

New Scientist

WEEKLY July 22 - 28, 2017

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Most of your DNA
really does nothing

THE ICE OF LIFE

Exotic state of water
could explain life's origin

FINS TO PINS

How fish walked
out of the water

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DANIEL HERNANZ RAMOS/GETTY

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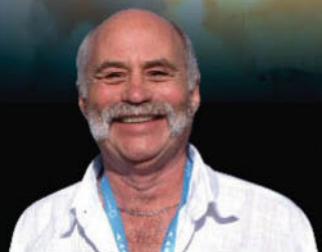
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Nigel
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》 QUIZ AN ASTRONAUT

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AXEL KILLIAN/PLANPICTURE

Oh, lonesome us

Loneliness is a neglected public health crisis. It's time to act

ALL the lonely people, where do they all come from? When The Beatles wrote *Eleanor Rigby* in 1966, they helped perpetuate the stereotype that loneliness is a problem of elderly and isolated people. Maybe it was true 50 years ago, but no longer. Loneliness can and does affect anybody. And yet we barely talk about it.

If loneliness were just a social problem, it would be bad enough. But it is also a public health disaster, linked to a slew of chronic illnesses (see page 30). Surveys suggest it is a routine feature of modern life. In the UK, for example, the Co-op and the British Red Cross found that more than 9 million adults are always or often lonely. Children and people with disabilities also report high levels of loneliness.

It is not hard to find plausible reasons. More people live alone, and the number of single-parent households is rising. Education and work mean that many of us live far away from our families. At the same time, technology has changed the way we work, shop, socialise and entertain ourselves, largely serving to reduce the amount of face-to-face contact we get. This is exacerbated by an insidious "cult of busyness" that elevates productive work time above everything else.

This adds up to an epidemic of loneliness – and that is not a word that is used casually. Chronic loneliness is dreadfully damaging to people's mental and physical well-being. As a public health problem it is up there with smoking and obesity, yet it hardly registers in the public mind. For campaigners, it has proved a lonely furrow.

This is not for lack of trying. In 2010, UK charity the Mental

"We can't stop social trends driving the epidemic, but our collective denial still needs to change"

Health Foundation published a report called "The Lonely Society?", which flagged up the mismatch between the seriousness of the problem and its relative neglect by health professions and obscurity in the collective consciousness.

The report closed with a series of recommendations. The first was to increase awareness of loneliness, in part to tackle the stigma and shame attached to it. The second was for doctors and social workers to gain a better understanding of its potential consequences, and to educate them about the services that are available to deal with it.

Those recommendations are as pressing now as they were at the time. If anything, the trends driving increased loneliness have become even more apparent, and our scientific understanding of its impact has become much clearer. We also know how to intervene, quite easily and cheaply. Curing loneliness might just be the most cost effective public health intervention available.

There may not be much we can do about social trends driving the epidemic, but our collective denial of it still needs to change. There are welcome signs that this is happening. Before she was murdered in 2016, British MP Jo Cox was working to create a national commission on loneliness. That has now been realised posthumously, bringing together MPs and various campaigns to raise awareness.

In her maiden speech to the House of Commons in 2015, Cox famously said "we have far more in common with each other than things that divide us". One of the things we have in common is our propensity for loneliness and our unwillingness to talk about it. Until we change that, we will keep on asking ourselves "where do they all come from?", as if loneliness is something that happens to other people. ■

Ancient footprints at risk

IT'S only a matter of time. Scientists studying tremors in east Africa's rift valley say an eruption from the Ol Doinyo Lengai volcano is imminent. This could threaten ancient hominin footprints preserved at two sites.

The volcano lies 120 kilometres north-west of Arusha in Tanzania. It has erupted three times in the last century, propelling debris and ash high into the air. Increased earthquakes, ash emissions and a widening crack on the west side of the volcano all suggest it will erupt soon, says D. Sarah Stamps at Virginia Tech in Blacksburg.

The volcano is a mere 14.5 kilometres from Engare Sero, where anthropologists recently unearthed over 400 hominin footprints dating back 19,000 years.

A large volcanic debris flow could, in theory, swamp the area.

The iconic site of Laetoli, with 3.7-million-year-old hominin footprints, is 113 kilometres away and perhaps safer from harm.

Marco Cherin at the University of Perugia, Italy, is concerned for the Engare Sero prints. "They are amazing for their extraordinary state of preservation," he says.

