New Scientist

WEEKLY 6 February 2016

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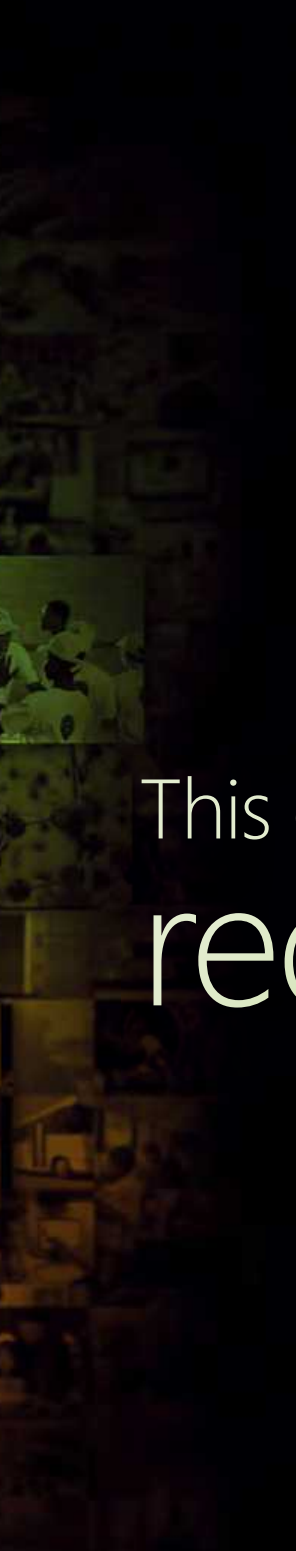

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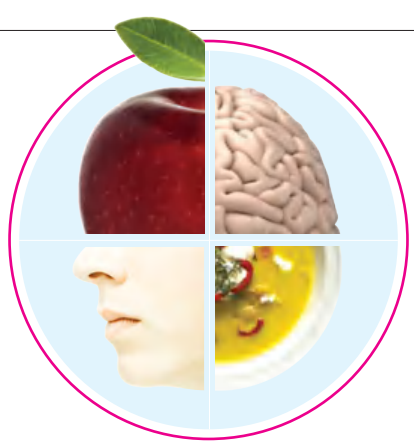

Coming next week...

Once in 100 trillion trillion years
Searching for the rarest event in the universe

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What makes the flying furballs so long lived?

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EDUARDO MUNOZ/REUTERS

Customer or lobbyist?

Internet giants may be throwing your weight around

THE bigger, the better. For the most part, internet companies are judged by the number of users they have. Sign up enough people, the thinking goes, and revenues and profits will follow.

A large customer base can be useful in other ways, too. As internet companies have muscled in on existing business models, from taxi services to hotels, they have rubbed up against existing regulations. And so they have started lobbying to change them, just like their corporate brethren.

But conventional advocacy is not enough for such disruptive types. Not content to rely on well-placed lobbyists with the ears of politicians, they are recruiting users to promote their cause.

Facebook did this when India's telecoms regulator sought public consultation on services that offer limited access to internet sites via phones, a model catching on in the developing world (see page 18). One such service is Free Basics, owned by Facebook. Its reaction to the consultation was to invite millions of its users to send boilerplate emails of support, deluging the unamused regulator.

Others are also marshalling users to their cause. Uber, for example, last year defeated a proposed cap on the number of its vehicles in New York City. One of its tactics was to roll out a new mode on its app named "De Blasio" – after the city mayor championing the cap. The mode made all of Uber's cars disappear from the map and directed users to a petition. And home-stay giant Airbnb is organising its US users into "guilds" to fight proposed regulations on short-term rentals around the country.

Internet services have spent vast sums learning how to direct their users' activity. That makes for a powerful political force – which can be exercised with little transparency. As *The Times of India* reported, many Facebook users claimed they were enlisted in its campaign unwittingly. It's all very well for internet firms to throw their audiences' weight around, but they should strive to capture nuance as well as numbers. After all, might doesn't make right. ■

Sort it out, nuclear family

ARE nations duty-bound to deal with their own nuclear waste, or do we need a transnational solution? It is a pertinent question. Germany, despite decisively ditching nuclear power five years ago, still can't decide what to do with the leftovers.

Anti-nuclear activists there are vowing to block the return of spent fuel from the country's reactors, being reprocessed in France and the UK. They have also boycotted a parliamentary commission scheduled to report later this year on a final resting place for plutonium-rich waste, which needs keeping out of harm's way for tens of thousands of years (see page 10).

Their campaign may succeed, but only temporarily by dodging the big issue and saddling other countries with German waste.

Perhaps the real problem is narrow nationalism. Does it really make sense to insist that waste be disposed of within the country that produced it? Maybe a few international repositories would be better.

Germany is entitled to abandon nuclear power, but it cannot duck its responsibility to clean up. With nuclear waste piling up in more than 30 nations, the quandary could be a useful opportunity for the nuclear family to sit down together and sort out the mess. ■

Cruz win built on data

DID Ted Cruz cruise to victory on a sea of social media data? The Texas Senator won the first battle in the race for the Republican presidential nomination, winning the Iowa caucus with a comfortable 3 per cent lead over the favourite, Donald Trump.

Although Trump had polled ahead in the state, Cruz used the services of a firm called Cambridge Analytica to build psychological profiles of Iowan voters by sucking up data from Facebook profiles; it is well known that what you like on Facebook gives away your personality. The Cruz campaign used this to home in on his likely supporters through the social network, and motivate them to get out and vote.

"Campaigns are like wars, and trying to use the digital side is definitely an edge," says Carl Miller, research director of the Centre for the Analysis of Social Media at UK think tank Demos. For example, these techniques make sure high earners see messages about tax, while older voters in rural areas will probably be targeted with family values messages, he says.

Iowa is an important state because it is the first to go to the polls and successful presidential candidates almost always win there.

In an interview with *The Guardian* in December, Cruz said that his campaign "is very much the Obama model – a data-driven, grassroots-driven campaign – and it is a reason why our campaign is steadily gathering strength".

DDP USA/REX SHUTTERSTOCK

I'd like to thank my friends

Cancer moonshot

"LET'S make America the country that cures cancer once and for all." So proclaimed US president Barack Obama in his final State of the Union speech in January. On Monday, his administration revealed it will be requesting nearly $1 billion dollars from Congress to work towards this aim.

The move, which is being led by vice-president Joe Biden, has been likened to the US push to beat the Soviet Union to the moon. But this time, the goal, according to a presidential memorandum signed last week, is to "achieve in just 5 years research and treatment gains that otherwise might take a decade or more".

"Somebody with a national overview can make things happen that couldn't be done by Congress"

"We're excited about this," says Barrett Rollins at Dana-Farber Cancer Institute in Boston. "Now you have somebody with a national overview of what's going on, who can potentially do things that couldn't be done by congressional mandate, much less by any one society or individual."

One way to achieve such a goal could be to encourage researchers to share patient data, and help remove technological and privacy barriers to doing so. Detailed information is collected from each cancer patient, but it is usually kept in different institutions, and can be tricky to bring together and analyse to uncover new insights.

Only about 3 per cent of patients participate in research, so data from the remaining 97 per cent is not being used, says Julie Vose, president of the American Society of Clinical Oncology. "This is a way to try to make inroads in all different types of cancer, even the rare ones."

This US "moonshot" is haunted by a similar space-race analogy once made by former president Richard Nixon, who declared a "war on cancer" in 1971. Today, cancer remains one of the leading causes of death in the US, surpassed only by heart disease.

UK gene go-ahead

READY, set... go? The UK Human Fertilisation and Embryology Authority has given the go-ahead for a gene-editing project in human embryos. A team led by Kathy Niakan of the Francis Crick Institute in London could be the first outside China to try the technique in humans.

The team wants to use the CRISPR method of gene-editing to unpick which genes control early development in humans. Niakan plans to use CRISPR to disable genes in single-cell embryos to see what effect this will have on their later structure. They hope this research could ultimately help reduce the number of miscarriages and improve fertility treatments, since the project should provide insights into early embryo health.

To proceed, the team also needs to secure the approval of a separate ethics committee. If they do, they will then start collecting frozen IVF embryos, donated by parents – a process that could take several months.

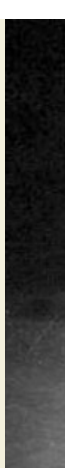
New lion group found in Ethiopia

IN THE savannah of Alatash national park, the lion sleeps tonight. This remote part of north-west Ethiopia was a possible habitat for lions, but it is seldom visited by people.

Now an expedition by the University of Oxford's Wildlife Conservation Research Unit has discovered lions in the park – a rare extension of their known range.

"I have had to revise the lion distribution map many times," says Hans Bauer, who led the expedition to set up camera traps on a dry riverbed to spot the lions (shown right). "I have deleted one population after the other. This is the first and probably the last time that I'm putting a new one up there."

Alatash is adjacent to the much larger Dinder national park in Sudan. Bauer believes there may be undiscovered lions there, too, adding up to a possible 100 to 200 individuals in the two parks. "The situation is fairly positive," he says.



Crippled by snoops

MASS surveillance ain't cheap. Members of Parliament charged with scrutinising UK government plans to monitor online communications believe that

"Internet connection records don't exist as far as internet service providers are concerned"

laws in the proposed Investigatory Powers Bill could put the country's tech sector at a competitive disadvantage. The cost of collecting and storing the data would place a heavy burden on firms in that industry, they say.

One of the new bill's most contentious elements is a requirement for internet service providers (ISPs) to keep a record of every website their customers have visited in the past 12 months.

These internet connection records would aid the police and security services in their investigations and are simply the online equivalent of an itemised phone bill, says home secretary Theresa May.

ISPs told the committee this isn't the case, because they don't routinely collect such details. "The whole idea of an internet connection record does not exist as far as internet service providers are concerned," said James Blessing of the Internet Service Providers' Association.

WILDLIFE CONSERVATION RESEARCH UNIT (WILDCRU)

Rare good news

MATT CARDY/GETTY

Expect more of this

Future floods...

EUROPE'S flood problem is about to get much worse. The good news is there is a solution, says a report from the European Environment Agency – the first pan-European flood assessment.

There have been more than 3500 floods since 1980, says the report, and the trend is upwards. In 2010, 27 nations were affected by 321 floods. The report predicts a five-fold increase in flood damage by 2050. "The recent flood

"The recent floods in the UK are adding to the evidence of worsening flood problems in Europe"

problems in the UK are adding to evidence of worsening flood problems in Europe," says co-author Beate Werner.

Several studies have now linked the recent floods in northern UK and those in southern England in 2014 to climate change, which leads to more extreme rainfall (*Nature Climate Change*, doi.org/bb8k).

While extreme rainfall is part of the problem, much of the damage arises because rivers are cut off from their floodplains, and floodplains keep being developed.

"We need to free up areas for a more natural way of flood protection, giving room for the river," Werner says.

Germany and the Netherlands have torn down defences in rural areas where few properties would be affected – reconnecting rivers to floodplains. Other countries, including the UK, where the House of Commons has just announced an inquiry into flood prevention, need to adopt the same approach, the report says.

...and extreme heat

IT'S a good time to be alive if you love hot summers. Europe's summers over the past 30 years have been the warmest since Roman times, according to an analysis of temperature from the past 2000 years.

The study used tree ring data and other proxies for temperature. "We now have a detailed picture of how summer temperatures have changed over Europe for more than 2000 years," says Jürg Luterbacher at the University of Giessen, Germany.

The analysis uncovered much higher variability between decades than we previously thought. This suggests that models based on our current understanding of climate may be underestimating just how extreme future climate events are likely to be (*Environmental Research Letters*, doi.org/bb8m).

60 SECONDS

Moon changes rain

The moon can make for lighter rain. Fifteen years' worth of rainfall data suggests that the extra gravitational pull on clouds when the moon is directly overhead can help them retain moisture. But the impact is tiny, accounting for 1 per cent of variation in rainfall (*Geophysical Research Letters*, doi.org/bb73).

Internet drones

Google is testing whether solar-powered drones in New Mexico could deliver high-speed internet, *The Guardian* has revealed. The SkyBender drones transmit millimetre-long radio waves that could form the basis of 5G wireless internet – if they can work over larger distances than they do now.

Giraffe neck cheat

Mystery solved. All mammals, from mice to giraffes, have the same number of neck vertebrae: seven. But now we know that giraffes have evolved a cheat – they have co-opted the first of their thoracic vertebrae to act as an eighth neck bone, helping to explain how the giraffe got its long neck (*Royal Society Open Science*, DOI: 10.1098/rsos.150604).

Neutrino seeker

Particle hunters at CERN may get a new toy. The organisation has approved a design for the Search for Hidden Particles experiment, which would look for "sterile neutrinos". Thought to hardly interact with normal matter, these particles could explain the lack of antimatter and the nature of dark matter in our universe. The device could start recording data in 2026.

Smoke-free flicks

Films featuring smoking should be given an adult rating, according to the World Health Organization. Citing that 36 per cent of films rated PG-13 and below in 2014 contained smoking, the WHO has warned that tobacco firms are using movies to recruit young smokers.

Waging war on Zika mosquitoes

From spraying to genetic modification, **Clare Wilson** looks at the weapons available

SEBASTIAO MOREIRA/EPA

ZIKA is officially a global public health emergency. The declaration, by the World Health Organization on Monday, means that it can now take the lead in coordinating the global response to a virus it has estimated could infect up to 4 million people in the Americas over the next year.

"I am now declaring that recent cases of microcephaly and neurological abnormalities... constitute a public health emergency of international concern," said Margaret Chan, director-general of the WHO.

"Recent cases of microcephaly constitute a public health emergency of international concern"

Zika, which was first detected in the region in May, has now spread "explosively" to at least 25 countries.

The emergency designation will help the WHO to ramp up research and organise international efforts to combat the *Aedes* mosquitoes that spread the disease. From the sensible to the ambitious, here are seven tactics countries could consider in the war on mosquitoes.

Don't get bitten

"Easier said than done," says Cameron Webb, a mosquito researcher at the University of Sydney, Australia. People need to cover up and spray all exposed skin with repellent such as DEET. But many people can't afford repellents and those who can tend not to apply them properly, Webb says. "If there's a chink in your armour, they'll find it."

How likely to be implemented: standard advice
Effectiveness: high but only if followed perfectly

Don't get pregnant

Some countries are advising women to postpone pregnancy. That is more practical for some than others due to the varying influence of the Catholic Church's ban on artificial contraception. In Brazil the edict is widely flouted, but elsewhere contraception is less available or affordable. In most of South and Central America abortion is legal only in very limited circumstances.

How likely: advice just introduced
Effectiveness: no guarantees

Eliminate mosquitoes

The virus is mainly carried by *Aedes aegypti* mosquitoes, which live in urban areas. They lay their eggs in pools of standing water in places such as plant pot saucers and blocked gutters.

The species also transmits yellow fever, and in the 1960s several South American countries – including Brazil – eliminated it by spraying with DDT and urging households to get rid of breeding sites. Unfortunately the mosquitoes survived in a few locations, and after the development of a yellow fever vaccine, campaigns dwindled and mosquito numbers increased again.

The strategy would be harder

WHAT COULD LIFE BE LIKE FOR THE BABIES?

Cases of microcephaly – a condition in which babies are born with brain damage and unusually small heads – have jumped 20-fold in Brazil since the Zika virus arrived. Some children aren't neurologically impaired, while others can be severely affected.

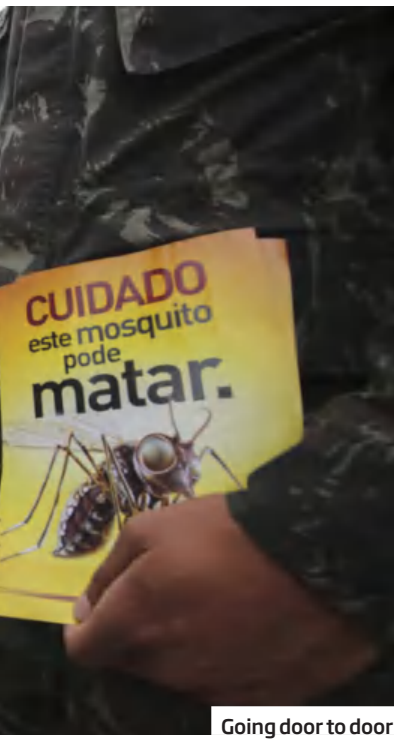
"They may not be able to recognise their parents or perceive pain, and will need constant attention because they wouldn't be able to indicate when they need food or drink," says Geoff Woods at the University of Cambridge, who has seen brain scans and early case reports from Brazil.

Based on the scans, it appears that the brain stem and the cerebellum are most affected. These oversee many functions that don't require active thought, such as swallowing, controlling body temperature and blood pressure, says Woods. Affected babies are prone to choking and fits.

The condition is poorly understood. "The need for information is more important than ever," journalist Ana Carolina Caceres told the BBC. "People need to put their prejudices aside and learn about this syndrome." Caceres has microcephaly and had surgery five times as a child. She was able to go to school and university, and today plays the violin.

PERCIO CAMPOS/EPA

"I am aware that not everyone will be lucky enough to have a life like mine. But I recommend to pregnant women that they remain calm. Microcephaly is an ugly name but it's not an evil monster." Andy Coghlan



Going door to door

to implement today as DDT is widely banned and there is resistance to other insecticides, but it is not impossible.
How likely: needs massive coordinated campaigns
Effectiveness: worked last time

Modify mosquitoes

As the mosquitoes that carry Zika also transmit the potentially deadly dengue fever, there are already high-tech eradication methods in the works. The most advanced involves making genetically modified mosquitoes whose offspring die as larvae. This requires regular releases of GM males to reduce the population. (Only females bite people.)

In a recent trial in Brazil, the number of native mosquitoes shrunk by 95 per cent within six months. There is wide opposition to GM animals in some countries but Zika could change things. "This could be the killer app for GMOs," says Anthony Wilson of the Pirbright Institute in Woking, UK.
How likely: field trials under way
Effectiveness: cuts mosquitoes, but not yet proven to reduce disease

Enlist bacteria

This approach would not wipe out mosquitoes but could make them less able to pass on Zika. The mosquito's ability to transmit the dengue virus is cut if the insect is also infected with a bacterium called *Wolbachia*.

It's likely that *Wolbachia* also blocks Zika, says Webb. These bacteria are naturally present in nearly two-thirds of all insects, including some mosquitoes, though not *A. aegypti*. Trials with the species have shown infection spreads fast among local insects. "The modified mosquitoes find all those other insects hidden away that humans have a hard time finding – they do the work for you," says Webb.
How likely: field trials under way
Effectiveness: not known if it blocks Zika, though likely

Gene drive

If we could work out a way to genetically alter mosquitoes so they are resistant to carrying Zika, we could spread that resistance. In a method known as a gene drive, the insects are given DNA that is passed on to all of their offspring, not just half, as with conventional reproduction. The technique has already been used to spread resistance to the malaria parasite in a different mosquito species, although there is concern about taking such an irreversible step.
How likely: several years away
Effectiveness: unknown

Make a vaccine

We have a head start here, as Zika is closely related to two viruses for which vaccines are already in development, says Anthony Fauci of the US National Institutes of Health.

A DNA-based vaccine for West Nile virus could be altered to include Zika genes. And a live dengue vaccine has already reached large-scale trials, so a similar approach will be tried for Zika.
How likely: several years away
Effectiveness: unknown

Stone tools hint humans reached Asia much earlier

THE first early humans to leave Africa did so half a million years earlier than we thought, according to an analysis of simple stone tools and three cow bones with cut marks found in Asia. But not everyone is convinced yet.

A joint Indian-French team found the artefacts on the Siwalik hills about 300 kilometres north of New Delhi, India, where tectonic activity has exposed an outcrop of bedrock dating back at least 2.6 million years.

The bones and tools were found lying on the surface, which made their dating tricky. But given that artefacts are rare in the younger rocks surrounding the outcrop, and the latest finds were preserved in the same way as those previously uncovered in the ancient bedrock, they probably eroded out of the bedrock on which they sit, the team says (*Comptes Rendus Palevol*, doi.org/bb7c).

"There is no doubt regarding their origin," says Mukesh Singh of the Society for Archaeological and Anthropological Research in India, who co-led the team.

