 90 minutes and we slept four hours at most. I was terrified just thinking about feeding them.

After three months we all came down with winter vomiting sickness and my milk was gone; we had to switch exclusively to formula. The kids were happy and we finally all got some ➤

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sleep. I appreciated the help I got in hospital with breastfeeding. But this shouldn't be a dogma that makes women feel guilty if things don't work out as planned. From my experience the "Fed is Best" campaign seems to be a much-needed push in the right direction.

### The green revolution has been an utter failure

*From Charles Merfield, Canterbury, New Zealand*

I was surprised that Marta Zaraska wrote of the "success of the green revolution" (25 March, p 32). Sixty years into the experiment that is industrial agriculture, we produce enough for all, but 793 million adults are undernourished and nearly 160 million children are stunted due to malnourishment – while 600 million are obese and, most perversely, many of these have nutrient deficiencies. That is not success. It is utter failure.

To feed everyone well we have to limit population, not grow more food. Fortunately, there are ways to do that without resorting to the utterly morally repugnant ideas of Robert Malthus, or the

more recent one-child policy in China. Education, especially for girls, empowering women, good public pensions, affordable healthcare and a social safety net all result in decreases in birth rates.

### Putting legal limits on self-driving cars

*From Steve Tunn, Carnforth, North Yorkshire, UK*  
Carl Zetie is concerned about "programmed selfishness" in autonomous vehicles (Letters, 4 February) and Nicholas Thomas about passengers who suddenly have to take control (Letters, 18 February).

Left in the hands of private companies and free-market competition, I believe cars will continually be pushed beyond their safe operating envelope.

But we have an opportunity to significantly reduce the death and destruction caused by cars. I propose that if a vehicle fitted with autonomous control is involved in a collision, the legal presumption should be that the computer was responsible and the chief officers of the manufacturer

are personally liable for its actions and all consequent loss of life, harm and damage to property.

*From Flora Nuttgens, Wantage, Oxfordshire*

One factor not mentioned in discussion of self-driving cars is travel sickness. I can read while my husband drives and so can one of our children, but my husband and other two children would only be able to take advantage of the freedom endowed by self-drive if they were constantly medicated against car sickness – surely not desirable.

*From David Myers, Commugny, Switzerland*

In yet another article on self-driving cars, you report a major manufacturer claiming it will skip from cars with computer-assisted driving to vehicles with no brake pedal or steering wheel (7 January, p 36). Really?

I recently took a PostBus up a Swiss mountain road one vehicle wide with no barrier to protect against a large drop. As the bus has precedence, oncoming drivers must reverse into a passing-place.

In a standoff between a Tesla and the driver of a Swiss PostBus I shall put my money on the bus.

### I won't holiday in other species' misery

*From Donald Windsor, Norwich, New York, US*

You showed us images of birds killed by illegal sharpshooters in Malta (25 March, p 26). A tourist boycott might curtail this senseless slaughter of migrating birds. Thank you for publicising it.

### They spy with their little eye but they can't see me

*From Michael Zehse, London, UK*

Sally Adey discusses why it is worrying that your browsing history is now for sale (8 April, p 25). Those who don't want internet service providers to spy on them can use a "virtual private network". Still more amusingly, you can use two or more VPNs chained together.

### Getting to the bottom of sheer denier cheek

*From Crispin Piney, Mougin, France*

Recently, scientific journals and the news media have been full of articles about "climate change deniers" (for example, 8 April, p 5). I was suddenly struck by the fact that the term "denier" is also used to define the sheerness, fineness and transparency of stockings.

I suggest applying the denier scale to categorise people who reject the science of climate change, going from 10 for gauzy obscurity all the way up to 70+ for impenetrably woolly thinking.