"[They're] not like fossilised bones that we can dig up and walk away with," says Kevin Hatala at Chatham University in Pittsburgh, Pennsylvania.

Although 3D scans of the prints at both Engare Sero and Laetoli exist, losing either would be a blow. Computer models are "not the same as having the actual site", Hatala says.



About to blow?

The 51-qubit feat

A TEAM in the US has created a simulator with 51 quantum bits – the largest of its kind so far. Mikhail Lukin at Harvard University announced the achievement on 14 July at the International Conference on Quantum Technologies in Moscow.

Quantum simulators are used to model the minute behaviour of molecules, and could help study how drugs act within the human body. They aren't full-blown quantum computers, though,

other hand, are theoretically capable of handling any equation you throw at them. But they are a much bigger challenge to build, says Devitt.

The simulator has a high error rate, but because it simulates just one mathematical model, it can still produce useful results some of the time. Full-blown quantum computers must achieve much lower error rates, but will produce better results.

Today's most advanced quantum systems – such as the 49-qubit computer Google is working on – exploit superconductivity to store information, using electrons at extremely low temperatures.

Lukin's work takes a different approach. His qubits are each made from a single rubidium atom, trapped in place using lasers and programmed via fluctuations in the laser beam.

Although less complex than quantum computers, simulators are still extremely expensive to build, says Devitt, so it's unlikely that they will find many practical applications beyond physics departments for the time being.

"The device has a high error rate but simulates just one mathematical model, so can give useful results"

says Simon Devitt at Macquarie University in Sydney.

Lukin's system was specifically built to solve one equation that models the interactions between certain atoms. If you wanted to solve a different equation, you'd have to rebuild the system from scratch.

Quantum computers, on the

No smoking

TIME for the English to stub out their cigarettes. That's the aim of the UK government's latest plan to discourage smoking, ultimately driving the proportion of adult smokers below 5 per cent (see page 22).

Over the past six years, the proportion of adult smokers in England has already fallen from 20.2 to 15.5 per cent, the lowest since records began. But the goal now is to get it down to less than 12 per cent by 2022.

Another key aim of the plan is to produce a generation of non-smokers by reducing the proportion of under-15s who smoke from 8 to 3 per cent by 2022. More than three-quarters of adult smokers began as teens.

Anti-smoking lobby groups have welcomed the plan, but warn that it won't work unless the government reverses cuts in budgets and resources for smoking cessation services offered through the National Health Service and by local authorities.

Moon mine planned for 2020

COULD there be a mining outpost on the moon by 2020? The US firm Moon Express has raised \$45 million for three expeditions to the moon, ending with a robotic mining operation.

The Lunar Scout expedition aims to carry a telescope and a laser array to the moon. In 2019, Moon Express plans to land a second craft at the south pole, to prospect for water and useful minerals. The third expedition, Harvest Moon, would begin the mining operation in 2020. This lander

may have the capability to launch a capsule full of samples back to Earth while it continues mining.

Those lunar samples would be the first to return to the US since 1972. All samples from prior US missions are owned by the US government, but recent US legislation encourages commercial use of resources in space, as long as they aren't alive. That means that if Moon Express finds aliens, it can't keep them, but minerals and water are fair game.

60 SECONDS

US health fraud

HUNDREDS of people have been charged with acts of healthcare fraud in the largest crackdown in US history.

In all, the allegedly fraudulent insurance claims are said to add up to \$1.3 billion. A total of 412

"Just one doctor allegedly gave out prescriptions for over 2 million illegal painkiller doses"

people have been charged, US attorney general Jeff Sessions and Tom Price, US secretary of health and human services, announced last week.

Many charges relate to treatments that were deemed unnecessary or weren't provided but were billed to the federally and state-funded healthcare programmes, as well as an insurance programme provided for members of the military and their families.

The crackdown was coordinated by multiple federal and state law enforcement agencies. Over 120 of the defendants are alleged to have played a hand in illegal opioid distribution.

"An illegal clinic in Houston allegedly gave out prescriptions for cash," said Sessions. "Just one doctor at this clinic allegedly gave out 12,000 opioid prescriptions for over 2 million illegal painkiller doses."