The team's examination of the cut marks suggests that they were made with a stone tool (*Comptes Rendus Palevol*, doi.org/bb7d). "We are absolutely confident," says Singh. "Hominins lived in sub-Himalayan floodplains 2.6 million years ago."

The earliest accepted evidence of early humans outside Africa so far is *Homo erectus* remains found at a site at Dmanisi, Georgia, that date back about 1.85 million years. Taken at face value, the new finds suggest that our *Homo* genus had migrated into Asia much earlier – it may even have evolved in Asia before moving into Africa.

Another possibility is that the Siwalik finds are evidence that earlier ape-like hominins in the genus *Australopithecus* lived in Asia as well as Africa. But Anne Dambricourt Malassé at the Institute of Human Palaeontology in Paris – another co-head of the team – says this is unlikely because australopiths were adapted to life in trees and probably wouldn't have undertaken long migrations across the savannahs.

"The discovery suggests early humans first left Africa half a million years earlier than we thought"

Meanwhile, other researchers say stronger evidence is needed to back the team's extraordinary claim. It is problematic that the stone tools and bones were found on the surface rather than in a dateable rock layer, says Shannon McPherron at the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany. Also, proving that cut marks on bones were made by hominins is a huge challenge, he says, as description and interpretation of such marks is an area of contentious debate.

Michael Petraglia at the University of Oxford, who studies the early spread of humans from Africa, is also cautious. "There is a lot to prove with respect to deposits, age of deposits, cut marks and whether these are human-manufactured tools," he says.

This isn't the first find that hints at a much earlier human presence outside Africa. Last year, a research team reported very early stone tools from a cave in China dated to 2.48 million years ago. Colin Barras ■


A. DAMBRICOURT MALASSÉ
Handy tool

Forever haunted by its nuclear past

Fred Pearce, Asse, Germany

HALF a kilometre beneath the forests of northern Germany, in an old salt mine, a nightmare is playing out. A scheme to dig up previously buried nuclear waste is threatening to wreck public support for Germany's efforts to make a safe transition to a non-nuclear future.

The German government bought the abandoned mine in 1965, ostensibly to research the suitability of salt domes for disposing of radioactive waste. Yet after two years, and without waiting for scientific reports, the authorities secretly turned it into a cheap, supposedly permanent dump. Enough plutonium-bearing waste is stored here to fill 20 Olympic swimming pools.

In the 1970s, when engineers backfilled the chambers, holding 126,000 drums, they thought the waste was safe forever. But now, the walls of the Asse mine are collapsing because of pressure from the surrounding rocks, and brine is seeping in at a rate of around 12,000 litres a day. The race is on to dig it all up before radioactive residues are flushed to the surface. "It is a disastrous situation," says Jochen Flasbarth, state secretary at the Federal Ministry of the Environment.

Deep trouble

Three sites are involved in the disposal of some of Germany's nuclear waste. But grave problems at the **Asse mine** threaten to derail the whole project

The risks of protection

Many experts fear that digging up the drums, with consequent risks of radioactive leaks, could create a much greater hazard than leaving them where they are. "There could be a conflict between protecting future generations and creating risks for today," says Ingo Bautz of the Federal Office for Radiation Protection (BfS), who oversees activities at the site.

This is just one part of Germany's nuclear nightmare. The country is also wrestling with a growing backlog of spent fuel. And it has to worry about vast volumes of radioactive rubble that will be created by the decommissioning of all its 17 nuclear plants, scheduled to take place by 2022. Their fate was decided five years ago, in the wake of Japan's Fukushima disaster.

Some 300,000 cubic metres of low and intermediate-level waste that will need shielded storage, including what is dug from the Asse mine, is earmarked for final burial at the Konrad iron mine in Lower Saxony (see map, left).

What will happen to stuff that must be locked away for up to a million years – high-level waste, spent fuel and other highly radioactive material – is still being debated. Later this year, a Final Storage Commission, made up of politicians and scientists, will advise on criteria for choosing a site for deep burial or long-term storage, to be under way by 2050.

RONALD FROMMANN / CLEAN ENERGY WIRE

But its own chairman, veteran parliamentarian Michael Muller, says that timetable is unlikely to be met. "We all believe deep geology is the best option, but I'm not sure if there is enough [public] trust to get the job done," he says.

Many anti-nuclear groups are boycotting the commission. They agree that Germany must deal with its own waste, but do not trust the process of choosing a site. They fear that the authorities are secretly fixed on reviving plans for burial at Gorleben, another Lower Saxony salt dome, which already stores 113 flasks of high-level waste.

"One flask of this high-level waste contains as much radioactivity as 30 Hiroshima bombs"

"One flask of high-level waste contains as much radioactivity as 30 Hiroshima bombs," says Wolfgang Ehmke, who has been a campaigner for 40 years. "We cannot bury this waste here in northern Germany [because] there could be 10 ice ages, with glaciers scraping away the rocks, before the waste is safe."

The protesters have broad popular support. And the problems at the Asse salt mine have led to further distrust of engineers and their solutions.

In 2011, the BfS ruled that the waste had to be removed. But the task is so difficult that it is likely to take decades. Just checking the state of the 13 chambers holding the waste drums is painfully slow. Those drilling to reach them through 20 metres of rock have no idea whether the drums have leaked, and they cannot risk a release of radioactivity. Since work started in 2012, just one borehole has been completed into one of the chambers.

Before the drums can be extracted, engineers say they will need to sink a second shaft and open up big new galleries, where the drums can be made safe before they are retrieved. But exploratory drilling has already revealed that the salt dome is not

Salted away, but not for good

as big as thought, says Bautz.

And unless care is taken to keep clear of the impervious rock forming a barrier around the mine, the excavations risk allowing more water in. "We can't rule out that the mine could flood," he says. "If that happened, retrieval would be impossible. We would backfill it all."

Nothing will be moved until at least 2033, says Bautz. Meanwhile, the bills keep rising. It costs €140 million a year just to keep the mine safe for work to continue. The final bill will run into billions.

Germany may ultimately perform a service to the world if it can pioneer solutions that other countries may emulate, including the UK, which is struggling with its own waste legacy.

But if the German people ever thought that abandoning nuclear power would end their nuclear problems, they couldn't have been more wrong. ■

Fred Pearce's trip to the Asse mine was partly paid for by Clean Energy Wire, an independent non-profit media service

Milky Way's bar stirs up stars like candy floss

THE Milky Way's centre hosts a propeller stirring up chaos in its wake. That's one way to explain a fraying ribbon of stars called the Ophiuchus stream. Looking at similar stellar streams with this in mind may help us map our galaxy from the inside out.

That's no easy feat, because Earth is embedded in the Milky Way galaxy's disc. From here, material blocking our view means we can't easily map the bar of stars at the spiral's centre, or the halo of dark matter surrounding the galaxy. But we can see structures orbiting above and below the disc, like dwarf galaxies and tight beehives of stars called globular clusters.

We also see streams of stars, many of which stretch across tens of thousands of light-years: the strewn wreckage of Milky Way satellites that have been torn apart. When a globular cluster falls through the galactic disc, the kick of energy it receives can make it burst like a piñata, scattering stars in a thin line along the path it used to follow. Over time, the stream stretches and lengthens.

But one stream, in the direction of the constellation Ophiuchus, looks peculiar. It's unusually short, which implies either that the cluster it came from burst all at once about 400 million years ago – or that it has been shedding stars here and there for billions of years.

Adrian Price-Whelan of Columbia University in New York favours the latter explanation. His team argues that the Ophiuchus stream has been fraying at its edges due to the chaotic gravitational influences from the Milky Way, and claims the galaxy's central bar is to blame (arxiv.org/abs/1601.06790).

Simulations suggest that the core of the Milky Way hosts a dense bar of stars that spins around inside the galactic disc like a propeller or a pinwheel. In Price-Whelan's model, gravity from that rotating central bar has been unravelling threads of stars from the globular cluster that birthed the Ophiuchus stream for billions of years, then churning them into the Milky Way like strands of candy floss.

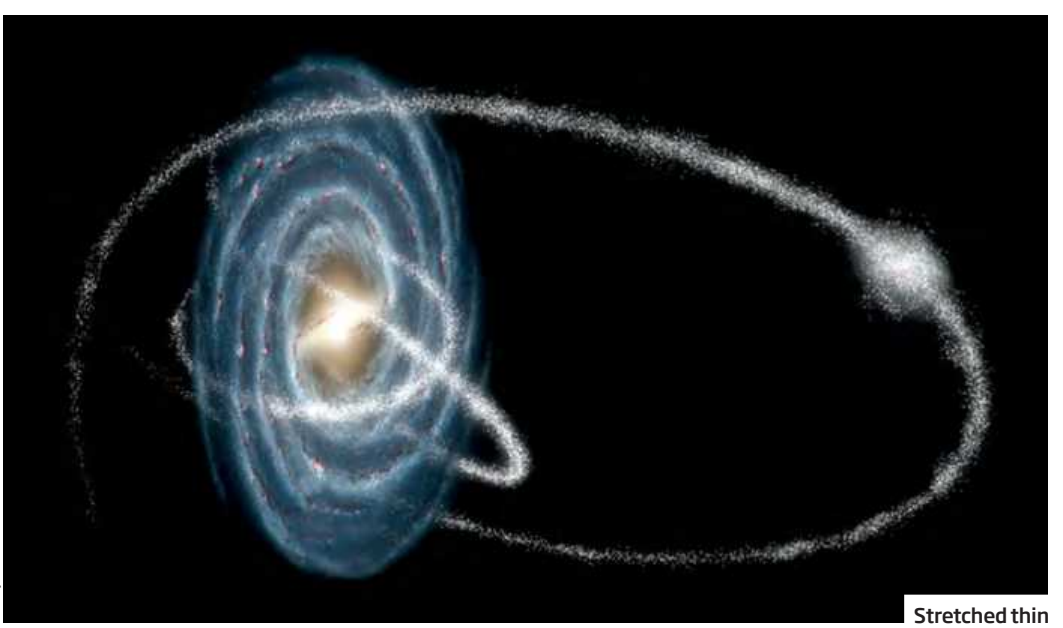
"All we're seeing now is that last clump of stars slowly spreading out into a stream," Price-Whelan says. "In another 500 million years or so that will disappear – that will be dispersed into chaos."

The same mixing process could allow the Milky Way to hide past crimes. Long, thin stellar streams mark where dwarf galaxies or globular clusters were cannibalised, but the stars left behind from other episodes may be hard to find if they have been stirred into the galaxy. This could help explain why we see fewer satellites than expected: the streams marking their demise may have been erased.

Studying the short Ophiuchus stream may also help us map the bar itself, says Ana Bonaca of Yale University, who was not part of the research. "It is really the location of the stream that makes it so interesting," says Bonaca. Identifying more stars at the thin edges of the stream will help us better understand how the bar stirs them in.

"The galaxy hosts a dense, central bar of stars that acts like a propeller, stirring chaos in its wake"

Price-Whelan's colleagues are already looking for more of those fringe stars. The European Space Agency's Gaia spacecraft, which maps stars across the galaxy, should help, allowing us to use tattered streams to understand the shape of the inside of the Milky Way and the halo of dark matter around it. Joshua Sokol ■



NASA/JPL-CALTECH/R. HURT (SSC/CALTECH)

Stretched thin

Drug quickly quells suicidal thoughts

Mallory Locklear

COULD a painkiller turn people away from suicide? A preliminary trial of an opioid called buprenorphine shows that the drug can reduce suicidal thoughts after just one week. If validated in larger studies, it could become the first fast-acting anti-suicide drug.

Such a drug is sorely needed. More than 9 million adults in the US reported having suicidal thoughts in 2013. Over a million went on to attempt suicide. "Around 400,000 suicidal people are coming to emergency rooms every year," says Elizabeth Ballard at the National Institute of Mental Health. "Pharmacologically, nothing has been approved for acute treatment of suicidal ideation, so anything that can help them is greatly needed."

When people seek help, they may be offered behavioural therapy or drugs such as antidepressants. But neither is guaranteed to alleviate feelings, and they can take six weeks or more to kick in. Ketamine is being considered as an immediate treatment, but the drug can cause hallucinations and its effects wear off quickly. "Having something you could use on your own outside of a hospital would be beneficial," says Ballard.

Jaak Panksepp at Washington State University in Pullman and his colleagues decided to test whether an opioid can counter suicidal feelings. Opioids are one of the brain's natural feel-good chemicals. They are released to relieve pain when we hurt ourselves, and are involved when we deal with mental pain, such as that caused by social rejection, a contributor to suicidal thoughts.

Recent studies have shown that the system seems to malfunction in people with depression. Separate work has shown that giving people low doses of opioids decreases their perception of social rejection. "Converging lines of evidence point to a connection between mental pain, depression, suicidal ideation and the body's natural opioids," says Panksepp.

Safer scores

Panksepp's team and his collaborators at the University of Haifa in Israel gave very low doses of buprenorphine to 40 people identified as being severely suicidal – almost two-thirds of the group had already tried to kill themselves. A second group received a placebo. The severity of the participants' thoughts was measured via a questionnaire every week for a month by a psychiatrist. Half the participants were given their drug to take at home, the other half received it in the hospitals where they were staying for treatment.

At the start of the month-long trial, the average score of the participants was about 20. People given buprenorphine dropped an average of six points after one week and nearly 10 points by the end. Those given a placebo only dropped two points in the end. To put this in context, a score of 20 is deemed worrying enough to require hospitalising someone for their own safety. This isn't generally the case for a score of 10.

Although some participants were so ill they were unable to complete the trial, a week after it had finished, everyone who had completed it reported no worsening of their condition (*The American Journal of Psychiatry*, doi.org/bb7t).

"Anything with effects even at the two-week to a month level would help a lot of people," says Ballard. Panksepp thinks higher doses would make the effect kick in even earlier.

Upping the dose is likely to be controversial, though, especially in the US, where abuse of prescription opioids is so bad it is being called an epidemic.

An overdose of opioids can dampen a person's breathing to lethal levels. But buprenorphine carries a low risk of this, because there's a dose beyond which users get no additional pain-relief or high. It is even prescribed to people who are addicted to other opioids. What's more, the daily doses in the team's study were 30 times lower than the amount needed to create an addiction and no one reported withdrawal symptoms.

"I think they're onto something. Buprenorphine acts on a number of different opioid receptors and it's still unclear which one or ones are playing a role in the anti-suicidal effects," says Joan Striebel, a psychiatrist with the California Department of State Hospitals. "I hope this work spurs more interest in what specific molecules could be involved in suicidal thought."

"Anything with effects even at the two-week to a month level would help a lot of people"

"As a psychiatrist, I have spent the last 25 years of my life talking to people who want to kill themselves. Studying and treating the neurochemistry may help us prevent broken lives," says co-author Yoram Yovell at the University of Haifa. ■

LESLYE DAVIS/THE NEW YORK TIMES/REDUX/EYEVINE

Used for opioid additions

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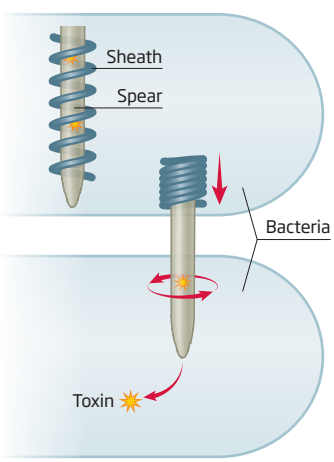
Spear fights figure in bug family feuds

Michael Le Page

GUN owners are more likely to get shot than people who don't own weapons – and something similar seems to be true for bacteria. Some superbugs kill rivals with powerful poison-tipped spearguns. But in crowded conditions they often end up brawling with the nearest family member.

Spear duels

A bacterium's spear consists of a hollow tube containing toxins. When triggered, the surrounding sheath contracts and twists rapidly, propelling the spear into its opponent



No superbugs actually die in kin combat, because they are immune to their own spears. So the fights, which seem to continue indefinitely, appear to be futile and a waste of energy. Why they happen at all puzzled many of the bacteriologists at a Royal Society meeting in London last week.

"It's mystifying given how costly it is," says Richard Moxon of the University of Oxford, who studies bacterial infections. These weapons were only discovered a decade ago, but have turned out to be widespread in one large group of bacteria. The innocuous name – Type VI secretory systems, or T6SS – belies the fact that these astonishing weapons resemble the spearguns used by divers.

The spear consists of a hollow tube, with various kinds of poisons loaded on to the tip or into the tube (see left). A hollow sheath surrounds the tube, whose tip is positioned just inside the cell wall of a bacterium. When triggered, the sheath contracts and twists rapidly, both propelling the spear out of the cell and rotating at it at an incredible 100,000 revolutions per minute. "These machines have this enormous power," says Marek

DAVID M. PHILLIPS/SCIENCE PHOTO LIBRARY

Likes pointless battles

Basler of the University of Basel, Switzerland, whose team is working out their structure, and who presented the latest findings at the meeting.

Basler's team has tagged a speargun protein with fluorescent molecules so they can watch the guns self-assemble. It turns out that *Pseudomonas aeruginosa*, a hospital superbug, normally uses its guns in self-defence. It aims and fires back only when attacked by others armed with T6SS spearguns. *Pseudomonas* will rapidly dispatch the indiscriminate shooter *Vibrio cholerae*, for instance, when the two are in close proximity.

In crowded conditions, though, *Pseudomonas* start spearing each other. More and more cells engage in this "duelling" over time, Basler says. And the fights carry on for as long as researchers are able to watch the bacteria: hours at least.

While Basler uses a mutant strain in his studies, the family feuds do reflect natural behaviour, thinks Martin Welch of the University of Cambridge, who studies *Pseudomonas*.

Much about the Type VI spearguns remains mysterious. While *Pseudomonas* respond to being fired on, it is not clear what triggers the firing or how they manage to aim their spears in the direction of their attackers.

Some bacteria even release weapons resembling T6SS into the intercellular medium, where they bind to and destroy specific rival species. These smart mines, known as pyocins, are being developed for treating gut infections.

Liquid droplets can be moulded like Play-Doh

IT'S a puddle you can poke. A new material that looks just like an ordinary liquid can be shaped, moulded and sliced like Play-Doh or plasticine. It could be used to make novel lenses or mini containers for chemical reactions.

Shape-holding liquids called liquid marbles have been developed before, by coating water droplets in a hydrophobic powder. But the powder made them opaque and they were always spherical. Xiaoguang Li of Tongji University in Shanghai, China, and his colleagues wanted to remove these restrictions and make one that was transparent and mouldable.

To do so, the team created layers of silica 20 nanometres thick, then placed water droplets on top. This coated each droplet in a single layer of silica particles. "The droplet is as transparent as a pure liquid," says Li.

Once applied, the particles bunch together, holding the water inside. The team found they could manipulate these conglomerations into any shape they liked, including slicing them up and spelling out "water". They call the material liquid plasticine (*Soft Matter*, doi.org/bb7w).

"The team could manipulate the liquid into any shape, including slicing it up and spelling out 'water'"

Since the droplets are convex, they could potentially act as a liquid magnifying lens, says Li. Chemicals encased in the droplets took time to diffuse through the material, slowing down chemical reactions and making the droplets good as mini test tubes.