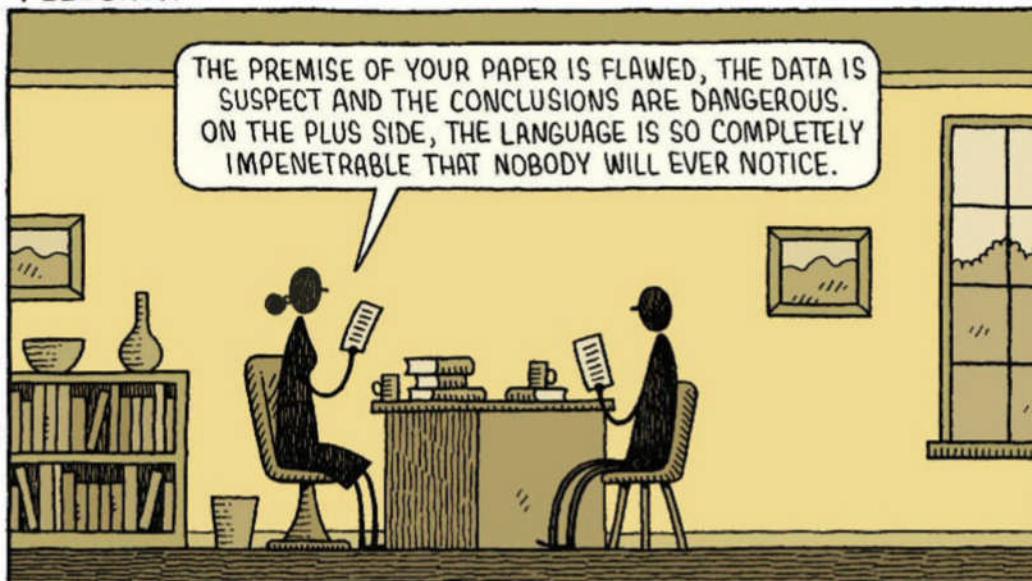
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TOM GAULD

## FEEDBACK



## SIGNAL BOOST

Giving your projects a helping hand



JASON ALDEN

### A say in our flying future

AMAZON has filed a US patent to deliver parcels via drones to customers' gardens using parachutes and magnets, while UPS is testing ways to launch fleets of drones from trucks. Within a decade, drones are likely to be performing a number of services in our cities, from parcel delivery and healthcare provision to live broadcasting, air pollution monitoring and railway maintenance.

Their potential is immense, but we need smart policy development and a wider conversation about how they will affect our communities. At the Challenge Prize Centre, run by innovation foundation Nesta, we are investigating how drones can enhance city life rather than damage it.

As a society, we have decisions to make. For instance, should drones be restricted to defined routes or be free to roam? We will face ethical choices around prioritising functions – such as the delivery of a life-saving organ – or allowing operators to pay for premium routing access. Drones raise safety, security and privacy alarms, so we must determine how regulators should handle real-time data sharing and in-flight interventions.

In addition, we need to look at their wider impacts on things like jobs and insurance rates, and whether we'll introduce drone taxes and fees. Local authorities will want to know who will own and maintain shared infrastructure such as landing pads, sensors and charging stations. And while local governments will want to deploy drones for public services, they can't be left holding the bill for work to enable private drone delivery services.

All too often, cities must find ways of adapting to a new technology. But we can bring together cities, technologists, regulators and the public to shape cities' futures.

Nesta recently gathered key stakeholders to look at various funding opportunities and is planning live, large-scale projects to demonstrate urban drone systems. **Tris Dyson, director, Challenge Prize Centre at Nesta**

If you want to get involved, you can contact us at  
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FLAT Earth adherents have offered a prize of \$8250 to anyone who can prove the world is round before their forthcoming congress ends (15 April). David Garret accepted the challenge, and outlines his methodology thus: "I'll need a garden chair, some rope, 10 high-altitude weather balloons, a lot of helium and one volunteer from the Flat Earthers' meeting." After all, they do say that seeing is believing.