NASA/JPL-CALTECH/MSSS/SWRI/KEVIN M. GILL



See spot stun

Red Spot spotted

IT'S the first close-up of the biggest storm in our solar system. On 10 July, NASA's Juno spacecraft flew closer to Jupiter's Great Red Spot than ever before, passing within 9000 kilometres of its swirling clouds.

The first images from the flyby show the tops of clouds stirred by winds at speeds well over 600 kilometres per hour.

Juno reached Jupiter in July 2016 after a five-year trip. Since

"How a storm, 16,000 kilometres wide, could persist for centuries is still a mystery"

then, it has studied the planet's atmosphere, magnetic field and auroras to get a handle on the gas giant's structure and formation.

During the flyby, all eight of Juno's scientific instruments were running, observing the magnetic field and atmosphere around the Great Red Spot in detail. They will study the molecular make-up and temperatures of areas within the storm and peer through the cloud to determine how deep the spot extends into Jupiter's gassy interior.

We've been able to see the Great Red Spot for more than 150 years, and it may be much older than that. How the 16,000-kilometre-

MOONEXPRESS



What will it send back?

wide storm has lasted so long is still a mystery. Researchers hope that taking a deeper look into its roiling clouds will reveal the secret of its longevity – other, smaller storms dissipate much more quickly. Some think that the storm begins deep within the gaseous planet, but we've never sent a spacecraft close enough to confirm those suspicions.

Lifespan gain slows

ANNUAL rises in life expectancy have begun to stall in England, finds an analysis of mortality rates and causes of death.

Between 2000 and 2009, women in England were on average living a year longer every five years, and men every 3.5 years. But since then, a one-year increase in longevity would take 10 years for women and six for men.

"Since 2010, the rate of increase in life expectancy has about halved," says Michael Marmot, director of the Institute of Health Equity at University College London, who led the work.

The reasons for the slowdown aren't clear, Marmot says, but it coincides with austerity-driven cuts in health and social care spending. Prior to 2010, UK National Health Service spending rose annually by about 3.8 per cent, but this has since fallen to 1.1 per cent a year, he says.

Maths world mourns

Iranian mathematician Maryam Mirzakhani has died of breast cancer at the age of 40. She was the only woman to have won the Fields Medal, sometimes called the Nobel prize of maths, for her work on the geometric structures of surfaces.

Climate forecast

We are heading for over 4°C of warming by 2100. This dire warning comes not from scientists, but from an asset management firm called Schroders, which looks after assets worth \$520 billion for investors. It has done its own analysis of trends in fossil fuel production and efforts to curb emissions.

Dockless sharing fails

Two dockless bike schemes in the UK - oBike in London and mobike in Manchester - have had underwhelming results. Both offered bikes for rent that could be picked up and left anywhere, using only GPS and a phone app. But instead of encouraging a cycling boom, the bikes were left scattered on pavements, in canals, in bins and generally vandalised.

Live long and prosper

Tube worms living near cold seeps on the floor of the Gulf of Mexico may live for 300 years or more, according to an estimate based on their growth rates. Researchers think the animals grow so old partly because they are faced with so few natural threats (*The Science of Nature*, doi.org/b9qh).

Pull my finger

Listening to a sound that rises in pitch while pulling your own finger can make you think your finger is longer than it is. This was discovered in a series of experiments in which women estimated the length of their index fingers (*Scientific Reports*, doi.org/b9q4). It is the first evidence that pairing artificial sounds to a person's action can change how they perceive their body.

Most of your DNA is junk after all

It's taken decades, but we're coming to terms with the junk in our genome

Michael Le Page

YOU'RE far from a perfect product. The code that makes us has to be at least 75 per cent rubbish, according to the latest study.

After 20 years of biologists arguing that most of the human genome must have some kind of function, it now seems that, because of the way evolution works, the vast majority of our DNA has to be useless – a suggestion that contradicts claims from prominent researchers.

When we first worked out how the bases of DNA function as a blueprint for making proteins, it was assumed that almost all DNA codes for proteins. However, by the 1970s, it became clear that only a tiny proportion of a genome encodes proteins – about 1 per cent in the case of humans.

Biologists realised that some of

the non-coding DNA might still have a role, such as regulating the activity of the protein-coding genes. But around 90 per cent of our genome is still junk DNA, they suggested – an uncomfortable idea for creationists, who struggled to explain why an intelligently designed genome would consist mostly of rubbish.