"Their high transparency facilitates observation of the biochemistry process, which is a significant challenge for liquid marbles," says Li. He believes there are other effects on chemistry waiting to be discovered. Jacob Aron ■

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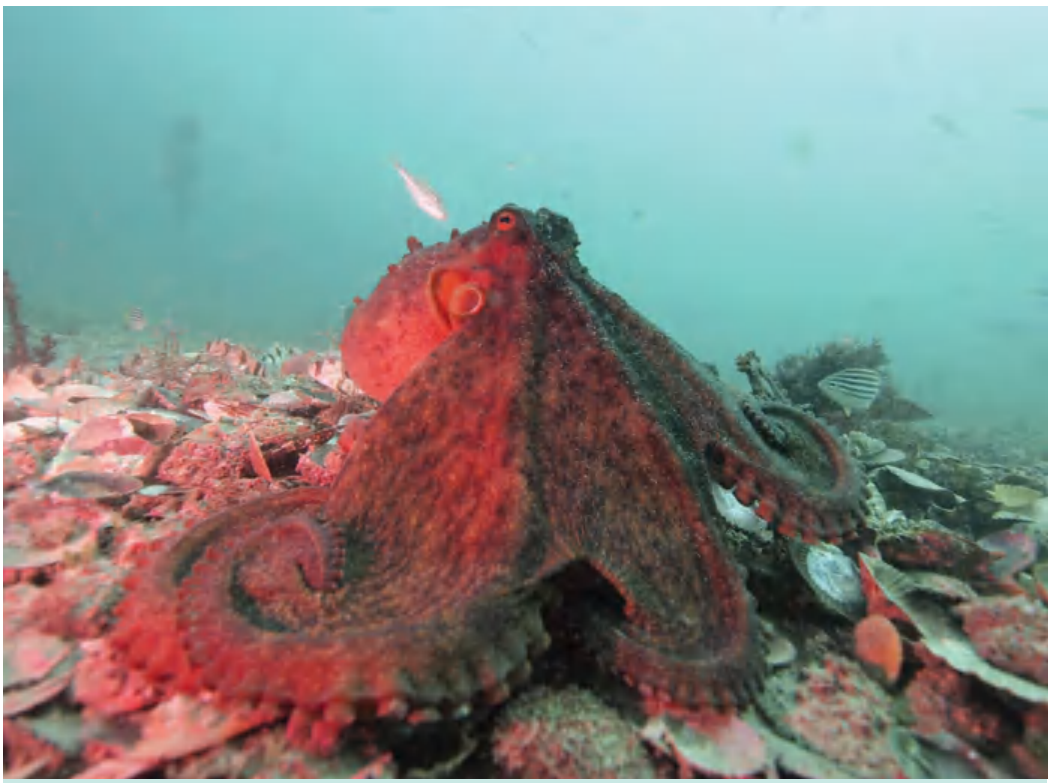

DAVID SCHEEL

Octopus body language reveals their social side

OCTOPUSES aren't as solitary as we thought. They change body colour and posture not just to blend in and avoid predation, but also to communicate.

David Scheel of Alaska Pacific University in Anchorage and his colleagues have documented shallow-water octopuses (*Octopus tetricus*) engaging in strange displays during disputes at Jervis Bay in Australia. Turning dark signalled combat to an attacker; turning pale retreat. Starting an interaction could involve standing tall on all eight arms, or spreading out the arms and moving to higher ground. "We suspect this behaviour makes the octopus appear as large and conspicuous as it can," says Scheel.

On some occasions they saw many octopuses gathering in the same place, but not many fights. This suggests that the body-language signalling may be effective at reducing conflict between the animals (*Current Biology*, doi.org/bb6f). "What is interesting is the tolerance they have for one another," says Scheel. "There must be some incentive to get along."

Despite all this, they do still live largely solitary lives. The most common social gesture observed was one octopus reaching out an arm towards another, often from the comfort of its den, and sometimes receiving an arm-reach in return. "We don't know what this behaviour is about, but we'd like to find out," says Scheel.

Boost C-section baby with vaginal bugs

GIVING babies born by caesarian a swab of vaginal fluid makes their gut bacteria resemble those of a conventionally born baby.

The dramatic transition from womb to world is the time when a baby ingests the bacteria that will colonise its guts. But babies born by C-section end up with a different microbiome – including some from the operating room.

Studies have found that this may make the child vulnerable to asthma, food allergies and obesity later in life. "Maybe we can reduce this risk by restoring their microbiome," says Jose Clemente at Mount Sinai School of Medicine in New York City.

Clemente's team gave women planning a caesarean a sterile gauze, which they inserted like a tampon. This was removed just before surgery and was used to wipe the newborn's mouth, body and anus.

The results suggest that swabbing really does give a C-section baby a more "vaginal birth-like" microbiome (*Nature Medicine*, doi.org/bb7x).

It is hard to know what, if any, effect the changes will have on health, says David MacIntyre of Imperial College London. "But it's a cheap and easy way of exposing C-section babies to vaginal bacteria at birth."

Intense workout = less energy burned

SORRY fitness fans. Those intense workouts may not help you lose as much weight as you thought.

People who are very physically active seem to become more efficient at using energy, and so burn fewer calories when not exercising than the rest of us.

Researchers used wearable devices to measure 332 people's activity and energy expenditure. Unsurprisingly, people who were moderately active burned more energy per day than the couch potatoes. But those who were most active used the same energy as the moderate group (*Current Biology*, doi.org/bb7s).

Two people on a treadmill burn the same calories even if one is a fitness fanatic and one not, says study author Herman Pontzer of Hunter College, New York. But highly active people make up for a long workout by burning fewer calories over the rest of the day as their bodily systems adapt.

Bees work harder ahead of rainy days

BUSY bees get busier if the next day will be rainy.

So found Xu-Jiang He and colleagues at Jiangxi Agricultural University in Nanchang, China, who attached radio-frequency identification tags to 300 worker honeybees from three hives.

The bees spent more time out of the hive foraging, and stopped work later, on days when the following day proved to be rainy rather than sunny. They may be responding to cues such as changes in humidity, temperature and air pressure that precede rainstorms (*Insect Science*, doi.org/bb6m).

"Honeybees may attempt to collect more food before rainy days as a food shortage prevention," He's team writes.

Not just a load of old balls

HOW many ways can you arrange 128 balls? We now have an answer – and it could one day help predict the path of avalanches or the motion of sand dunes.

Mathematicians thought that there were so many ways to arrange balls in a box that counting them would require a computer larger than the universe.

Now Stefano Martiniani of the University of Cambridge and his colleagues have found a clever solution. By simulating sample packings and using these to estimate the properties of others, they were able to show there are 10^{250} ways to arrange 128 jammed spheres – far more than the 10^{80} atoms in the universe.

It took a while, though – each simulation lasted 300 hours, and they ran 1000 of them (*Physical Review E*, doi.org/bb6g). "We're talking about a huge amount of computer time," says Martiniani.

But why bother? The technique could prove useful in developing a new kind of thermodynamics for real-life jammed systems, like sand and snow. This is impossible at the moment because of the high numbers involved.

"This idea was abandoned because it was thought to be numerically intractable, but we've shown it can be done," says Martiniani.

PHILIP LEE HARVEY/GETTY

Map of Jupiter's path shows Babylonians' advanced maths

ANCIENT Babylonians were maths whizzes. A mysterious trapezoid described on cuneiform tablets could be a map of Jupiter's path across the sky – and shows that Babylonians beat Europeans to the ideas that led to integral calculus by at least 1500 years.

Four cuneiform tablets at London's British Museum refer to a trapezoid shape while discussing Jupiter.

No one knew why until 2015, when a colleague from Vienna handed a stack of 50-year-old photos to Mathieu Ossendrijver of Humboldt University in Berlin. Those pictures showed cuneiform tablets from around 100 or 200 BC that had been excavated in the 19th century and transported to the British Museum.

One tablet, inscribed with a calculation involving Jupiter, was unfamiliar. Ossendrijver believes the calculation and trapezoid descriptions are recipes for the same process: predicting Jupiter's place in the sky.

He thinks the slanted top of the trapezoid is like a graph of Jupiter's speed across the sky in the days after it first appears above the horizon.

By calculating the area inside the trapezoid, Babylonian astronomers could find where the planet would be – exploiting the same link between velocity and displacement taught in calculus classes (*Science*, doi.org/bb6h).

Scholars in Europe during the 14th century are typically credited with the same insight – but the Babylonians had them far earlier.

"It's quite modern, and it's highly unexpected," Ossendrijver says.

Star pair's eclipse smashes records

TALK about a long-distance relationship. A pair of stars have the longest and most infrequent eclipses ever seen – and one star may be devouring the other.

Eclipsing binary stars orbit each other so that one star periodically blocks its partner's light from our viewpoint on Earth. Until now, the longest gap between eclipses was 27.1 years, a record held by a binary called Epsilon Aurigae.

Now Joseph Rodriguez of Vanderbilt University in Nashville, Tennessee, and colleagues have found an eclipsing binary named TYC 2505-672-1 with a record-breaking period of 69.1 years.

By combining 120 years of historical data with contemporary data, the team showed that the main star, a red giant, faded once during the second world war and again from 2011 to 2014. The eclipses lasted a remarkable 3.45 years – also a new record (arxiv.org/abs/1601.00135).

The lengthy eclipse is due to a huge disc around the second star. Rodriguez thinks the red giant may be cannibalising its sibling, pulling material off to form the disc.

The next eclipse won't occur until 2080. But Rodriguez, now 27, hopes to live to see it.

FRIEDHELM ADAM/IMAGEBROKER/CORBIS

Songbirds polish their act in Africa

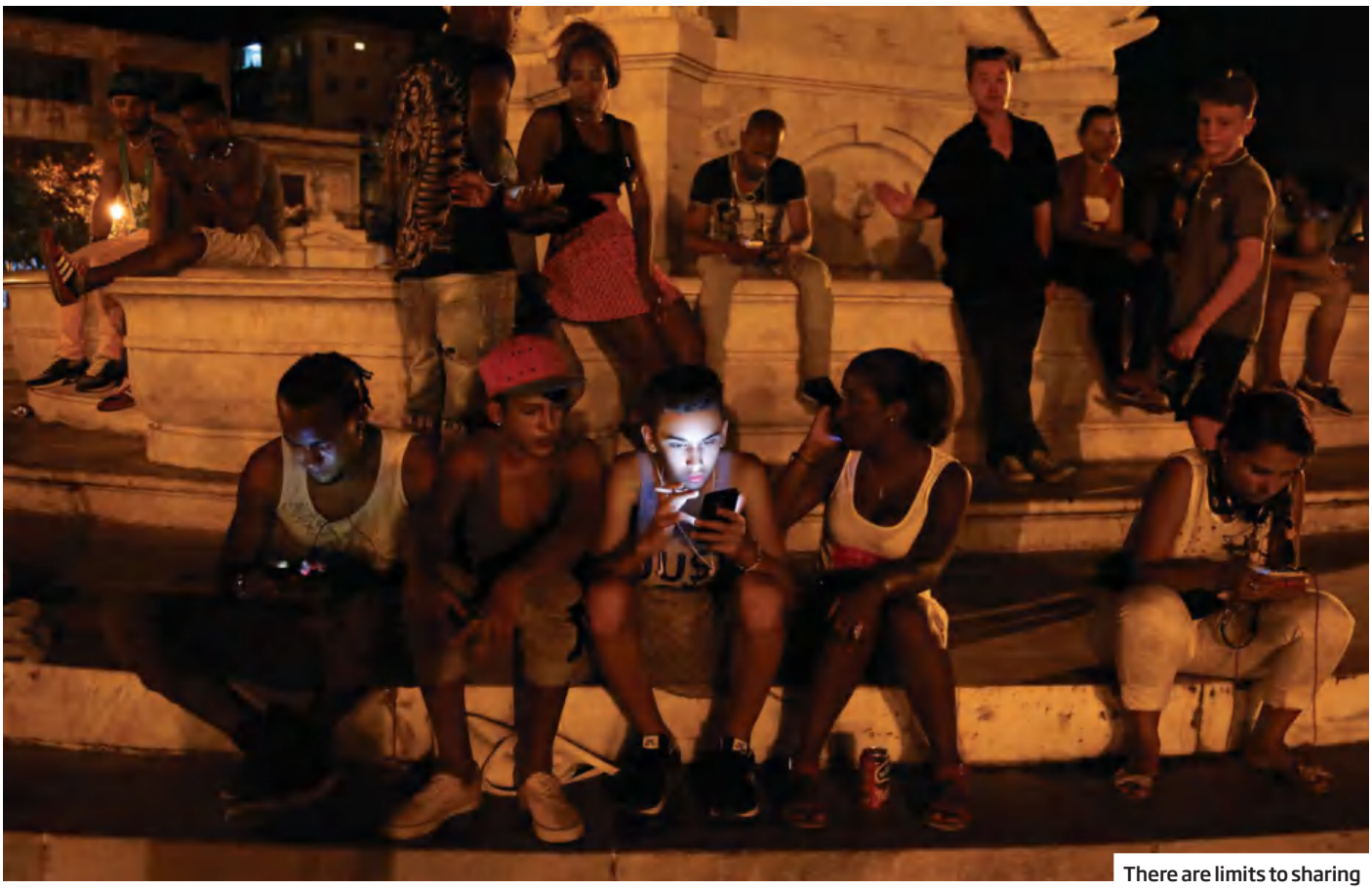
WINTER migration isn't just about finding food – it's band camp. Singing remains a preoccupation for many European songbirds when they fly south to Africa. The mystery is why they retain this courtship behaviour even when not breeding, since it can attract predators and uses up energy.

Marjorie Sorensen at the University of Cambridge and her team tested different theories by studying the great reed warbler (pictured). In Europe, the males use their complex songs to help them win mates.

In Zambia, the team found that the birds' territories overlapped and that they weren't aggressive towards others. This ruled out the idea that their singing is territorial.

By comparing 57 migratory species, the team found that those with the most complex songs also sing the most in Africa. That suggests the birds are honing their skills ahead of the next breeding season (*The American Naturalist*, doi.org/bb6j).

"Perhaps they're hearing sounds in Africa and incorporating them into their repertoires," Sorensen says. "Or they're practising their songs, maintaining their complexity so they're ready for reproduction."



DESMOND BOYLAN/AP/PA

There are limits to sharing

First-time surfers

Large parts of the world could be about to get online at last. **Aviva Rutkin** looks at the rewards and the downside

SOMEONE in Cuba wants to know about AC/DC. The query pops up on a screen in Atlanta. After a quick web search, the answer is on its way back to Cuba. Next up: a request for the English translation of a Spanish phrase.

Launched last week, Cuba Intercambio is an email-based service that connects Cubans to people who act as their online proxies. The service exists because Cuba's internet provision is one of the most restricted anywhere, and expensive to access. Only 5 per cent of the population is hooked up to the full web, although the state telecoms company has announced that it will begin offering home broadband access. But censorship could still make even a Google search impossible for most.

However, many people in Cuba have access to the national email system, so Amy Bruckman and her colleagues at the Georgia Institute of Technology built Cuba Intercambio around that. It receives users' queries by email and puts them up on a Facebook group. Anyone outside Cuba can look up the information requested and send it back. The set-up is deliberately low-tech, says Bruckman.

Cuba Intercambio is one of several projects trying to bridge the gap between internet haves and have-nots. Many parts of the world, including large swathes of Africa, South America and Asia, have limited or no access. Last May, the UN's International Telecommunication Union estimated that there were about 3.2 billion people using the internet, meaning more than half of the world's population is still offline.

"What Facebook are doing might be more palatable if they weren't pretending it was an act of charity"

Use of the internet has already reached saturation levels in the rich world, so extending the net's reach elsewhere is a way for tech giants like Facebook and Google to grow their user bases. Facebook's Internet.org project aspires to bring the net to offline parts of India and Africa – possibly with high-flying drones that will beam it to ground stations using lasers. Google has plans to connect the world using solar-powered balloon relays. Others are working on internet by satellite or servers that dish up preloaded web content and can be carried in a backpack.

Such projects make lofty promises: better education, more entrepreneurship, greater access to crucial information, a globally connected world. But not all

interventions have been greeted with open arms.

Facebook's Free Basics platform, which gives relatively humble phones free access to Facebook, Facebook Messenger and a limited list of partner websites, was criticised for violating net neutrality – the principle that internet providers should not favour some services over others. In India, public opposition mounted and the platform was suspended in December. For reasons that are unclear, Free Basics hit another snag in Egypt at the end of last year, shutting down after just two months.

The uproar might seem counter-intuitive. Shouldn't people be happy to receive the internet, even in limited form, rather than have nothing at all? Or, as Mark Zuckerberg put it in an article for *The Times of India* in December: "Who could possibly be against this?"

The danger of a service like Free Basics, says Mark Graham at the University of Oxford's Internet Institute, is that it could give Facebook a monopoly over how an entire region of the world gets online, turning millions into locked-in customers. Graham compares it to an electricity company offering free power that can only be used to run appliances they supply.

"What they are doing might be more palatable if they weren't pretending that it is a pure act of charity," he says. "If they genuinely want to help the poor, and genuinely want to stand behind the claim that they are not benefiting themselves, why not offer access to the open internet?"

One way to do that might be to find new ways for users to pay for their connections. For example, Grameenphone, a Bangladeshi service partnered with Mozilla – the organisation behind the Firefox web browser – offers 20 megabytes of free data per day, supported by advertisements.

"Walled-garden initiatives that give net access to naive users could leave them open to exploitation"

Other approaches are more radical. In Paraguay, developer Matias Insaurralde is working on an app called Facebook Tunnel that uses Facebook Messenger to connect users with limited internet access to those with good access – in effect hijacking Facebook's app to create a virtual network. Similar services, like the free Lantern app, have allowed people in China to circumvent the Great Firewall.

The idea for Cuba Intercambio came from field interviews by Bruckman and her colleagues. They found that Cubans wanted to use the internet to find trustworthy sources of information – alternatives to the national media or government sources. Their work will be presented later this month at the Computer-Supported Cooperative Work and Social Computing conference in San Francisco.

The chance to observe people using the internet for the first time is a powerful one, says Bruckman – especially as a lens to see how the net can transform lives. "Cuba is one of the last places in the world where we can watch the introduction of the internet to a relatively developed culture," says Bruckman. This matters because people tend to have utopian assumptions about its impact. "They're in 1993 when they think about the internet."

In some parts of the world, the online world remains hard to conceive of. A study due to be published later this year, for example, surveys mobile phone owners in rural Zambia with little or no experience of Facebook about what they imagine it to be like. "If I were on Facebook, at least I would be able to send photos of my crops to those who support me with fertiliser and seeds," says one respondent. "I have never used Facebook before," says another. "I have just heard about it, it is where people find friends. You can get to have more friends throughout the world."

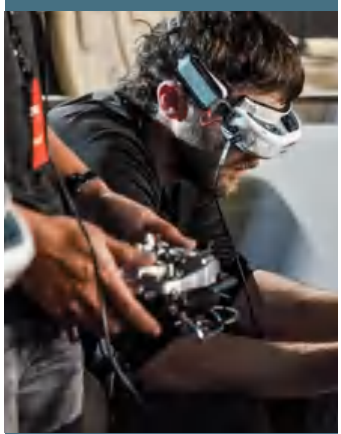
The findings suggest that walled-garden initiatives involving users with no concept of net neutrality or what it may mean to share personal data with a corporation could throw up a host of issues – and that Silicon Valley might take advantage of that naivety.

"All of these things that most of us take for granted and mostly understand from using a computer most of our lives, all of this stuff will be unfamiliar to large segments of the world's population," says Susan Wyche at Michigan State University in East Lansing. "It's really tricky to get into this mindset where you have no idea what the internet is." ■

GOOGLE

Ticket to cyberspace, or hot air?

ONE PER CENT



DRONE RACING LEAGUE

Contestants ready!

Last week, the US Drone Racing League announced its first official competitive season. The inaugural race – where drones will zip around a course at up to 160 kilometres an hour – is scheduled for 22 February in Miami, Florida. As drone racing turns into an international sport it is attracting high-profile investors. Matt Bellamy of rock band Muse and Stephen Ross, the owner of American football team Miami Dolphins, are reported to be among those who have collectively given over $8 million to get the league off the ground.

1000km

The amount of road to be paved with photovoltaic cells in France in the next five years, according to ecology and energy minister Ségolène Royal

Supersonic pod

Hyperloop now has a train to go with the tracks SpaceX is building in California. A team at the Massachusetts Institute of Technology won a competition to design a passenger pod for the transport system that will propel people through a tube at near supersonic speeds. SpaceX CEO Elon Musk hopes the competition will finally silence sceptics.

England's health service to get drones this year

PAGING doctor drone. Specialist ambulance teams in the English National Health Service will get a technological boost this year, when they start using remote-controlled UAVs to help handle emergencies.

NHS England has 15 Hazardous Area Response Teams (HART) that deal with medical emergencies involving chemical, biological or nuclear materials. They work in challenging situations involving confined spaces, heights or water. Last month the National Ambulance Resilience Unit (NARU), which manages the teams, awarded a contract to provide each HART unit with a reconnaissance drone.