ROGER HILL adds that a flat Earth defies not only the laws of physics, but the law of the land. He alerts us to a legal precedent: "Alfred Russel Wallace, the co-discoverer of evolution by natural selection, proved in an English court that the world was round."

The case followed a bet in 1870 between Wallace and Flat Earther John Hampden as to the shape of the planet. Their test centred on observations made along the Bedford drainage canal, a 6-mile length of supposedly flat water.

After correcting for refraction, Wallace's measurements showed the world was still curved, but Hampden refused to accept the result and the case dragged on through the courts for over a decade. Eventually, Hampden was jailed for death threats and libel. Wallace regretted ever taking on the bet, writing that such people "can never be convinced".

Feedback cautions David Garret: there must be less troublesome ways to earn \$8250.

**CHINA** is well known for its love affair with the 1997 James Cameron film *Titanic*. In an increasingly materialistic society, the tale of a wealthy aristocratic woman falling for a charming but penniless man seems to sweep away any concerns about the consequences of improper ship design.

Now Hillary Shaw tells us that the Seven Star International Cultural Tourism Resort is planning to build

PAUL MCDEVITT

**Enceladus sounds positively inviting, finds Alban de la Soudiere:** France24 reports that Saturn's moon offers any alien life present the energy equivalent of "300 pizzas a day".

a "6D" Titanic experience for holidaymakers. "I'm used to the usual four dimensions, three in space and one time," says Hillary, "but two extra dimensions would surely have given the doomed ship more leeway to swerve that iceberg."

Feedback is still waiting for the powers that be to standardise those additional entertainment dimensions, but in Yongle's case they must represent love and cold water.

A night in the most expensive cabin on board their replica ship will cost upwards of £11,000, which presumably includes a free transfer to an open-topped lifeboat at 2 am, while those in the cheaper berths are ditched straight into the water, without so much as a lovestruck heiress to keep them company.

A DRUG-ADDICTED python is one of hundreds of animals being cared for by inmates at a prison in Sydney, reports the BBC. The "very aggressive" animal was rescued from a methamphetamine lab, having apparently absorbed the drug through its skin. The snake will be rehomed following the trial of the alleged drug producers, prompting Feedback to wonder if the authorities are planning to call it as a witness – perhaps to put the squeeze on the defendants?

OUR colleague tells us Adobe Analytics wants him to update his login credentials, while reassuring him that "This login will never expire". He says: "I suspect the cold truth is this claim is thermodynamically untenable, but for the moment I'm basking in the warm glow of knowing that at least something of me will be left when I'm gone."

WE HAVE been taking a long look at the issue of telescope names, and the shortage of superlatives for them (17 April). Kir Angwin thinks the solution is to "stop using the word 'telescope' and adopt the old pirate nomenclature of the 'bring 'em near'".

That way, he says, "we could have the 'bring 'em nearer', the 'bring 'em even nearer', and even

then the 'bring 'em roight alongside'."

Feedback isn't sure about the practicality of this idea, though we do like the notion of renaming the European Southern Observatory "the Bring Me the Horizon Institute".

**AN UNEXPECTED consequence of the first law of thermodynamics?** Charles Joynson comments that, as discussed in this magazine, information is now at the core of particle physics. This has consequences for biology, too, he argues. "We are losing 100 species to extinction each day," says Charles, each representing the loss of whatever information was stored in that creature's DNA. "At the same time, the total amount of information stored in our computers is growing."

Correlation, or causation? If, as Charles ventures, there is only a fixed



amount of information that can exist in the universe, the best way to save pandas might be to forget you ever knew they existed.

THOSE with a bit of spare change left over after shelling out £55,000 on a pair of Sennheiser HE 1 headphones (8 April) can pick up a corresponding travel case from Geekria on Amazon, reveals Adam Justice-Mills. A snip at £20.46, you'd be mad to board your private jet without one.

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

## Swimming school

My Year 7 class and I have been trying to find out whether sharks can swim backwards. Can anyone settle the issue please?