But throughout the 2000s, a number of studies purported to show that junk DNA was nothing of the sort, after demonstrating that some tiny bits of non-coding DNA had some use or other. The grandest claim came in 2012, when a consortium of genomics researchers called ENCODE declared that 80 per cent of the DNA in the human genome has a function. "They had spent \$400 million, they wanted something big to say," says Dan Graur of the University of Houston.

Graur is one of many who didn't believe this claim. ENCODE defined DNA as functional if it showed any biochemical activity, however slight. But Graur doesn't think this is enough to prove DNA has a meaningful use. Instead, he argues a sequence can only be described as functional if it has

"We're walking around with a genome where only 1 in 10 of the bases actually matters"

evolved to do something useful, and if a mutation disrupting it would have a harmful effect.

DNA mutates at random for several reasons, such as UV radiation or mistakes made when DNA replicates during cell division. Our children inherit a shuffled bag of mutations, and those with a lot of particularly

bad ones are more likely to die before having children of their own. This is how evolution stops bad mutations building up to dangerously high levels in a species.

Following Graur's logic, if most of our DNA is functional, most mutations would fall in important sequences and be bad for us. But if most of our DNA is junk, the majority of mutations would have no effect. Graur's team has now calculated how many children a couple would need to conceive for evolution to stop us accumulating too many bad mutations in different cases.

If the entire genome has a function, couples would need to have around 100 million children, and almost all would have to die, they found. Even if just a quarter of the genome is functional, each couple would still need to have nearly four children on average, with only two surviving to adulthood.

Taking into account estimates of the mutation rate and average prehistorical reproduction rate, Graur's team calculated that only around 8 to 14 per cent of our DNA is likely to have a function (*Genome Biology and Evolution*, doi.org/b9q3). This ties in nicely with a 2014 study that compared our genome with other species and concluded that around 8 per cent of it is functional.

"We are walking around with a genome where only 1 in 10 bases actually matters," says Chris Ponting of the University of Edinburgh, UK, who was part of the 2014 study.

The challenge for those who still think most non-coding DNA is vital is to explain why an onion needs five times as much of it as we do, says Ryan Gregory of the University of Guelph in Canada. ■



Happy babies, healthy genomes

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Earliest Australians are a prehistoric puzzle

HUMANS may have arrived in Australia 15,000 years earlier than we thought. Artefacts found in the north of the country suggest that the region was occupied 65,000 years ago – which raises all sorts of questions about how the country's first inhabitants interacted with wildlife and what became of them.

Until recently, the oldest evidence of human occupation in Australia came from 50,000-year-old stone artefacts found in a rock shelter in the country's north.

Now Chris Clarkson at the University of Queensland and his colleagues have found artefacts dating back 65,000 years in a different rock shelter – this one in Kakadu National Park in the far north of the country. The artefacts include fireplace remains, stone axes, grinding stones, ground plant matter and ground ochre – a type of red pigment commonly found in ancient rock art in northern Australia. Clarkson's team calculated the age of the artefacts by dating charcoal and quartz grains buried in the same layer of sediment (*Nature*, DOI: 10.1038/nature22968).

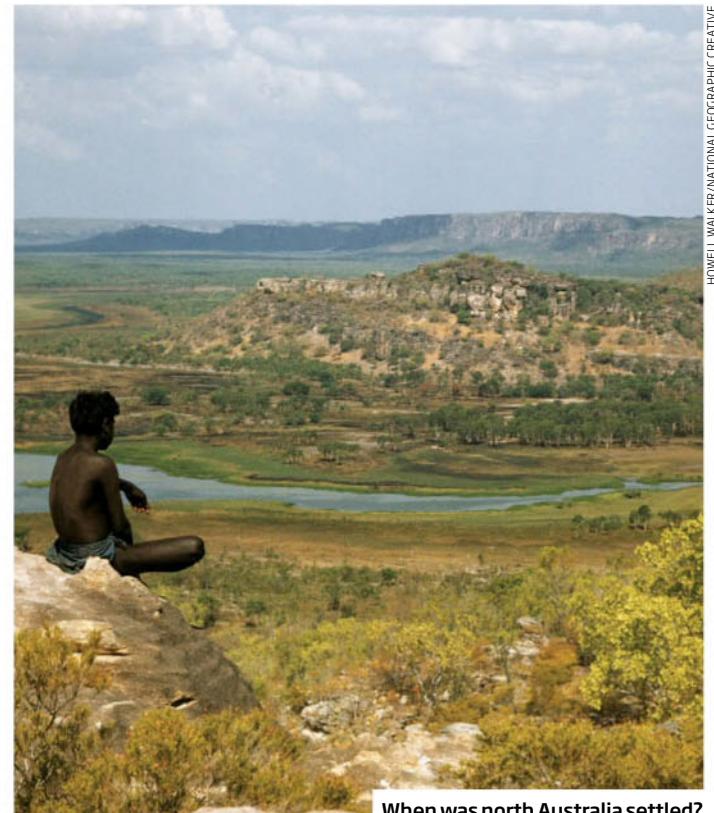
Alan Cooper at the University of Adelaide is perplexed by the discovery, given that nothing so