The drones will have cameras on board to provide an eye in the sky at accident scenes. Each team will have a trained drone operator working alongside paramedics. "The drone will allow the HART leader to observe the high-risk incident ground quickly and prior to the deployment of staff," says Christian Cooper of NARU. The drone will also give teams a quick overview of patients' condition and location, allowing the leader to direct paramedics towards them, he says.

The NHS is not the only UK service investigating drones – police in Dorset, Devon and Cornwall began a six-month trial last November, using them to help with missing person searches and crime scene photography.

NARU is working with other emergency services and government departments to develop a combined national strategy for drones, which will determine the final specifications for HART's drones. Each is expected to cost between £10,000 and £30,000.

NARU has not decided which regions of England will receive drones first, but expects teams to start using the technology soon. "The first NHS ambulance services to replace their technology will receive the specified drone for use by their HART teams this year," says Cooper. Jacob Aron ■

FRANK PERRY/AFP/GETTY IMAGES

I owe it all to the avatars

Virtual confidence

Public performance is nerve racking. **Sam Wong** finds a digital fix

STANDING up to speak or perform in front of a live audience can be utterly terrifying. But virtual auditoriums are helping teachers, musicians, police and business people practice face-to-face interactions with groups.

The system was first developed by Charles Hughes at the University of Central Florida (UCF) to allow teachers to hone their technique. When a teacher greets the virtual class on the large screen, or asks questions, they respond just like real students.

"It's a little bit intimidating at first but I very quickly forgot that I wasn't talking to real people," says Jacquelyn Chini, a lecturer at UCF who has tried the system. The secret to the immersive crowd is that trained interactors control the avatars' responses.

Eighty-five universities have adopted the technology, and more than 10,000 prospective teachers. To test how well it works, Hughes and his colleagues assessed teachers in front of a real class, then gave them four 10-minute sessions in the simulator. Their performance on measures like asking open questions and allowing children plenty of time to think before answering improved after each session.

At the teachers' request the avatars look like cartoon characters, says Hughes. "We all know that's fake but when you start interacting with it you feel like it's real," says Chini.

The system also monitors body position to give teachers instant feedback. "Even if we give feedback from a computer and it actually came from a human, people buy into it more because they view it as objective," says Hughes.

"The secret to the immersive crowd is that trained interactors control the avatars' responses"

A company called Mursion is commercialising UCF's platform to help other professions, such as doctors and police. "I'm working with police on de-escalation skills," says Hughes. "All one has to do is read the news to know why that's important."

The Royal College of Music (RCM) in London uses a similar tool to help musicians with live performance. The simulator conjures up a small concert audience, or an intimate audition panel, programmed to be enthusiastic, neutral or hostile. Ringing phones and coughs create distraction. Cameras record the performances so musicians can review them later.

Business students will be next to get a virtual confidence boost. The RCM is working with Imperial College London to develop the tool for training executives in presentation skills. ■

New Scientist events

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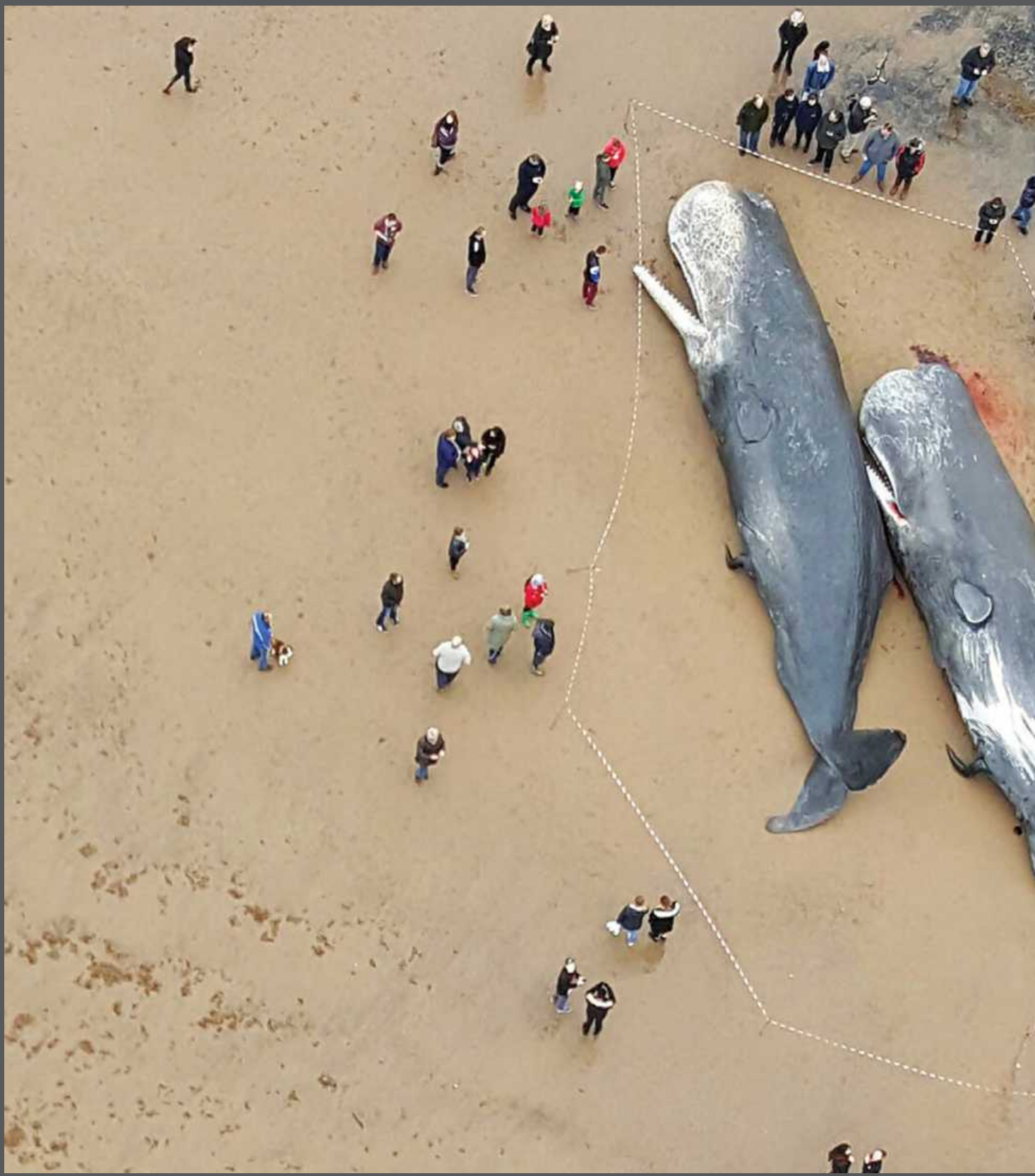


Death on a beach

SPECTACULAR and sad. These sperm whales are two of the five that died after beaching on England's east coast last week.

Since 11 January, 12 sperm whales have become stranded on the Dutch island of Texel and the German islands of Wangerooge and Helgoland. It's likely that they were all part of the same group, says Rob Deaville at the Zoological Society of London, who has been studying the whales in England.

Around 600 cetaceans become beached in the UK each year, most of them porpoises and dolphins. The causes are unknown: whales can become stranded after being hit by ships or entangled in fishing lines or nets. Pollution and marine noise have also been implicated.

Why the sperm whales strayed into the North Sea is unclear, says Deaville. Those he has examined had little in their stomachs beside a few squid beaks eaten some time ago. Their intestines were stained green from bile, another sign they hadn't fed in a while.

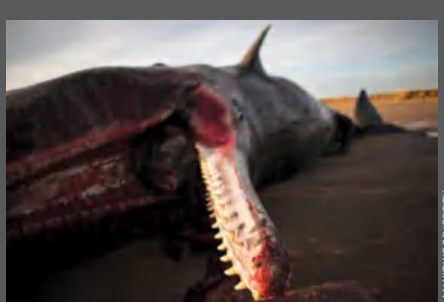
When whales are beached, the weight of their bodies damages their internal organs and muscles. The protein myoglobin is released from the muscles into the blood and reaches the kidneys, where it is highly toxic. Dehydration and kidney damage are the most common causes of death.

Once they die, the whales start to decompose, producing a stench that attracts scavengers, and causing gas to build up inside their blubber.

"They act like pressure cookers," says Deaville. "One of them exploded when we opened it up."

The whales have now been taken to landfill.

Sam Wong



DAN KITWOOD/GETTY

Photograph
KNS News

Slaves to destruction

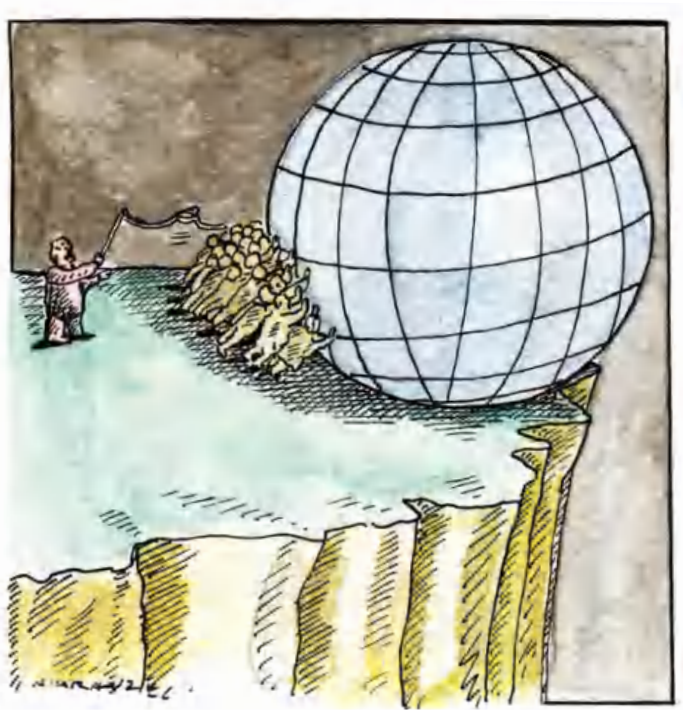
Forced labour is unjust in its own right, but recognising its effect on the environment may help hasten its end, says **Kevin Bales**

MODERN slavery is a blight on our planet in many ways.

First and foremost on the lives of those caught in its net. The latest measures estimate there are 36 million slaves globally. The International Labour Organization believes this adds $150 billion annually to the criminal economy. Even if historically it has never been a smaller proportion of human existence, any amount of forced labour is too much.

It is also becoming clear that modern slavery is bad in other ways – in particular its vastly disproportionate impact on climate change and species loss. Highlighting this might help spur nations to work harder to end it.

The link is obvious on the Bay of Bengal, specifically the seafood processing camps in the Sundarbans World Heritage Site,



staffed by slaves. This vast area of protected mangrove forest is a major carbon sink, home to protected species, and a crucial buffer for coastal towns against cyclones. Slaves are made to clear the forest, which releases CO_2 and also pushes protected tigers to the brink. The profits driving this destruction come from the global market for shrimp and pet food.

These camps are one example of many slave-based enterprises in food production, mining, brick making, logging, charcoal making and other industries.

Their combined impact on the climate is severe. If all slavery were a country it would have Canada's population and the GDP of Kuwait, but would rank third for CO_2 emissions, after China and the US. I hope that such facts will add new impetus to efforts to end

Dangerous times

The Doomsday Clock may be in its 70th year, but it's still relevant, says **Debora MacKenzie**

IT CAN'T have been easy to work out what to do with the Doomsday Clock this year.

A panel of experts last week ceremoniously set the hands of this symbolic timepiece. This has been done every year since 1947 to express how well they think existential threats have been reduced, initially just from nuclear weapons.

The closer to midnight, the worse we've done. The hands have hovered around 5 minutes to the hour for a decade, but in 2015, after a lack of progress on nuclear non-proliferation and climate change, they moved to 3 minutes to midnight. This year, the sages left them there.

Why? There was agreement, albeit feeble, at the climate-change conference in Paris to limit global warming. Iran accepted limits on its nuclear activities. But China and Pakistan are increasing their nuclear arsenals, North Korea tested what may have been a more usable nuke, and the US and Russia plan to modernise their own arsenals, at a cost of $350 billion in the US. As one panellist pointed out, you're unlikely to reduce reliance on nukes if you spend that much on them.

"These days, global threats go well beyond nuclear war, and inputs for the clock have expanded"

Those behind the clock stand by its importance in its 70th year.

"It is a metaphor for how close we are to destroying the planet," said Rachel Bronson, head of the global security journal *Bulletin of the Atomic Scientists* (she means for destroying civilisation).

These days, global threats extend well beyond nuclear war, and inputs for the clock have rightly expanded. Climate change was added in 2007, and a "doomsday dashboard" now tabulates threats that provide a quasi-quantitative basis for its "direness" index.

That said, the final call on

forced labour.

Enforcement of existing anti-slavery laws would diminish both CO_2 emissions and species loss, while also warding off the threat of rising sea levels and destructive deforestation. This would have little or no economic cost for existing (non-criminal) industries and markets, and would help lift depressed economic areas.

If freed slaves were paid to replant the forests they were forced to cut, this could generate carbon credits. Selling these credits would help to fund the rehabilitation of land and people.

Ending slavery will require a big investment in things like law enforcement, but this can be offset by a freedom dividend that accrues as millions more people fully participate in the economy, stimulating much-needed growth in developing countries.

Ending slavery is bad for criminals and corrupt officials but good for those forced to work, and for the economy, the environment and consumers.

It turns out that doing this might just save the world. ■

Kevin Bales studies contemporary slavery at the University of Hull, UK, and is the author of *Blood and Earth: Modern slavery, ecocide, and the secret to saving the world* (Spiegel & Grau)

setting the clock seems as much about gut feeling as a calculation on the back of an eminent scientist's envelope – but these are pretty eminent guts. I suspect this is as valid a prediction as any you can get in a complex world.

As a metaphor, the Doomsday Clock is undeniably powerful, judging from the press coverage of this ritual alone. One wonders, though, how many onlookers really heed its warnings. At least they can't say we didn't try to warn them – with a retro, but still relevant, bit of graphics. ■

Debora MacKenzie is a consultant for *New Scientist*

ONE MINUTE INTERVIEW

Why believe in a flat Earth?

Those who distrust received wisdom are following the traditions of the Enlightenment, says psychologist **Rob Brotherton**

PROFILE

Rob Brotherton is a psychologist at Barnard College in New York City who specialises in the psychology of conspiracy theories. His book *Suspicious Minds: Why we believe conspiracy theories* (Bloomsbury Sigma) is out now

Last week the rapper B.o.B claimed that the Earth is flat. Are you surprised that this idea is still being touted in the 21st century?

I was surprised and delighted: I love hip hop and conspiracy theories, and this combines both. The psychology that underlies this kind of thinking is fascinating, but I never thought flat Earth theory would get much attention.

It seems a surprising idea to get behind, when the evidence from space photos and other things seems incontrovertible…

The belief that Earth isn't spherical is one of those things that, at first glance, is easy to write off. But when you look closer, it entails complex arguments about how gravity exists if Earth is a flat disc, and how there must be a conspiracy by NASA or other authorities to hide the fact that Earth is flat.

What leads people to believe in conspiracies?

It is reasonable to think that conspiracies occur, because sometimes they do. Belief in conspiracy theories shouldn't be seen as a strange quirk that few people have. Surveys show that many people in the US believe that there was some kind of conspiracy behind the 9/11 attacks, or at least that the US government is not telling the whole story. Our brains also have cognitive biases that make us prone to seeing conspiracies, real or imagined.

What cognitive biases lead to a belief in conspiracy theories?

When something big happens we tend to assume that something big must have caused it. This is the proportionality bias. Then there's intentionality bias, which means that when something ambiguous happens, we assume that it was intended. When Malaysia Airlines flight MH370 disappeared – a very ambiguous event as no one knows what happened – we assume that someone planned it this way. Our personality type also affects whether we believe in things like the flat Earth theory.

How does personality affect our beliefs?

People who believe conspiracy theories tend to distrust received wisdom and the things that people in authority tell us. And our built-in confirmation bias means we look for evidence that supports our beliefs. All of us do this. We also suffer from the "illusion of understanding", a tendency to overestimate our knowledge of how things work. This could lead flat-Earthers to think that NASA is misrepresenting evidence.

So you think we should have more empathy for conspiracy theorists and flat-Earthers?

All of our beliefs are more weird than we would like to think. Conspiracy theories are seen as contrary to the Enlightenment, to scientific values. But the Enlightenment was all about not trusting received wisdom, and thinking for yourself. It made sense to reject the religious doctrine that prevailed at the time, to distrust what you were told. It is inherently rational to question received wisdom, even if you disagree with the conclusion that some people reach.

Interview by Alison George

The eloquent ape

Frogs croak, birds sing and monkeys chatter. But no other species has our rich and infinitely adaptable language skills. Without them, trade, tribes, religions and nations couldn't have existed, to say nothing of the internet or the ink on this page.

To what do we owe our ability to share thoughts and influence others? How does it shape us, and how will it change?

Here's our guide to the nine biggest questions

VASAVA

WHO SPOKE THE FIRST WORDS?

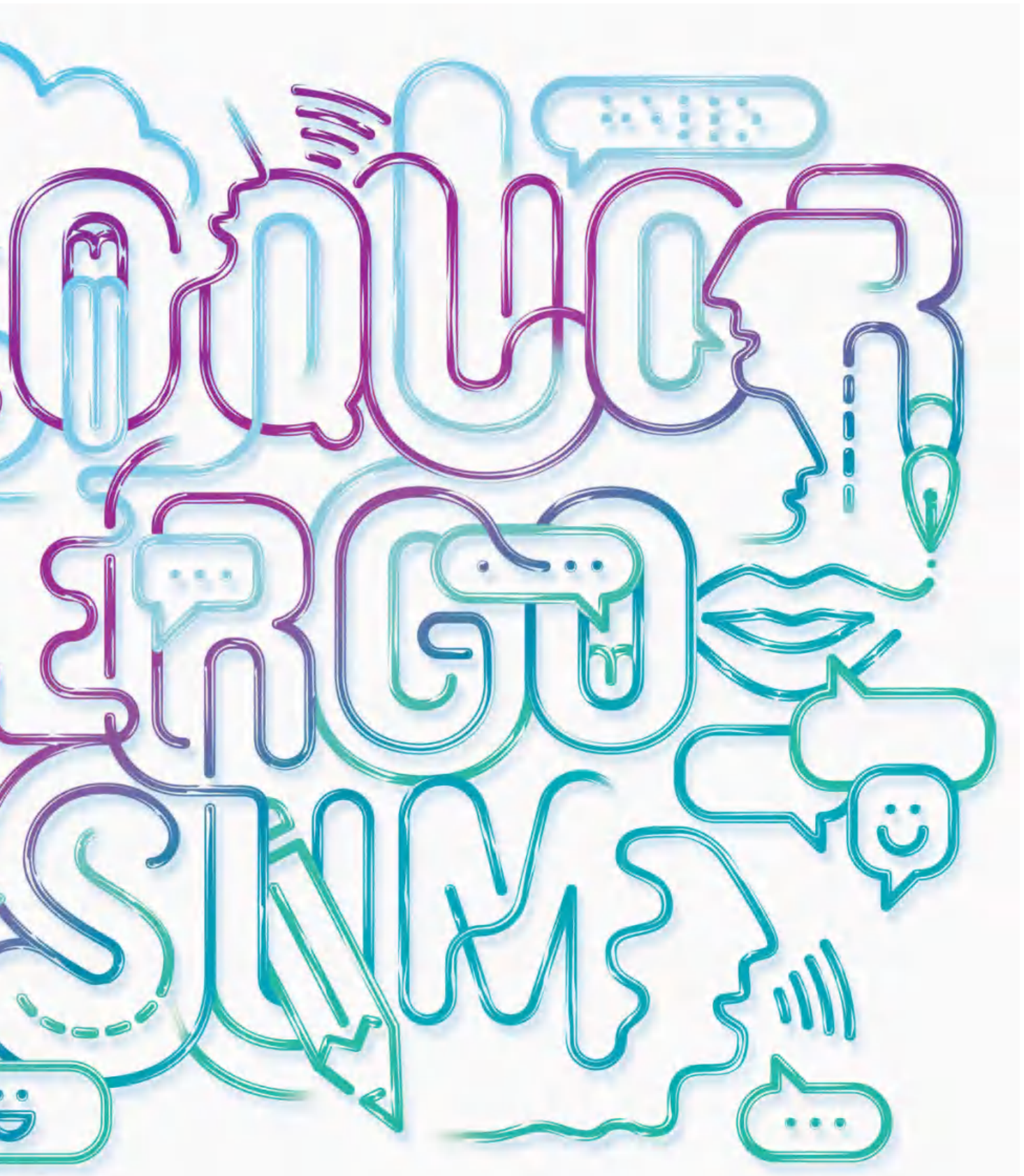
Language is a powerful piece of social technology. It conveys your thoughts as coded puffs of air or dozens of drawn symbols, to be decoded by someone else. It can move information about the past, present and future, formalise ideas, trigger action, persuade, cajole and deceive.