■ The forward motion of sharks is due principally, and in some large and fast-swimming species almost exclusively, to lateral beats of their tail fin. Numerous species of small, slender sharks also propel themselves in part by curving the rear two-thirds of their body from side to side in waves that flow towards their tails. So, when in contact with the walls of a crevice or the grasping hands of a human, dogfish and other small sharks can wriggle to escape, and this may involve some tailwards (or backwards) motion. Nevertheless, no shark can "swim" backwards in open water.

Some other types of fish can. These bony fish do so by rotating and beating their pectoral and pelvic fins. But sharks can't rotate

## "Sharks cannot swim backwards. They can't rotate their fins, which are like fixed aircraft wings"

these fins, which are more like the fixed wings of an aircraft.

Incidentally, it is not true that all sharks must keep swimming forwards to obtain oxygen (known as ram ventilation). Some sharks lie on the bottom facing into the current and can pump water over their gills by opening and closing their mouth. Some species can

also draw water in through apertures, called spiracles, behind their eyes.

*Oliver Crimmen  
Senior fish curator  
The Natural History Museum  
London, UK*

## Seasons in the sun

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

*Although the answers below don't specifically address the subject of the intensity of the sun's radiation, they do cover some of the issues in the question. Maybe readers can help with the rest of the specifics – Ed*

■ We glider pilots use rising currents of warm air to stay aloft without an engine. In reasonable summer weather, we can stay up all day and fly hundreds of kilometres – this is solar power without the panels.

Glider pilots soon learn that the sun heats the ground and the ground heats the air. Where some parts of the ground are hotter than others (such as a ploughed field in the middle of a grassy area), then a body of warmer air is created, which eventually breaks away from the ground

and starts to rise. These are the thermals that we use to stay aloft.

Early in the year, even though the sun is already strong, the ground is still cold after the winter and the sun struggles to warm it up. As the year wears on, the average ground temperature rises, and hence the air temperature with it. On the rare occasion we get a long succession of sunny days in June, July and August in the UK, this raises the ground temperature to its highest level, leading to much greater air temperatures than earlier in the year, even though the days are getting shorter.

*Chris Lewis  
Ely, Cambridgeshire, UK*

■ This is known as seasonal lag and is mainly caused by thermal inertia. When winter turns to spring, the amount of sunlight increases, in terms of both light intensity and the number of hours of sunlight. However, some of this solar energy is absorbed by big reservoirs of thermal energy, particularly the surface waters of the oceans, which have a huge heat capacity. This means that not all of the extra solar energy results in an immediate rise in air temperature.

Similarly, when we head towards winter, the temperature doesn't plummet as fast as the solar energy falls, because heat leaking out of the thermal reservoirs helps keep temperatures higher for a while.

There is virtually no seasonal lag on Mars or Venus because they

have no oceans to store thermal energy. However, there is a significant seasonal lag on the gas giants Jupiter and Saturn – equivalent to a quarter of their orbit – possibly because the thermal energy is stored to quite a depth in their outer layers of gas.

*Mike Follows  
Sutton Coldfield, West Midlands, UK*

## This week's questions

### NOT MY CUP OF TEA

I live in a hard-water area and find that vinegar is a cheap and effective way to descale my kettle. But no matter how much I rinse afterwards, I won't get a decent cuppa for a week. Given that the kettle is stainless steel and plastic, why does the taint stay so long?

A proprietary citric acid descaler presents no such problem, but is less effective and more expensive.

*Robert Bull  
Bath, Somerset, UK*

### MENTAL BLOCK

My elderly uncle is in hospital with a urine infection. His capacity for normal behaviour and thought is greatly reduced by the infection and I'm told the same happens with other old people with the same kind of infection. Why is this? If I (a 43-year-old) picked up a urine infection it might sting, but wouldn't lead to mental incapability.

*Billy Gilligan  
London, UK*

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