Today, there are 7102 such codes spoken around the world. All human societies have language, and no language is "better" than any other: all can communicate the full range of human experience. To those of us who study human evolution, this incredible universality suggests that our species has had language right from when *Homo sapiens* arose in Africa between 200,000 and 160,000 years ago. A more recent origin could not explain how groups that stayed in Africa after *H. sapiens* migrated to the rest of the world 60,000 years ago also have language.

If *H. sapiens* has always had language, could other extinct human species have had it too? Some believe that Neanderthals did – which would imply we both inherited it from our common ancestor some 500,000 or more years ago. This theory is consistent with the discovery that *FOXP2*, a gene that is essential to speech, is identical at two key positions in humans and Neanderthals but different in chimpanzees. But a single gene is not enough to explain language. And recent genetic evidence shows that the Neanderthal brain regulated its version of *FOXP2* differently.

What's more, language is inherently symbolic – sounds stand for words that stand for real objects and actions. But there is scant evidence that Neanderthals had art or other symbolic behaviour – a few pieces of pigment and some disputed etchings. By comparison, the humans who lived alongside them in Western Europe painted beautiful murals, made musical instruments and had a wide variety of tools and weapons.

Suggestions that language evolved even earlier – for example in *Homo erectus*, an upright ape that walked on the African savannah two million years ago – are little more than idle speculation. It seems more likely, from the existing evidence at least, that our ability to bend each other's ears is indeed unique. **Mark Pagel** is an evolutionary biologist at the University of Reading, UK



WHY DID WE EVOLVE LANGUAGE?

Our language skills didn't come for free. Humans had to evolve complex brain circuits and sophisticated machinery in order to speak, and spend precious years teaching their children. Why pay that price?

Many people attribute our linguistic skills to our large brains, ability to make complex hand gestures, distinctive vocal tracts and to the gene *FOXP2*, which gives us the fine-tuned control of our facial muscles. But on their own, these traits do not explain why we evolved language. There are animals with larger brains, gesturing is widespread among primates and some bird species can imitate human speech without our descended larynx or our particular version of *FOXP2*.

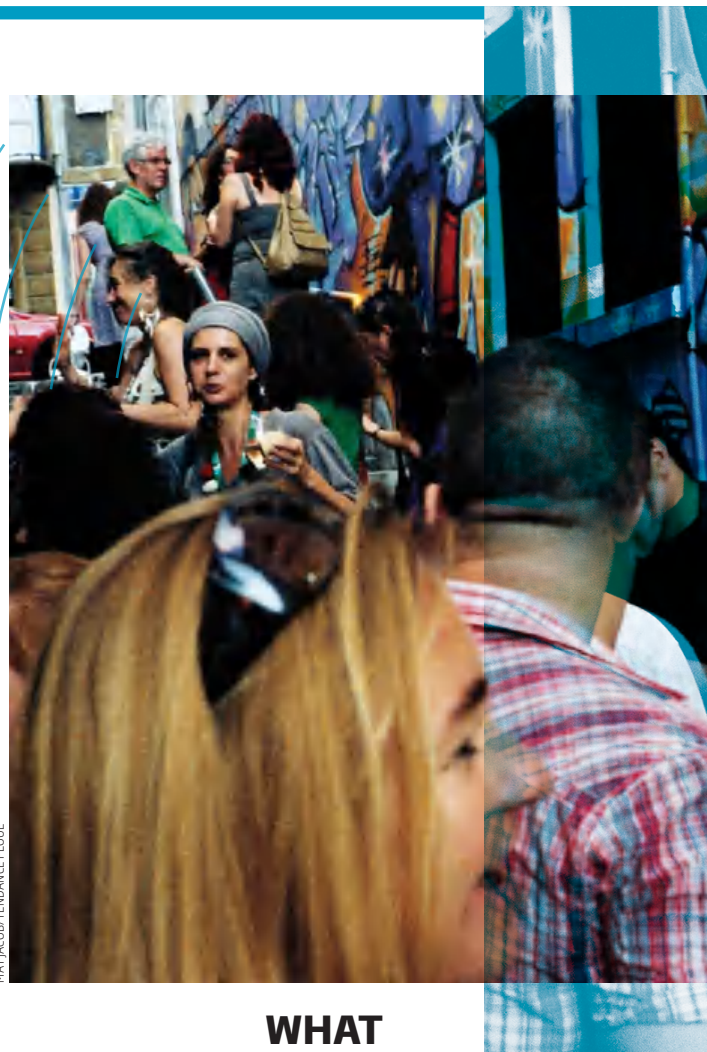
Instead, the feature that most clearly separates us from other animals is the sophistication of our symbolic and cooperative social behaviour. Humans are the only species that routinely exchanges favours, goods and services with others outside their immediate family. We have an elaborate division of labour, we specialise at tasks and then trade our products with others. And we have learned to act in coordinated ways outside the family unit, such as when a nation goes to war or people combine their efforts to build a bridge.

We take the complexity of our social behaviour for granted, but all these actions rest on the ability to negotiate, bargain, reach agreements and hold people to them. This requires a conduit – like a modern USB cable – to carry complex information back and forth between individuals. Language is that conduit.

Some social insects – ants, bees and wasps – have a level of cooperation without language. But they tend to belong to highly related family groups, genetically programmed to act largely for the good of the group. Human societies must police anyone who tries to take advantage. With words and symbols, we can expose them as cheats and tarnish their reputations. We can lavish praise on those worthy of it, whose reputations will be elevated even among those they have never met: words can travel further than a single action.

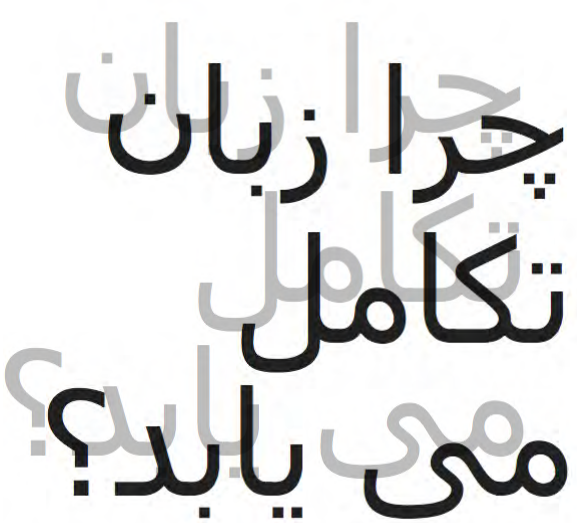
All these complicated social acts require more than the grunts, chirrups, odours, colours and roars of the rest of the animal kingdom. They tell us why we and we alone have language: our particular brand of sociality could not exist without it.

Mark Pagel



MATJACOB/TENDANCE FLOUE

"TOK, TIK, DIK AND TAK MAY ALL DESCEND FROM AN ANCIENT WORD FOR TOE"



WHAT WERE THE FIRST WORDS?

It's a fair guess that there was once an original mother tongue – the ancestor to all living and dead human languages. The evidence for this is that all human languages, unlike other forms of animal communication, string together words into sentences that have subjects, verbs and objects ("I kicked the ball"), and anyone can learn any language.

Comparative linguists search for sounds that come up again and again in languages from all over the world. They argue that if any relics of a mother tongue still exist today, they will be in those sounds. Merritt Ruhlen at Stanford University in California, for example, argues that sounds like *tok*, *tik*, *dik*, and *tak* are repeatedly used in different languages to signify a toe, a digit or the number one. Although studies by Ruhlen and others are contentious, the list of

CAN LEARNING A LANGUAGE REWIRE YOUR BRAIN?

As our species evolved parts of our brain expanded, resulting in more computing power for language. It's what makes us hard-wired for communication. What is perhaps more surprising is how language can shape our brains throughout our lives.

Most of the evidence for this comes from studies of people who are bilingual. Brain scan studies show that switching between two languages triggers different patterns of brain activity compared with speaking in one language, particularly in the prefrontal cortex. That part of the brain, at the very front of our skulls, is involved in organising and acting on information, including using working memory, reasoning and planning. Other studies show that bilinguals are faster at getting to grips with a new language.

Quadrilinguist Arturo Hernandez, director of the Laboratory for the Neural Bases of Bilingualism at the University of Houston in Texas, says these differences could reflect differences in the architecture of bilingual brains. In other words, learning another language could change how your brain is wired. "It would make sense, if you have had this very different linguistic experience, to see some sort of stable, long-lasting effect," Hernandez says.

It may also make the brain more resilient. Ellen Bialystok at York University in Toronto, Canada, has found that lifelong bilinguals tend to be diagnosed with dementia on average 4.5 years later than monolinguals, and have more white matter, including in their prefrontal cortex. White matter is made of nerve fibres that connect different brain regions, shuttling information back and forth between them. So boosting language skills appears to build more connected brains – although Bialystok cautions that this still needs to be confirmed.

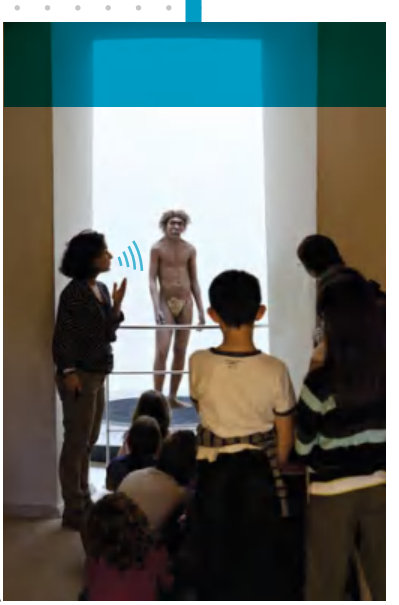
More evidence for the benefits of second languages came last year from a study of 608 people who had had a stroke. Thomas Bak of the University of Edinburgh, UK, found that of the bilinguals among them, 40 per cent recovered full function, compared with only 20 per cent of monolinguals. Bak speculates that the mental gymnastics involved in speaking several languages could build extra connections that improve function and help cope with damage. "The idea is that if you have a lot of mental exercise, your brain is trained and can compensate better," says Bak. **Megan Scudellari** is a science writer in Boston

words they say are globally shared because they sound almost the same also includes *who, what, two* and *water*.

Another approach is to look at words that change very slowly over long periods of time. My own team has used such statistical studies to show that words for the numbers 1 to 5 are some of the slowest evolving. Also on this list are words involved in social communication, like *who, what, where, why, when, I, you, she, he* and *it*. This list fits with the expectation that language evolved because of its social role (see "Why did we evolve language?", page 28). It also has some overlap with Ruhlen's list.

More broadly, we can say with some confidence that the first words probably fitted into just a few categories. The first ones may have been simple names, like those used by some of our primate relatives.

Some sounds could be relics of an ancestral mother tongue



JUAN MANUEL CASTRO PRIETO/AGENCE VU'/CAMERA PRESS

Vervet monkeys give distinct alarm calls for leopards, martial eagles and pythons, and young vervets must learn these. In humans, *mama* is a strong candidate for a very early noun, given how naturally the sound appears in babbling and how dependent babies are on their mothers. The sound "*m*" is also present in nearly all the world's languages.

Imperatives like *look* or *listen* are also likely to have appeared early on, perhaps alongside verbs like *stab* or *trade* that would have helped coordinate hunting or exchanges. Even this simple lexicon allows sentences like "look, wildebeest" or "trade arrows". Finally, simple social words like *you, me* and *I, yes* and *no*, were probably part of our early vocab. Amusingly, a recent study suggested that *huh* is universal, prompting headlines that it was among the first human words. Perhaps it was the second.

Mark Pagel

CAN LANGUAGE INFLUENCE HOW YOU SEE THE WORLD?

Time flows from back to front for English-speakers: we "cast our minds back" to the 1990s, and "hope for good times ahead". It's an example of a cultural concept encoded in language, but can language in turn influence how we think?

Maria Sera is a native Spanish-speaker who grew up believing all squirrels were female. The Spanish word for squirrel, *ardilla*, is feminine. As a linguist at the University of Minnesota, she has found some substance for her childhood belief. Studies of French and Spanish speakers, whose languages attribute genders to objects, suggest they associate those objects with masculine or feminine properties.

The idea that the language you speak could influence how you think dates back to 1940, when linguist Benjamin Lee Whorf proposed that people whose languages lack words for a concept would not understand it. It was relegated to fringe science until the early 2000s, when a few people began probing a related but more nuanced idea: that language can influence perception.

Greek, for instance, has two words for blue – *ghalazio* for light blue and *ble* for a darker shade. A study found that Greek speakers could discriminate shades of blue faster and better than native English speakers.

Language even seems to affect our sense of space and time. Some peoples, like the Guugu Yimithirr in Australia, don't have words for relative space, like left and right, but do have terms for north, south, east and west. Studies have shown that they tend to be unusually skilled at keeping track of where they are in unfamiliar places. There is also some evidence that the direction in which your first language is written can influence your sense of time, with speakers of Mandarin more likely to think of time running from top to bottom than English speakers. And the language you speak may affect how you perceive others (see "Does your language shape your personality?", right).

More generally, language helps us understand the world by allowing us to categorise things. Children are better at grouping objects if they have already learned the names of the categories they belong to. Conversely, after a stroke, people who have lost language skills can have trouble grouping objects. "It's not that language just affects some high-level reasoning part of the brain," says Gary Lupyan of the University of Wisconsin-Madison. "It's changing our basic perceptual representations." **Megan Scudellari**

"GREEKS HAVE TWO WORDS FOR BLUE AND ARE FASTER AT TELLING SHADES OF BLUE APART"

KIKE CALVO/NATIONAL GEOGRAPHIC CREATIVE

What's in a word? It depends who you're talking to

DOES YOUR LANGUAGE SHAPE YOUR PERSONALITY?

"To have another language is to possess a second soul," Charlemagne is rumoured to have said. He may have been on to something. In the 1960s, sociolinguist Susan Ervin-Tripp of the University of California at Berkeley asked English-Japanese bilinguals to describe what was going on in ambiguous pictures. One person, for example, told a different tale depending on their storytelling language. A picture of a woman leaning against a couch elicited a story in Japanese about a woman contemplating suicide after the loss of her fiancé. The same person, asked to respond at a separate session in English, said the woman was completing a sewing project for a class. "In general, there was more emotion in the Japanese stories," Ervin-Tripp wrote in a description of the experiment. "The switch in language draws with it the cultural baggage associated with that language."

Nairán Ramírez-Esparza at the University of Connecticut asked bilingual Mexicans to rate their personalities using both English and Spanish questionnaires. English responses emphasised openness and extroversion, while Spanish responses were more humble and reserved. "Language is such a powerful thing. It obviously makes you see yourself differently," Ramírez-Esparza says.

According to Shai Danziger of Ben-Gurion University in Israel and Robert Ward of Bangor University in the UK, it can also influence how you think of others. They asked Arabic-Hebrew bilinguals to match Arab and Jewish names with positive or negative trait words by pressing a key. They say participants showed more involuntary positive attitudes towards Jews when tested in Hebrew than when tested in Arabic. Paula Rubio-Fernandez of the University of Oslo, meanwhile, has found that bilingual children perform better on tests that require them to understand a situation from someone else's perspective.

Evidence is mounting that the words we speak and think shape our brains, perceptions, and personalities. Who knows what else? Perhaps our tastes, habits, or values. The door is wide open.

Megan Scudellari

MARTIN PARR/MAGNUM PHOTOS

English will move outside of native speakers' control

WILL WE ALL ONE DAY SPEAK THE SAME LANGUAGE?

With over a billion native speakers, Mandarin Chinese is the language spoken by the greatest number of people. English comes third, after Spanish. But unlike Mandarin and Spanish – both spoken in more than 30 countries – English is found in at least 100. In addition to the 335 million people for whom it is their first language, 550 million cite it as their second. It dominates international relations, business and science.

All this suggests English is on course to be the planet's lingua franca. It just probably won't be the English that native speakers are used to.

Millions of second-language English speakers around the world have created dialects that incorporate elements of their native languages and cultures. Anna Mauranen of the University of Helsinki in Finland calls these varieties similects: Chinese-English, Brazilian-English, Nigerian-English. Taken together they – not American or British English – will chart the language's future path, she says.

"We used to think there were two possible futures," says Jennifer Jenkins at the University of Southampton, UK. "In one we'd all end up speaking American English. In the other, English would separate like Latin did, and we'd end up with [new] languages. I don't think either of those is happening."

Instead, English similects are probably here to stay. Even in a future where China, India and Nigeria are global superpowers, English is likely to be the language of choice for international discourse, simply because it is already installed. Weirdly, this puts native speakers at risk. "We're getting to the stage where all the educated people of the world have English," says Jenkins. "Once it's no longer a special thing, native speakers lose their advantage."

They could even be at a disadvantage. Non-native speakers are all tuned to each-other's linguistic quirks. "If you put a Chilean, a Japanese and a Polish person in a discussion in English, they understand each other perfectly," says Jenkins. "Put one with two native English speakers and there might be problems."

Mauranen envisions a future in which English similects begin to blend over national borders. New dialects are likely to form around trades or regions. She says these common goals will drive the evolution of the lingua franca, regardless of whether we call it English or not.

That is not to say that all other languages will vanish. German will remain the language of choice within German borders. Even Estonian, spoken by just 1 million people, is safe. "It's a fully fledged language, used for everything [in Estonia]," says Mauranen.

Likewise, the language directly descended from Shakespeare's English has staying power with Brits and Americans. But English, like football, will soon move outside their control, pulled into something new by the rest of the planet. **Hal Hodson** is a technology editor at *New Scientist* ›

SAVING ENDANGERED LANGUAGES

David Harrison has devoted his career to recording and studying languages that are spoken by just a handful of people. He tells **Hal Hodson** why they matter.

You've travelled the world chasing dying languages. Why?
Language diversity is an insurance against the extinction of ideas and knowledge. Ancient languages, like those of Indigenous Australians or Papua New Guineans, are an irreplaceable record of sustainable human living. These cultures have immense knowledge about plants and ecosystems, different ways of thinking. When you lose their languages, you're losing concepts that have been refined over millennia.

What pushes a language to extinction?
It is not number of speakers that predicts language vitality, it's the transmission rate. The largest Native American language is Navajo, with 50,000 speakers. But transmission rate is only 15 per cent.

The problem comes from an attitude, held both by dominant and minority language speakers, that small languages are backwards, obsolete, deficient in some way. I have worked in many communities where this attitude has taken hold. People abandon their language in despair. The last generation of people in a community who grow up speaking a language have a great sense of regret that this has happened.

These scenarios where you know the language is going to die are really sad. I've moved into a different area.

What are you focusing on now?
I'm working with small languages that still have speakers of all ages. Communities that are pushing back against the hegemony of big languages in clever ways. Papua New Guinea has the lion's share of the world's linguistic diversity – a lot of small and medium-sized languages that are not at risk. People might learn between five and 10 of them. There are intangible factors that keep these languages alive. An attitude of linguistic superiority – our language is the most beautiful or complicated language in the world – will help, for instance.

The Yokoim language has about 1200 speakers in three villages. It's threatened because children go to school with other ethnic groups and speak Tok Pisin. But it has a few charismatic individuals, like Louis Kolisi, who composes and sings original songs in Yokoim. That's an astonishing thing if you think about it: children are abandoning the language, and here you have this person doing something creative with it.

Or take Siletz Dee-Ni, a Native American language. It has one fluent speaker and a handful of learners. But they're actively inventing new words for their language. They might, for instance, invent a word that means "brain in a box" instead of adopting "computer".

So it is possible to save languages?
I think so. Biologists believe in storing live specimens to record and save biodiversity. You can do something similar for languages with the internet. In 2009, I visited Kundiman village, where they speak Yokoim. We made recordings and built a talking dictionary. They recorded stories and songs that are on YouTube now, and I'm recording them talking about their knowledge of plants. When I first visited, they had only heard about the internet – never used it. Now, their language has a presence online.

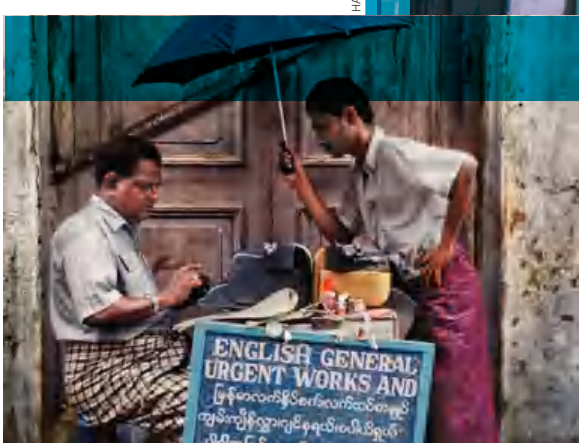
We've had requests from other offline Papuan communities to do the same. For several of them, their language is their first online presence. And when they do get the internet, they hear the voices of their elders speaking their languages. Think about those Papuans becoming computer programmers and technologists, and the diversity of thinking they could bring to that work.

David Harrison is a linguist at Swarthmore College in Pennsylvania

CHRIS RAINIER

Louis Kolisi is keeping Yokoim alive through his songs

HARRY GRUYAERT/MAGNUM PHOTOS



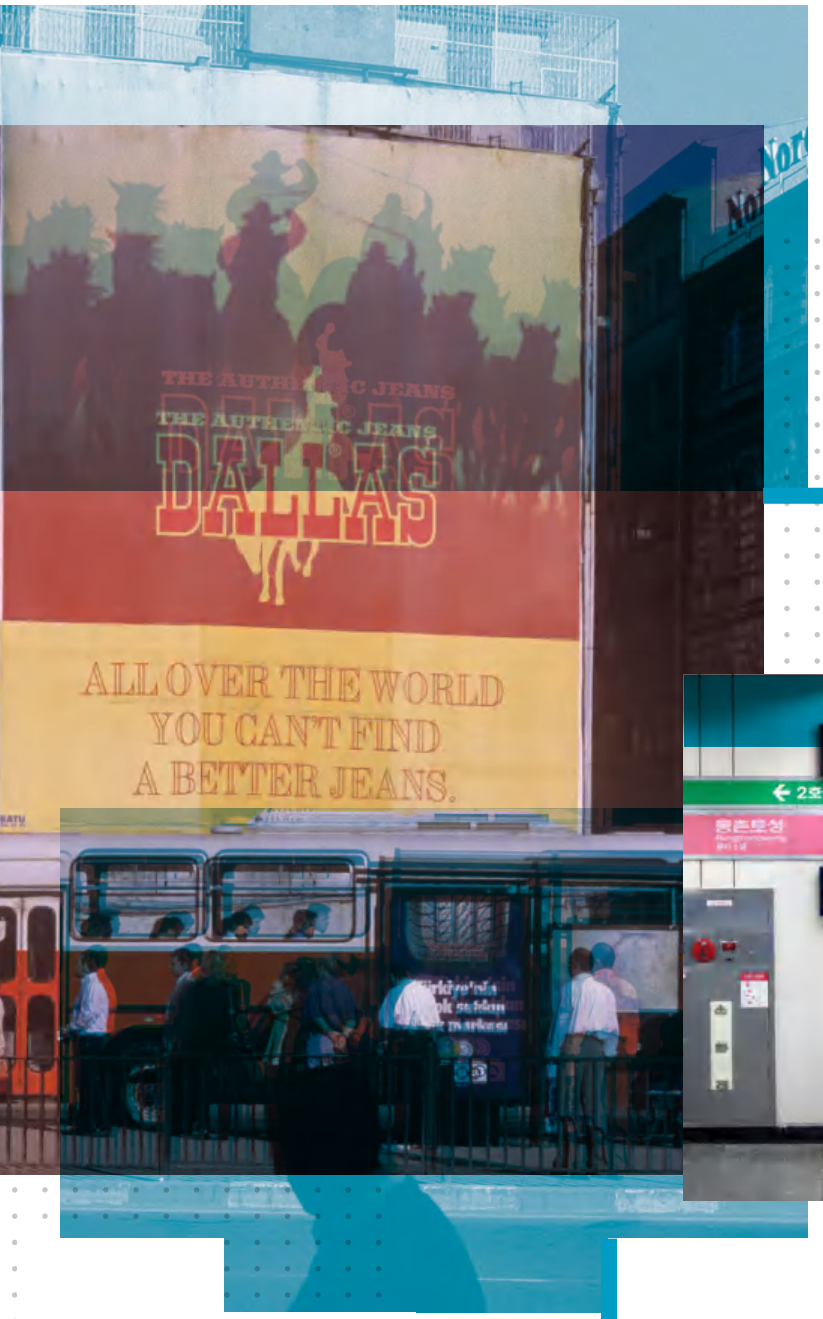
STEVE MCCURRY / MAGNUM PHOTOS

HOW IS TECHNOLOGY CHANGING LANGUAGE?

"Writing used to be very formal," says Lauren Collister of the University of Pittsburgh, Pennsylvania. "It was books, love letters or newspaper articles. Grammar and spelling were expected to be precise."

That is changing. Every day, millions of us have real-time conversations in writing, online and on our mobile phones. As a result, writing is evolving. "Chat rooms, instant messaging, they all contributed to informalisation of written language," says Collister. Goodbye "To whom this may concern"; hello txtspk , ¯_(ツ)_/¯ and DBEYR*. This evolution is happening so quickly that we are already seeing it move offline and back into speech and formal lexicons. In 2011, "lol" was added to the Oxford English Dictionary.

The question is, what new language is



coming down the internet pipeline?

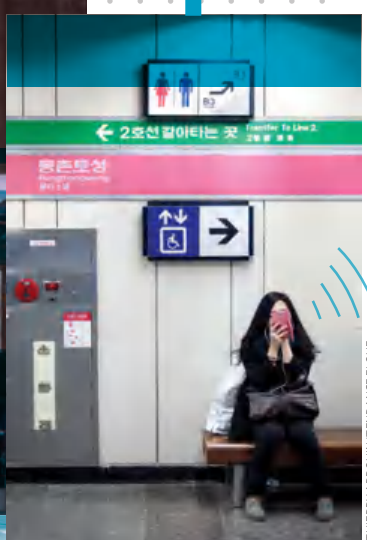
Internet-speak often bypasses language barriers, so the next netspeak could have foreign roots. Japanese forums use "Orz" to signify kneeling down: the O is the head, r the arms and body, and z is the kneeling legs. Depending on context, it is used to signify failure and despair, or sarcastic admiration. Chinese netspeak has adapted Orz to Chinese script, 囧rz, to convey a facial expression. Xiangxi Liu of the University of Massachusetts, Amherst, foresees an explosion of such online language, especially in Chinese, which can draw on thousands of characters.

Even the traditional building blocks of language – letters and words – are being upgraded. Ramesh Jain of the University of California, Irvine, thinks images will play a bigger role in future online communication, precisely because they cross language barriers. You only have to look at how Facebook, Google and chat companies like Line are continually growing their emoticon and sticker libraries to see the evidence for this.

This has created a strange new linguistic barrier: money. Line users pay for stickers. The company made $75 million from this scheme in its first year. Don't be deflated, though. If there is anything the explosion of internet memes and netspeak shows, it's how quick and crafty we are at inventing our own new words, which are adopted (or not) by the ruthless natural selection of social media. Hal Hodson

*Don't believe everything you read

COULD WE ONE DAY COMMUNICATE WITHOUT SPEAKING?



THIERRY ARDOUIN/TENDANCE FLOUE

Private thoughts fill your head every second of the day, safe from prying ears – for now. Lately, researchers have begun exploring ways to decipher our internal monologues from a distance. Don't jump for your tin foil hat just yet. The aim is to give a voice to people who are paralysed and unable to communicate, but fully aware of their surroundings.

Adrian Owen at the University of Western Ontario in Canada showed in 2010 that it was possible to communicate with such "locked-in" people through questions with yes or no answers. The person would imagine walking around their home for "yes", or playing tennis for "no". A scanner picked up on the distinct brain activity patterns that each scenario produces. With a small delay, the team was able to decode yes/home and no/tennis.

But a one-sided conversation isn't much fun. Philip Kennedy of Neural Signals in Duluth, Georgia, has designed a brain implant that records activity in areas that control the movement of your mouth when you shape a word. He is investigating whether this could be used to interpret a person's intention to speak, and command a speech synthesizer to do the actual talking.

An alternative is to decode brain activity associated with concepts, rather than words. João Correia at Maastricht University in the Netherlands has done this using non-invasive EEG recordings. He reckons this could one day give people enough mental "vocabulary" to form whole sentences, or at the very least a few vital words.

Meanwhile, Brian Pasley and his colleagues at the University of California, Berkeley have found that groups of neurons in the auditory areas are tuned to certain frequencies and rhythms. The activity is the same whether you hear a word or merely think it. Pasley has built an algorithm that analyses which neurons are active when people think about talking and converts that information back into speech.

It's a little rough and ready, and electrodes have to be implanted in the brain, but the outcome is impressive. Listening to one of the recordings, I was able to recognise the word "Waldo", produced from imagined speech. It may be far-fetched, says Correia, but it's also "the closest we've come to speaking with the mind". **Helen Thomson** is a *New Scientist* consultant

GPS goes galactic

Zombie stars in a spin point the way to exquisitely accurate navigation at the edges of the solar system and far beyond. Andy Ridgway gets his bearings

IT WAS a flying visit all right. NASA's New Horizons probe took nine and a half years to reach Pluto, and yet it could only observe the dwarf planet for three weeks as it zipped past and out into the farthest reaches of the solar system. The images it has beamed back are nothing short of breathtaking, revealing a complex world of enormous floating ice mountains, smooth plains and reddish patches reminiscent of Mars. But just imagine what we could be learning about Pluto had we been able to hang around a little longer.

A decade ago, when New Horizons launched, we couldn't plot a course accurately enough to get the craft into Pluto's orbit. If a little-known mission launching this year goes to plan, however, NASA will showcase a new form of celestial navigation that promises far superior precision. Instead of relying on Earthly clocks as we do now, this system relies on the universe's most reliable timepieces – rapidly rotating stellar corpses many hundreds of thousands of light years from home.

Harnessing the exquisite regularity of their pulses won't just help us achieve ever closer encounters of the dwarf planet kind, it would also enable crewed missions to reach Mars without relying on constant contact with Earth. In the long run, it could even help our descendants plot a course in interstellar space.

Currently, spacecraft in low Earth orbit, including the International Space Station (ISS), use the familiar Global Positioning System (GPS) to tell us where they are. This is a network of satellites orbiting our planet at an elevation of 20,000 kilometres. By intercepting signals sent by at least three of those satellites, a GPS receiver can calculate how far away each one is based on how long the signals take to arrive.

Going further from Earth is a bit trickier. Although research published this year by a team in Switzerland showed that spacecraft could use GPS for directions to the moon, beyond that it doesn't work: signals from our Earth-facing satellites can't reach that far.

Instead, NASA uses the Deep Space Network (DSN), a system of giant radio antennas in California, Spain and Australia. These tracking stations send out radio signals to a probe, then measure how long it takes for them to bounce back. When a spacecraft is visible from two tracking stations, you can determine its angular position on the sky.

The trouble is that each of the DSN's tracking stations covers a third of the sky, so for the most part we only know a probe's distance and speed along a straight line from one antenna. "At any given time, you can only usually track a probe from one station," says Shyam Bhaskaran, whose Outer Planet Navigation Group at NASA's Jet Propulsion Lab in Pasadena, California, is currently navigating the Cassini, Dawn and Juno missions.

Interpreting the information generated by the radio telescopes and weeding out glitches caused by the signals' passage through our atmosphere keeps a team of up to 20 astronomers busy. "We call it as much of an art as a science," says Bhaskaran. And although the DSN has helped astronomers guide probes close to all of our planetary neighbours, it is far from perfect. At Pluto's distance, roughly 7.5 billion kilometres from Earth, we have navigational accuracy down to the nearest 200 km. At the location of the Voyager 1 probe, which launched in 1977 and is now flirting with leaving the solar system some 20 billion kilometres from Earth, it falls to 500 km.

"Having a more sophisticated 3D-navigation system would allow us the possibility of entering the orbit of distant bodies – the moons and planets – and doing so with less fuel and more mass for instruments," says Zaven Arzoumanian at NASA's Goddard Space Flight Center in Greenbelt, Maryland. In other words, come up with a better way to chart our position in space and we could learn much more about the outer solar system, never mind the universe beyond.

So we need a new GPS – a galactic positioning system – and preferably one that works autonomously on board spacecraft. A fleet of satellites dotted around the cosmos would be ideal, but that is a long way off. Happily, the universe has supplied the brightest of alternatives. Pulsars are the highly magnetised, fast-spinning corpses of stars that have exploded as supernovae. They are incredibly dense bodies, packing in around 1.4 times the mass of our sun into a ball just 20 kilometres across.

Because they have shrunk so much, ›

> "We need a new GPS – a galactic positioning system that works on board spacecraft"

BRYAN OLSON

"Pulsars spin incredibly fast. One class can rotate up to 700 times per second"

pulsars spin incredibly fast. Most of them rotate a few times per second but one class, known as "millisecond pulsars", can spin up to 700 times a second. As they spin, pulsars emit an intense beam of electromagnetic radiation across several wavelengths, including radio and X-ray bands, from each of their two poles. Those beams sweep across space, much like the beams from a lighthouse, and pulse with exquisite regularity. They are so regular, in fact, that pulsars have been proposed as an alternative to the atomic clock for standardising time – and even as a way to catch the infinitesimal disturbances in space-time caused by passing gravitational waves.

The upshot is that pulsars, and particularly millisecond pulsars, are pretty much the perfect alternative to GPS satellites. And because there are hundreds of thousands of them scattered across our galaxy, they could provide reference points everywhere.

Astronomers have dreamed about navigating with pulsars since they were discovered in the 1960s. Here's how it would work. If you have an on-board system that measures the arrival times of individual pulses from a known pulsar and compares them with expected arrival times for a fixed reference location, you can calculate how much closer or further away the spacecraft is from the pulsar than that fixed point, albeit only in one direction. By combining measurements from at least three pulsars, you can calculate a precise three-dimensional location.

In 2013, Werner Becker at the Max Planck Institute for Extraterrestrial Physics in Munich, Germany, calculated that pulsar navigation could be accurate to the nearest 5 kilometres (*Acta Futura*, vol 7, p 11). Others suggest it could be even more precise. "We feel that on a deep-space mission, we could maybe get down to a 1 km solution and maybe a bit better," says Keith Gendreau, also at the Goddard Space Flight Center. It's all down to the amazing regularity of pulsar pulses, which enable precise distance measurements, and the fact that a spacecraft could be surrounded by pulsars in all directions.

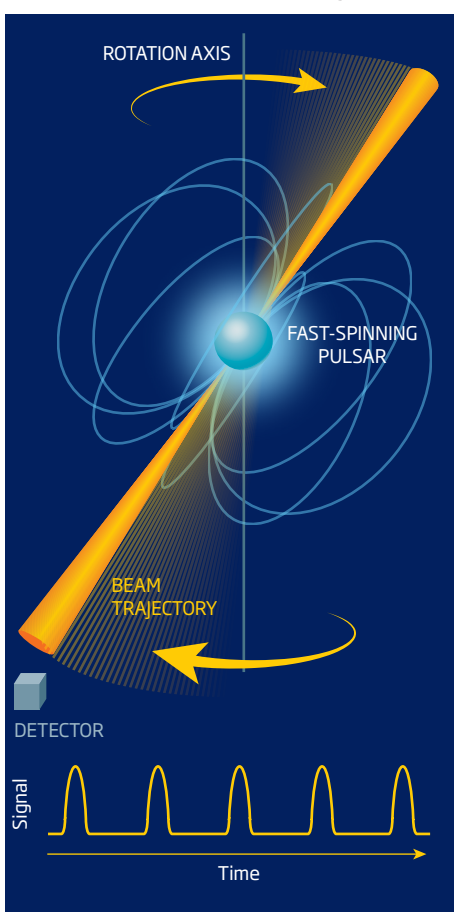
Pulsar navigation would also overcome another problem with the DSN. "One of the biggest constraints on deep-space navigation is that deep-space antennas are a very heavily used resource," says Bhaskaran. "With our current missions, it's manageable. But in the future, if we have a lot more missions, it's going to be very difficult."

So what's kept us from charting a course by these spinning stars? The problem is that we are still largely in the dark about what makes them tick. But as we get to know more pulsars, we are getting a better idea. What's more, we now know the location of over 2000 of them, including more than 200 millisecond pulsars, giving us an ever-growing reference map. Perhaps the most important jump, though, has been the advance of compact, lightweight telescopes to detect pulsars' X-ray emissions (It is possible to detect their radio emissions but radio telescopes tend to be huge).

The first test comes in October this year, when 56 X-ray telescopes, each the size of a poster tube and packed into a device the size of a large washing machine, will be hauled into space aboard a SpaceX Dragon cargo craft bound for the ISS. This hardware will play a central role in NASA's NICER/SEXTANT mission, which stands for Neutron-star Interior Composition Explorer/Station Explorer for X-ray Timing and Navigation Technology. The mission's primary goal is to investigate the innards of neutron stars, where densities and pressures outstrip even those found in atomic nuclei, by measuring their X-ray emissions. But it will also serve as the first real test of X-ray-based pulsar navigation.

Exquisite timing

Radiation beams emitted by pulsars sweep by with unparalleled regularity, making these stars ideal reference points for GPS-like space navigation



Flight of the navigator

It should be a stern examination. The ISS sits in low Earth orbit, so the telescopes on board will repeatedly lose contact with any pulsars as the station darts around the planet. The telescopes on a craft travelling long distances through space could keep receiving signals from the same pulsars over long periods, whereas the ISS orbits Earth every 90 minutes, severely limiting the time a pulsar is in a telescope's field of view. In addition, the ISS needs to occasionally boost itself to overcome atmospheric drag, so its speed varies much more than a probe in deep space.

This fast and bumpy ride will complicate the task of deriving positions and speeds. "We are intentionally putting ourselves in a challenging environment, but if it works here it will work anywhere," says Arzoumanian, who is on the mission team.

Becker, who is working on designs for both X-ray and radio-based pulsar navigation systems, isn't convinced that this new project is entirely necessary. He points out that earlier X-ray probes have already collected relevant data. But Gendreau says that NICER/SEXTANT will test an "autonomous navigation algorithm" designed to crunch the numbers on the relatively puny processors aboard the ISS rather than the hefty computers on Earth – something that is vital for future deep-space navigation. The modular telescope design will also allow astronomers to see if navigation can be achieved with minimal components.

"The result will be an autonomous navigation system that is of a practical size and is flight proven," says Gendreau.

So the future looks bright for pulsar navigation, particularly given that the next generation of radio observatories, such as the Square Kilometre Array in Australia and South Africa, will increase the number of mapped pulsars to between 20,000 and 30,000.

Plotting a course by these zombie stars would transform the way we explore space. For Gendreau, then, this mission is a chance to "demonstrate the technology that humankind will ultimately use to navigate our way out of the solar system and into the galaxy". ■

Andy Ridgway is a science writer based in Bristol, UK

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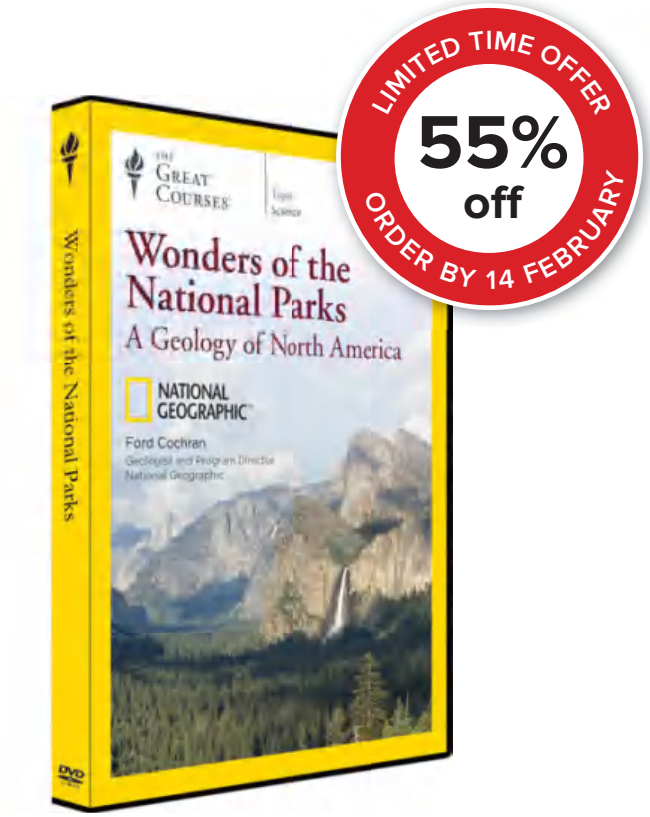

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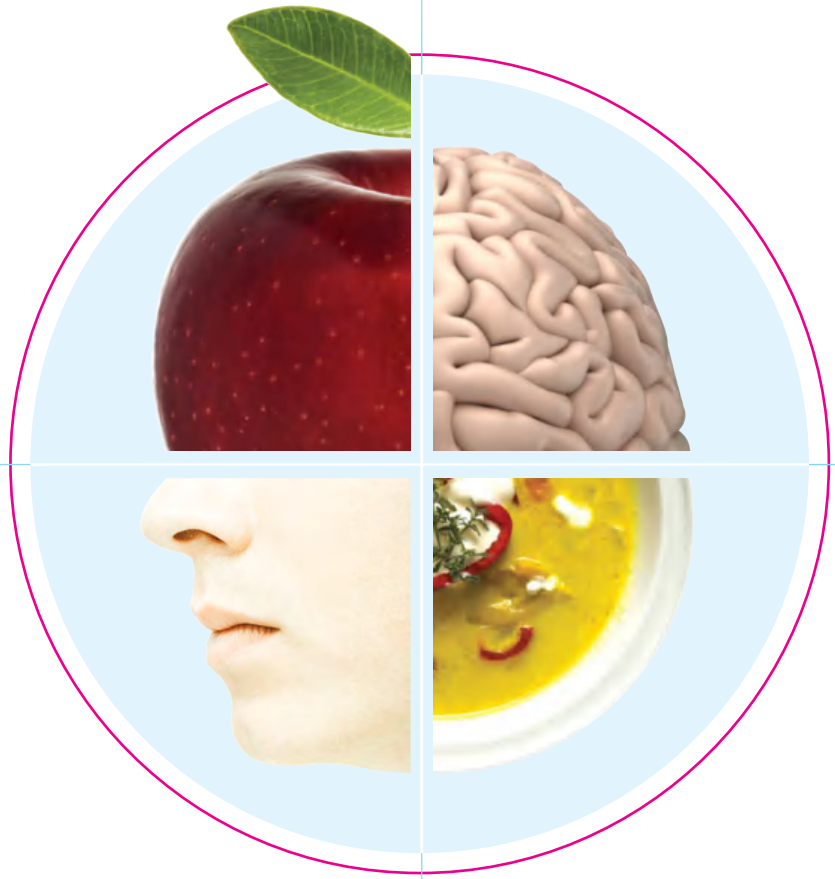

the FLAVOUR MAKERS

Hacking our smell receptors will allow us to create delicious, tailored food flavours. Jessica Wapner reports

IT WAS certainly an unconventional dish, but as Gina Mullins poured another spoonful of apple cider reduction over her tortilla, and sprinkled goji berries on top, she figured she had nothing to lose. She was used to being repulsed by food by this point and was game to try anything.

Mullins, who has lost much of her appetite and sense of taste as a result of chemotherapy, was at the University of Kentucky to judge an unusual cook-off. Chefs, neuroscientists and doctors had joined forces at the inaugural meeting of the International Society of Neurogastronomy. Their challenge? To create a dish that would rekindle the pleasure of eating for people with taste impairments.

The teams tickled the judges' taste buds with a spicy scallop tortilla accompanied by carrots, yogurt, goji berries and blackberry jam, and a hearty potato soup served with pungent, intensely flavoured garnishes. The two dishes were designed to appeal not just to the five basic tastes – sweet, sour, salty, bitter and umami – but also the other senses, which in recent years scientists have come to discover play an important part in how we experience flavour. But that was the extent of their toolbox. In reality, figuring out what might work was largely guesswork.

But what if we could remove the guesswork? One scientist at the meeting is trying to do just that. Instead of altering the food, Tim McClintock, a molecular biologist at the University of Kentucky, wants to change the way food tastes by manipulating signals in the brain. Our taste buds play only a small part in the way we perceive flavour – the biggest contributor is smell. If we could mimic or hijack the way the aroma of food creates flavours, we could not only tailor odours to stimulate the smell receptors of people who have trouble tasting, but it would also open the door to Willy Wonka-style gastronomic possibilities for all of us. We could tinker ›

GETTY IMAGES

"We're talking about modifying ingredients so the brain perceives them differently"

with the way natural ingredients taste or even create new smells and flavours.

Odours are volatile chemicals and so are gases at room temperature. When we sit down to a meal, smells enter our nose either as we inhale or, more powerfully, when we chew food, and odorous chemicals waft up through the back of the throat. When a smell hits the roof of the nose, it comes into contact with about 350 odour receptors – proteins that convert the chemicals they detect into an electrical signal.

Each smell triggers a unique pattern of receptors that some scientists refer to as a kind of "odour barcode". This barcode is then transmitted to the olfactory cortex, where it is shared with other parts of the brain that handle factors like memory, emotion and reward. Together, they form the brain's interpretation of the smell.

"Almost all the systems in the brain are affected," says Gordon Shepherd, a neuroscientist at Yale University who coined the term "neurogastronomy" in 2006 to describe the study of the interaction between the brain and food.

Future flavours

People have been trying to isolate the molecules responsible for odour in food since the 1960s, initially using gas chromatography. This can identify the compounds that make up a smell, but not what happens when it hits the nose. Deciphering that precise odour barcode has so far been impossible, but it's necessary if you really want to be able to tinker with the brain's perception of flavour. "Receptor identification is the future of flavour development," says McClintock.

So he and a handful of other researchers around the world have set about trying to crack the problem. Some 10 years ago, he became interested in the function a gene called *S100A5,* so he genetically engineered mice in which he exchanged *S100A5* for a green fluorescing protein.

At the time, *S100A5* was one of several newly discovered genes expressed in olfactory sensory neurons, but its exact function was unknown. We now know that it is activated when olfactory receptors in the nose are stimulated. McClintock's *S100A5*-deleted mice provided the perfect way to unlock the secrets of the olfactory system. "I realised that we could use this mouse to reveal which odorant receptors respond to any odour that we chose," he says. If a receptor responds to an odour smelled by one of these mice, the replaced gene will make fluorescent protein instead of making the *S100A5 protein*. So each neuron activated by a particular odour is tagged with a green fluorescent label.

Inside his lab, McClintock uses a set-up that he calls the Kentucky assay. A series of straw-like tubes pump clean air from a nearby compressor into clear containers containing his engineered mice. After 26 hours without food (to reduce the number of smells around), half of the mice are intermittently exposed to an odour for 14 hours. The other half inhale a more neutral substance.

After each session, all the olfactory sensory neurons are removed from the noses of the mice, mixed with an inert liquid and poured through a giant cell-sorting machine. This equipment detects the presence of the green protein and separates the fluid accordingly.

Every receptor is encoded by a unique gene. By sequencing the RNA of the cells in the green-fluorescing tube, McClintock identifies the exact pattern of receptors activated by an odour.

Last year, McClintock published his receptor barcodes for muscone – or musk – and eugenol, a chemical prominent in many spices, including clove. His company, Odorcept, provides receptor barcodes for private clients. He cannot disclose who his clients are, but says the system could be used by any firm seeking to create new odours, to alter how we perceive odours, or even to block them altogether.

Although mice have about 1000 odour receptors, far more than humans, research has shown that humans and mice share many similar odour receptor genes, and McClintock is confident that the Kentucky assay translates

Gina Mullins (left) tries new flavour combinations at the first meeting of the International Society of Neurogastronomy. The Kentucky assay (right) promises a whole new approach to creating novel flavours

CLOCKWISE FROM BOTTOM: JAMES K MORRISX3/UNIVERSITY OF KENTUCKY

to our own species. He also envisions engineering a mouse with a human receptor system several years from now.

It is still early days, but if the system does work in human cell receptors, it wouldn't just tell us what the barcode is for a particular odour, it could also be used to test a manufactured smell to see if it hits that same pattern of receptors. This set-up and similar systems in development in other labs will enable us to build an encyclopedia of odour barcodes. These will tell us which receptors need to be activated in order to know that any new chemical is having the desired sensory effect, says Joel Mainland at the Monell Chemical Senses Center in Philadelphia. "Once you have that you can start creating any odour you want," he says.

But the ultimate goal of McClintock's system is to reverse-engineer the barcode and create odours for a specific purpose, which means we could craft food to match our receptors. "We're talking about modifying ingredients through science so that the brain perceives it differently," says neuropsychologist Dan Han at the University of Kentucky in Lexington, who co-founded the neurogastronomy society and organised the meeting. "Foods that don't taste good can be manipulated so patients can stomach them better."

And McClintock hopes it would be possible to determine the patterns of receptors that evoke the most powerful, appealing flavour sensations, so you might use the system to drive people towards better diets. Healthy but unappetising foods could be given a whole new flavour, or delicious smells could be made more potent, thereby stimulating the appetites of people with taste and smell deprivation.

Take fruit and vegetables. The sweetest tomatoes don't necessarily contain the most sugar – rather, they contain a volatile compound that stimulates a pattern of receptors that our brains read as "sweet". If we know those receptors, says Mainland, then a vegetable can be bred to contain more of that particular volatile compound, therefore tasting sweeter. "If you're breeding and having consumers rate them, it's a very slow process," says Mainland. "If you're breeding and doing chemical analysis, that's much faster."

The usefulness of the findings extend beyond the dinner table. Knowing the receptor proteins responsible for any aroma – the smell of a new car, freshly cut grass, vanilla – raises the prospect of producing cheaper or improved versions of that smell, or creating artificial versions that evoke certain memories. Others see the technology going even further with visions of smells to accompany movies, cellphones that spray scents on demand and smell-emitting e-books.

Being able to decipher the receptor barcode could also be the key to finding out how dogs can sniff out specific chemicals linked to certain types of cancer so that artificial noses could one day do the same job.

Custard dreams

But for those gathered at the meeting in Kentucky, the most immediate goal is to manipulate the brain's perception of flavour to bring relief to the people who need it most.

Sid Kapoor, a neurologist at the University of Kentucky, is hoping to use the Kentucky assay, in combination with food technology and culinary creativity, to find a more palatable approach for the ketogenic diet, a high-fat diet used to prevent epileptic seizures. "It's literally like having to drink oil," says Kapoor at lunch before the cooking contest. "It can be very difficult to follow." Kapoor would like to see a greater range of flavours introduced to high fat foods, so that patients are not overloaded with the taste of "butter and meat".

Across the table, chef Fred Morin is already crafting recipes. "Custards of egg yolks and cream, geared for different flavours?" he suggests.

That vision is still some way off. McClintock is refining the system to be able to analyse more odours faster. "We are just in our infancy of understanding the patterns of receptors that respond to odours," he says. "Quite frankly, the vast majority of the odour universe is unexplored."

In the meantime, the scientists and chefs cooking for Mullins and her co-judge, Jen Cooper, whose sense of taste was also altered by chemotherapy, are awaiting the result of their educated guesswork. There can be only one winner, and it is the pungently garnished potato soup. "I just don't do scallops," says Mullins, hoping to soften the blow for the losers. For now, scallops still taste like scallops. But in the future, they could taste like pumpkin pie. Or chocolate. ■

Jessica Wapner is a freelance writer based in New York. You can follow her on Twitter @jessicawapner

Nothing quite like it?

Kicking the meat habit will be tough, finds **Caroline Morley**

Meathooked: The history and science of our 2.5-million-year obsession with meat by Marta Zaraska, Basic Books, $26.99

YOU probably know people who follow a more or less vegetarian diet and are fit and healthy, not lacking in any nutrients and do not feel they are missing out. You may even be one.

Most educated people know that eating meat is bad for the planet, potentially harmful to their health and cruel to animals. But the meat eaters I know can rarely come up with a better reason for consuming it than: "I just really love to eat meat."

In *Meathooked*, Marta Zaraska takes on the task of unpicking why so many people – in the West, especially – seem to be addicted to meat. She finds that there is no easy answer: our taste for flesh is rooted in evolutionary history, dietary requirements, chemistry and taste, big business and the political power it wields, psychology and culture.

Our ancestors' transition from herbivory to omnivory was, initially, a positive move. As Zaraska explains: "It enabled us to grow bigger brains, encouraged sharing and politics, and helped us move out of Africa and into colder climates."

Her journey takes us around the world, from the lush green fields of a Welsh beef farm to a steakhouse in India via the Smithsonian Institution and a research slaughterhouse at Pennsylvania State University. Along the way, she meets colourful characters who help answer her meaty question. Perhaps the most exciting is the cultural expert she meets during a bloody ceremony of chicken sacrifice at a temple in Benin: "Paul Akakpo, my guide to West African voodoo, adjusts the large python that is wrapped, jewelry-like, around his neck."

Zaraska's tone is light and she does well putting facts and figures to ideas we are familiar with – such as how powerful the meat industry is. "In 2011, in the US alone, the annual sales of meat were worth $186 billion," she writes. And she has a truly alarming figure up her sleeve: "During the 2013 election cycle, the animal products industry contributed $17.5 million to federal candidates."

So how much protein do we need each day? The daily dietary allowance recommended by the US Centers for Disease Control and Prevention is 0.8 grams per kilogram of body weight. And how far back does the habit go? Zaraska cites the oldest undisputed cut marks, which show humans started to butcher savannah animals as far back as 2.6 to 2.8 million years ago.

Normally a pescatarian, Zaraska describes sampling meat, fake meat and insect dishes in the course of research for this book.

"Our ancestors' move from herbivory to omnivory was, initially, positive - for growing bigger brains"

She enjoys the "enticing" Philly cheesesteak sandwich, but not so much the cricket she tries in an upmarket Parisian bar. "Once on my tongue, the thing collapses into greasy ash," she writes. "I chew and chew, the wings scratching the insides of my cheeks. I certainly wouldn't like to repeat the experience."

Even so, *Meathooked* is sometimes a little judgemental of meat eaters. It makes the case for vegetarianism, though Zaraska avoids straight-out preaching until the very end. Learning the facts is an important step to giving up meat, she says, "we should... become aware of meat's many meanings – only then can the hooks be released one by one".

But non-vegetarians can take heart: her vision of the short-term future is not entirely meat-free. After a whole book exploring our "addiction", she concludes that going cold turkey (pun intended) could backfire. "Even though I do believe that in the future humanity will eat mostly plant-based foods, I also believe that pushing for dietary purity is not the way to go," she writes.

Even after reading the book and confirming the sordid details about my destructive habit, I'm still not ready to go vegetarian – I just really love to eat meat. ■

Caroline Morley is a writer based in London

One day chickens may be replaced by plant or lab-grown alternatives

BARIS KARADENIZ/ALAMY

Third rock on the left

Exoplanet research is the hottest field in the universe, finds **Lewis Dartnell**

How Do You Find an Exoplanet?
by John Asher Johnson, Princeton University Press, $35.00/£24.95

ASTRONOMY has changed a lot in the days since you had to go and sit for hours with your eyeball at the focal point of a 5-metre-diameter telescope atop a mountain.

This is quickly evident in *How Do You Find an Exoplanet?* by John Asher Johnson, formerly a leading researcher at NASA. In 2012, his team discovered three exoplanets orbiting a red dwarf, including the smallest found to date. Now a professor at Harvard University, Johnson's enthusiasm for his vibrant field is palpable in this valuable, concise guide for amateur astronomers and anyone else not afraid of a few technicalities.

Today, telescopes are controlled from a computer in a heated room. We have also lived through a revolution in our understanding of the cosmos. At the time of writing, we have discovered 2042 worlds orbiting other stars. This is one of the hottest areas in current research, with new finds making headlines almost weekly.

Since these remote planets are vanishingly dim alongside the overwhelming glare of their host stars, how do we find them? Johnson rattles through the astronomers' main tricks. The two most successful techniques involve measuring the radial velocity, or wobble, of a star as it is tugged by an orbiting planet, and registering the minuscule dimming of starlight as a planet transits across the face of a star.

We are also getting good at capturing images of exoplanets alongside their stars. And then there is microlensing, where an exoplanet is detected by the way its gravity focuses the light of a distant background star. Einstein's general theory of relativity predicts this effect, but attempts to apply it to astronomy were abandoned in 1936 because of the limits of photographic plate technology at the time.

ESO/S. BRUNIER

Soon, Chile's giant telescope will search for Earth-like exoplanets

The greatest value of reading an "insider" book, though, is the insight the author can give us into what we can expect in the near future. For my money, the most exciting discoveries will come from ESPRESSO – a particularly apt acronym for this nocturnal profession – which stands for Echelle Spectrograph for Rocky Exoplanet and Stable Spectroscopic Observations. This ultra-high-resolution spectrometer will soon be installed in the Very Large Telescope in northern Chile, where it will simultaneously harness the light-gathering capabilities of four huge 8.2- metre telescopes. By measuring the wobble of a targeted star down to a velocity of just 10 centimetres per second, ESPRESSO will be able to detect Earth-like planets in the habitable zone of their star.

As those headlines about new exoplanets increase, after reading this book, you will be able to say you predicted as much. ■

Lewis Dartnell is the author of *The Knowledge: How to rebuild our world after an apocalypse*

An Anthropocene glossary

IN THE spirit of *Landmarks*, Robert Macfarlane's book of vanishing terms for natural phenomena, in our Christmas and New Year Special we asked you to help shape the direction of nature writing. The best three entries would win a copy of the book.

Roy Smith went straight for the jugular with *guardians of the countryside*, which he reserves for all those "who have managed the massive and sustained destruction of habitats and biodiversity in Britain over the last 70 years". Claire McMillan redefined *regression to the mean* as "someone reverting to selfish behaviours after a burst of recycling".

Other favourites include Tim Metcalf, who divides extinction events into phases (including a particularly creepy-sounding *verminal phase*); Martin Sahlén, who ends the climate-change blame game with his notion of *cosponsibility*; David Bassett for *chesticles* (don't ask); and James Parr for the elegiac *Great Vanishing*.

Our three winners are Christina Jenke, for *saltscape* (the land exposed by a shrinking inner sea), Giles Watson for *ghostroost* (a seabird nesting-area after a die-off) and Phoebe Beedell for *languing*, which refers to leaves that haven't dropped as normal during the winter. "The magnolia is languing on," Phoebe writes. "I'm worried it will be exhausted by springtime." ■

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Benchmark Vaccines Ltd (BVL), part of Benchmark's Animal Health division, develops improved health solutions that reduce the need for antibiotics. For over three decades, they have been developing and manufacturing licensed vaccines for the livestock, companion animal and aquaculture sectors. Their development team works closely with R&D, development partners and external customer to deliver state-of-the-art vaccine processes that are highly effective, safe and commercially viable.

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— *Ensuring the all capital manufacturing assets are developed appropriately for optimum efficiency and to meet capacity and capability needs.*
— *Ensuing all manufacturing operations comply with relevant health, safety and environmental law.*
— *Liaising with customers, both internal and external, in executing technology transfers for new product introductions.*

BVL Technical Director

Directing the vaccine development function of the company you will be responsible for:

Key Responsibilities:

— *Planning vaccine development projects from discovery handover to product licencing.*
— *Ensuring all operations are performed in accordance with internal quality procedures and requirements to meet EU product licencing regulations.*
— *Integrating vaccine development with the project planning of the animal health division*
— *Ensuring all capital development assets are in place and meet capacity, capability and timeline needs.*
— *Coordinating development operations with Benchmark's discovery, regulatory affairs and manufacturing functions.*
— *Liaising with customers, both internal and external in executing technology transfers for new product introductions.*
— *Raising the profile of the division through active, high-level involvement and thought leadership across the industry.*
— *Utilising existing individual industry recognition and gravitas to place BVL at the forefront of the industry.*

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Some of the areas may be grouped into themes for application purposes. Posts are due to start in September 2016.

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http://www.nshcs.org.uk/stp-recruitment

For Scientist Training Programme (STP) specialism and career information please visit Health Careers at:

www.healthcareers.nhs.uk/stp

*Please note applications for STP will open during 14th January 2016

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Unlike traditional schools students spend time each week working with scientific industry partners from across Cambridge's Science community developing their academic understanding of science in practical projects at the forefront of their field. Some of the projects being run this year include airship design with Hybrid Air Vehicles, DNA bar coding with the Sanger Centre and genetic engineering with the Babraham Institute. These are only a few examples of what are known as 'Challenge Projects' and sit alongside the students' GCSE, A Level and BTEC work.

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EDITOR'S PICK

When force of habit is derailed

From Jamie Carnie

Those who, like myself, have experienced brain illness or injury as adults become aware of how habit impairment can play a key role in interrupting the patterns of normal life that habits used to sustain (16 January, p 30).

Depending on the site of brain damage, one's habits may either be disrupted or may persist but with disruption to the cognitive capabilities on which their "automated" behaviours depend. In either case the old habits are no longer effective; indeed, in the latter they can even be counterproductive, as when habits induce behaviours a person is no longer capable of, resulting in confusion or risk.

For an adult, rehabilitation into "normal" life requires the re-creation of a set of habits that has been built up over a lifetime. For example, I had to re-establish basic life-skills originally acquired as a toddler, such as rapid arithmetic, time-keeping and road-crossing.

When tasks of daily living, including those previously catered for by habits, require full attention, the state of mental exhaustion that is often apparent following brain injury is exacerbated. If it can take a person of uncompromised neurological capability a year to acquire a single new habit, then one can appreciate why it can take a person in such a disordered state many years to reacquire a full set of habits.

Bath, UK

Odds of finding extraterrestrials

From Robin Wilson

Your article about detecting alien civilisations may underestimate the difficulty (16 January, p 38). As beings become more advanced they may become more ethical. (If not, then they may not survive long enough to leave a mark.)

One principle that might be adopted by ET, an Ethical Thing, is that of making as small an impact on the universe as they can. The green movement on Earth is already advocating this.

The Ethical Things may then live, develop and grow in their understanding of the universe while being careful to leave as little sign of their presence as possible. This would extend to deleting any signs of historic pollution. They might be invisible not because they are hiding, but because they don't want to make a fuss or leave any mess.

Harrogate, North Yorkshire, UK

From Eric Kvaalen

The visible, detectable universe isn't infinite. It seems to me very unlikely that life would start on any given Earth-like planet, let alone give rise to self-aware animals like us. So we have a very small probability multiplying a very large number of planets. We have no idea how small the product is. The fact that we exist doesn't help answer the question.

Les Essarts-le-Roi, France

From Anthony Castaldo

We invented radio about 120 years ago. Within 60 years or so we have invented efficient compression (to increase data bandwidth), good error correction (to increase reliability) and good encryption (to prevent eavesdropping). All of these make our transmissions look like randomised noise without any order. On top of that, our communications are progressively going "dark", using wires, fibres and lasers that leak very little information. Other technological civilisations would probably do the same. So there would be a vanishingly small window in the history of any technological civilisation in which eavesdropping could detect an unambiguously intelligent signal.

If I were sending a signal to make contact I would tailor it to be easily detected and understood – but only by a civilisation that could respond. A space-based solar-powered laser might be the most energy-efficient method. Once life had been detected in a star system, perhaps from its planets' emission spectra, I might pulse out a message to it for a year, every 10,000 years or so.

San Antonio, Texas, US

Entropy and typical universes

From Julian Barbour

I am surprised that your article describing how time might flow backwards (16 January, p 8) makes no mention of the 2014 paper "Identification of a gravitational arrow of time" (doi.org/bb4z), nor of the 2015 post "Entropy and the typicality of universes" (arxiv.org/abs/1507.06498). In these my collaborators and I published very similar ideas.

The model created by Sean Carroll and Alan Guth that your article describes is simply that of our 2014 paper with gravitational interaction removed: we already presented that simplification in our 2015 arXiv post.

I do not dispute that more than a decade ago Carroll suggested, with Jennifer Chen, the possibility of what we call a universe with one past and two futures, nor that Carroll expanded on this in his recent book *From Eternity to Here*. However, this had none of the mathematical results my team published. We are grateful to Carroll for his support as a referee in the publication of our paper. His comment on our 2014 paper, referring to his earlier intuition, was "I would personally count this work as an explicit example demonstrating that intuition". This is why I am so puzzled you made no mention of our work.

South Newington, Oxfordshire, UK

Chimeras' benefits and a forensic flaw

From Anthony Wheeler

Apparently fetal cells transferred across the placenta and retained in the mother can repair damage to the mother's heart muscle and other organs (9 January, p 26). Could this explain why women have a longer lifespan than men?

Mackay, Queensland, Australia

From Barry Isaacs

Where does the presence of cells from other people leave DNA fingerprinting?

Lamerton, Devon, UK

Reasons to invest in electric cars

From Richard Ellam

Peter Shand is right about electric cars (Letters, 23 January). Suppose we were to replace the UK's fleet of petrol and diesel cars with electric vehicles, using electricity from gas-fired thermal power stations. Back-of-the-envelope calculations suggest that carbon emissions from these cars would be between 30 and 50 per cent lower than from the present fleet.

Essentially, this is because burning fossil fuel in large power stations is more efficient than burning it in millions of little piston engines. Even after losses in transmission and charging you get at least a third more useful energy at the wheel rims.

Electric cars would also reduce the particulate pollution that is a major cause of poor air quality in cities. It is easier to control pollution at a few large power

"I hope it wasn't the result of humans screwing up these beautiful whales' sonar"

Beth Kattleman's heart hurts over beached wales in eastern England (newscientist.com/article/2075274).

stations than from those millions of car exhausts.

Here in the UK, politicians want to spend upwards of £100 billion on replacing obsolete nuclear missiles. If the money were invested in electrifying the UK's car fleet this would create and protect far more high-skilled jobs, kick-start an essential change in technology and do something beneficial for the planet and all of humanity instead of contributing to global insecurity, paranoia and terror.
Paulton, Somerset, UK

Grow shy microbes, pair by pair

From Philip Duke
Cynthia Graber's report on work by Slava Epstein and others on growing recalcitrant microbes was fascinating (2 January, p 36). I suggest a further experiment: dilute the microbes spread on the iChip growing apparatus so that there are two or three per cell. The aim would be to start to reveal the symbiotic existence of some of them, if that is as likely as I expect.

Some simple maths would be able to make predictions for behaviour with and without symbiosis. Pinpointing the symbiotic relationships would be more tricky, but rewarding.
Shipham, Somerset, UK

Slava Epstein writes:
■ I have been thinking about microbial symbioses, in terms of cultivation and otherwise. One issue is that some such consortia of microbes are "uncultivable" as a whole – not only their individual members, but the entire group resists being grown.

Clarity in the face of science's doubts

From Constance Lever-Tracy
Chris Ford suggests that climate scientists will connect better with the media if, instead of saying "It's impossible to say whether a particular flood event is or isn't caused by climate change", they answered "climate change will bring more storms like this" (Letters, 9 January). But reality has already caught up and moved on. Confident assertions by respected scientists about probable future climate disasters have become increasingly common. Sadly, this isn't enough to counteract public doubts about uncertain future scenarios. A better response would be "climate change is bringing more storms like this".
Adelaide, Australia

Hungry plants flower more

From Hazel Beneke
Researcher Robert Margolskee speculates that taste receptors in the testes might detect nutritional status to avoid wasting valuable energy making sperm when food is scarce (8 August 2015, p 38). This suggestion is anthropocentric.

Many a gardener has observed lack of flowering in pampered plants. Flowering and sperm production are a means of perpetuating the species, so are more likely to be favoured when food is scarce. Or are humans an exception to the rule?
Banksia Beach, Queensland, Australia

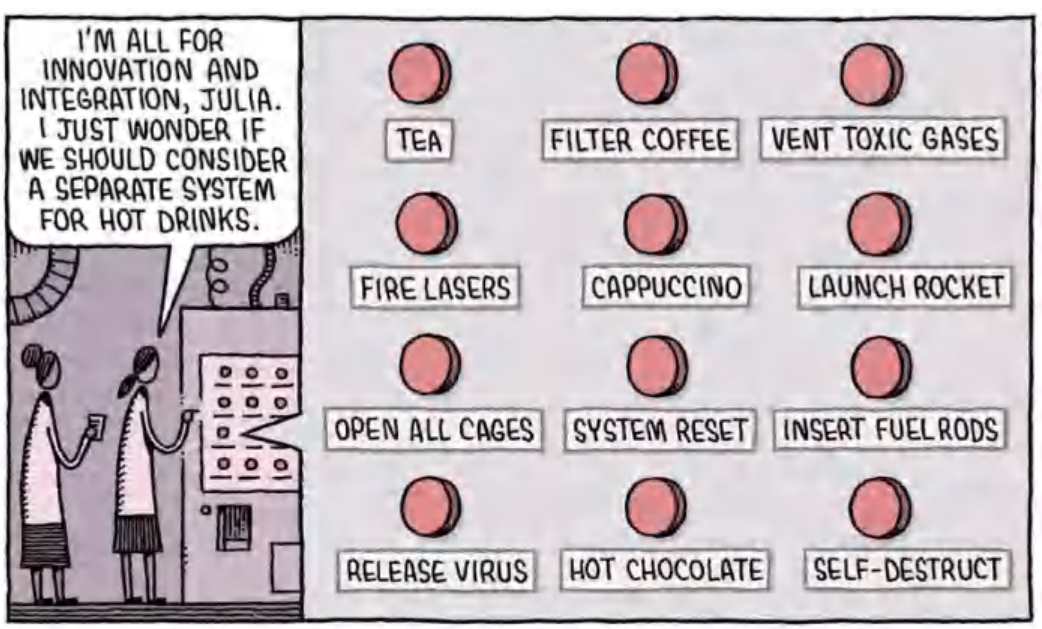
Exponential growth in reverse

From Derek Bolton
The article on exponential growth (12 December 2015, p 34) reminded me of a 1940s *Lloyd's Log Problem Book* puzzle. It described a lily that doubles in size every day, taking 36 days to completely cover a pond, and asks: how long does it take to half fill the pond? For some reason, having to think about it this way around seems more challenging for many people.
Birchgrove, New South Wales, Australia

For the Record

■ **A study of the health effects of cuts to UK disability allowance found that 725,000 more prescriptions for antidepressants were issued (21 November 2015, p 7).**
■ **World concrete production to date has been about 500 billion tonnes, which is enough to deliver 1 kilogram to every square metre of Earth (16 January, p 14).**
■ **A brain in a warmer vat: maverick surgeon Sergio Canavero reports cooling a monkey's head only to 15 °C before transplant (23 January, p 6).**
■ **Whoops. The curves showing the numbers of people not having relapses of schizophrenia, with standard drug treatment and with minimal treatment, were reversed (8 February 2014, p 32).**

TOM GAULD



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PAUL MCDEVITT

A HUGE winter storm made landfall in the eastern US last week, bringing massive drifts of snow and a flurry of unusual units to measure the deluge. Many of you wrote in to comment on strange advice from the BBC to "use your dog to measure the snowfall".

An accompanying image displays record snowfall depths for a variety of US states, illustrated according to whether this is enough to conceal a small, medium-sized or large dog.

Ian Beaver writes, "Wasn't it veteran BBC weatherman Ian McCaskill who told us during an evening forecast that the day's heavy rain had been 'a worrying time for small dogs'?".

IN FACT, canine units crop up with surprising frequency in meteorology. Romans have their "dog days" of wilting summer heat and, on the opposite side of the world, a cold snap in Australia might be called a "three-dog night". Here in the UK, they endure as units of precipitation – as in, "it's raining cats and dogs".

At the time of writing, the BBC had, inexplicably, added a panda to its chart. Advice to anyone caught in a blizzard: if you look outside and can't see a panda, it's safe to assume there are at least 40 inches of snow on the ground.

MORE questions emerge on Shield, the company that knits foil-coated prophylactics to protect your brain from electromagnetic signals (9 January). John Morton notes that the woollen hat claims to reflect signals from "cell phones, wi-fi routers, microwaves", and yet also claims to be radar-invisible.

"If it can reflect microwaves and be radar-invisible, it must be some sort of Schrödinger's hat, in that it can simultaneously reflect all microwaves while not reflecting them," writes John. Perhaps the military should start cloaking their aircraft in cardigans made of this tinselled yarn?

MEANWHILE, Dave Harton directs our attention to another trestle table set up in the Kickstarter market of ideas: Obshi, "The World's First Patented Multiverse Drain System".

It's easy to be fooled by its simplicity – a spout that opens with a quarter-turn of the fixture, allowing the contents to drain away. But the contents of what, exactly? And where are they draining to? "Surely it's got something to do with wormholes," suggests Dave. The Kickstarter page hints that Obshi is "designed for use with many applications". Indeed.

EAGLE-EYED Luke Sully spots that the consumer and community spokesman for Age UK, a charity dedicated to improving the lives of the elderly, is none other than Joe Oldman.

BURIED under a pile of boastful factlets from internet megamart Amazon (16 January), Feedback wondered what units should be used to measure such self-congratulatory press releases.

"Yawns, obviously!" cries Barrie Watson, while Jon Hinwood proposes that the units for self-congratulatory bilge ought to be "one pouter pigeon for a typical puff piece, but one peacock for strutting around and admiring one's own tail feathers".

Peter Bleackley says that the appropriate unit is the Montgolfier, "which measures how full of hot air something is" – named for the pioneering brothers of balloon flight. Feedback considers this just the thing to deflate swollen egos.

WOULD-BE poisoner and ginger supremacist Mark Colborne has been detained indefinitely under the Mental Health Act for plotting to kill Prince Charles so that his red-headed son Harry could ascend to the throne.

Following the story on BBC News, Charlie Wartnaby notices that the image used to illustrate the dangerous chemical substances seized by police from the man's home instead "shows a bottle of nice, pure distilled water". Feedback suggests that although this may seem innocuous, the royal patron of homeopathy would no doubt recognise an essential solvent for amplifying the potency of poisons.

FEEDBACK watched with dismay as the mind-bendingly foolish psychoactive substances bill – which would make the smell of flowers illegal – was nodded through Parliament and now looks set to become law.

A howl of anguish was raised by MP Paul Flynn in an early day motion, quoting *New Scientist* to lambast the bill as "one of the stupidest, most dangerous and unscientific pieces of drugs legislation ever conceived" (30 January, p 26).

In Westminster, such motions are known as "prayer"; Feedback suspects this keenly reflects both the authority needed to challenge such folly and the likelihood that such an intervention will happen.

IN THE spirit of questionable generosity, Shane Dwyer contributes to our list of things we'd be happier not knowing. He shares something he was "told years ago and [has] been trying to unlearn ever since" – that cockroaches like two things, moisture and darkness.

"What is the last thing you do every night before bed?" he asks. "You moisten your toothbrush, you hang it up and then you turn off the bathroom light." Thanks Shane. We'll be sleeping with the bathroom light on in future.

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

A colleague of Bernard Costello placed an order with a well-known chemical supplier, and was promised delivery within "±3 days". By tachyon, presumably.

Deckchair port

I notice that Heathrow Airport often tops the list of highest daily temperatures in summer in the UK. Why is this?

■ The south-east of England is an excellent candidate for containing the warmest place in the UK. Not only is it in the south, but it is also on the front line as regards exposure to the warm southerly or south-easterly continental winds that blow during a hot spell.

Heathrow has an additional advantage: the urban heat island effect. Most cities are warmer than the surrounding countryside because their technology-rich environment generates waste heat. Heavily tarmacked surfaces are also better than vegetation at absorbing heat energy from the sun. So it is not surprising that weather stations in London often register the highest temperatures.

"In fact, the highest ever UK temperature of 38.5°C didn't occur in London, but in Faversham, Kent"

However, I don't think Heathrow is necessarily more likely to experience heat extremes than other London airports; it's just that we tend to notice when it does. In fact, the highest UK temperature to date (38.5 °C, on 10 August 2003) wasn't recorded in London but close by at Faversham, Kent.

William Torgerson
Durham, County Durham, UK

Fishy hell

I don't like eating fish and I find their odour disagreeable. My wife says it's all in my head, but I think that many people have my aversion. Is there a genetic or evolutionary component to it, is it based on an unpleasant childhood experience, or do I have to concede to my wife's theory?

■ It's common not to be able to pinpoint the origin of someone's distastes. Some may be partly genetic. For example, people to whom the chemical phenylthiocarbamide (PTC) tastes bitter are genetically unable to taste the bitterness of the fruit of the Chinese laurel (*Antidesma bunius*), and vice versa.

Most often, however, one acquires preferences for tastes and smells that one grows up with, and distastes in reaction to bad associations, particularly in early childhood. Having loved the taste of kidneys at first, I vomited up a kidney meal at the age of 6, when I had scarlet fever. It took me decades to like them again.

As for fish, Richard Feynman once related how he used to hate fish as a child, but liked it as an adult when he tried some in Japan. Back home, he found that he still hated fish. It turned out what he hated was the taste of fish not quite as fresh as available in Japan.

Jon Richfield
Somerset West, South Africa

■ In my case at least, fish aversion seems to have been the result of an unpleasant childhood experience. This was only revealed to me when I revisited my childhood home after many years, and talked to one of our neighbours. "I remember you," she recounted. "Your mother often left you in the care of your older brothers, who bought fish and chips for lunch. The three of you then sat in the gutter, where they ate all the chips and forced you to eat the fish."

Subsequently I never ate fish and became almost nauseous from the smell, which I now know to be associated with unfresh fish. Eventually I was so embarrassed at asking for an alternative dish at dinner parties that I steeled myself for a fish course, which turned out to neither smell nor taste as I was sure it would.

Since then fish has become a real delicacy for me. That includes oysters (once an absolute anathema) as well as raw fish, which, curiously, has little flavour.

So I have to agree with your correspondent's wife that his aversion is probably the result of nurture rather than nature.

Don Ross
Vaucluse, New South Wales, Australia

Nutty question

Why is the scrotum so wrinkly?

■ The scrotum plays a valuable role in thermoregulation of the testicles, as sperm production is reduced at core body temperatures and above. Those of us with this piece of anatomy will have noticed that on a very cold day, or when emerging from a cold shower, the scrotum (and the rest) will be much smaller. The converse happens on a warm day or on emerging from a hot bath. The scrotum is quite smooth when relaxed and only wrinkles as it is pulled tight to the body.

This is because muscles within the scrotal wall contract to bring the testicles nearer the abdomen in cold conditions, and relax to keep them cool when it is hot. There is also a complex system of vasculature in the spermatic cord (the pampiniform plexus), where warm blood leaving the abdomen is cooled by a heat exchanger system before entering the testicles.

When farmers first started to rear Merino sheep in Australia, they found that the rams were sterile until sheared, so their testicles are shorn on a regular basis today. This breed of sheep originated in southern Portugal, where summer temperatures are not as high. Consequently the rams have unsuitably woolly scrotums for southern Australian conditions.

Bob Butler (retired vet)
Llangoed, Anglesey, UK

This week's question

BORN TO DRIVE

How did we evolve to be able to safely control cars travelling at 100 kilometres per hour?

Keith Evans
Pwllheli, Gwynedd, UK

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