ancient is found anywhere else in Australia. "We know these people were fast movers – they moved very quickly from Africa to Asia to Australia," he says. "So if they did arrive in northern Australia 65,000 years ago, why did they then just sit down and wait 15,000 years before spreading to the rest of the country?"

Adding to the mystery is the fact that it is unclear where the first Australians came from. The easiest route into Australia is via the chain of islands directly to the north, but there is little evidence that *Homo sapiens* was present on these islands much before 44,000 years ago, says Sue O'Connor at the Australian National University.

This is an evolving picture, though. For instance, there is some evidence that *H. sapiens* reached a more northerly island of South-East Asia – Luzon in the Philippines – 67,000 years ago.

O'Connor is also puzzled by the early humans' wanderlust. Sea levels were substantially lower 65,000 years ago, making it easier to move between Asia, Australia and the islands en route. But humans still had to cross open water stretching for 80 kilometres to make it to mainland Australia,



HOWELL WALKER/NATIONAL GEOGRAPHIC CREATIVE

When was north Australia settled?

she says. "There's no obvious reason like climate shifts to explain the rapid movement."

An earlier arrival date for humans is also in line with arguments that our species is responsible for the demise of some Australian megafauna. Creatures including giant versions of birds, echidnas and wombats, and tree-dwelling lions went

extinct about 45,000 years ago.

However, just because people co-existed with megafauna for 20,000 years doesn't mean they were responsible for the extinction, says O'Connor.

"Humans may have had an impact through fire practices and hunting but there's no solid evidence either way," she says.

Alice Klein ■

Drone buzz is the most annoying sound

BUZZ off. NASA may have flagged a future area of discord for Amazon, UPS, Domino's Pizza and other firms planning delivery services using drones: people find the noise they make more annoying than that of ground vehicles, even when the sounds are at the same volume.

"We didn't go into this test thinking there would be this

significant difference," says study co-author Andrew Christian of NASA's Langley Research Center, Virginia. The study's purpose was merely to prove that Langley's acoustics research facilities could contribute to NASA's wider efforts to study drones.

Nonetheless, the results indicate the extra irritation the 38 subjects experienced when listening to drone noises was as if a car were suddenly twice as close as it had been before (DOI: 10.2514/6.2017-4051).

Less clear was why drones sound so annoying. Participants didn't know

they were listening to drones and were unaware of the study's research focus. They only knew they were hearing sounds related to "the future of transportation".

One reason for the difference might relate to how slowly most commercially available drones move. A drone takes a lot longer to pass by than a car travelling down a residential street, and a common

"The irritation might be down to how slowly most commercially available drones move"

complaint was how the drone sounds seemed to loiter.

If loitering is the issue, this might be good news for Amazon as the commercial drones NASA studied are slower than those the company is developing, which are planned to reach 95 kilometres per hour.

But while the company says it is working on quieter drones, Christian says the new research indicates they will need to be significantly quieter than ground vehicles.

His hope is that NASA can help such companies before the inevitable complaints begin. Alasdair Wilkins ■

Galaxy of games bursts filter bubble

Douglas Heaven

THE constellations spin dizzyingly, 15,000 stars against the blackness. Click, zoom in, and individual dots pop up from the nearest clusters: *Everybody's Gone to the Rapture* (2015), *Red Dead Redemption* (2010), *Nancy Drew Dossier: Lights, Camera, Curses* (2008).

This is GameSpace, an experimental online tool designed to help you find the next video game to play. It doesn't just work for gamers, though – it could soon make life a bit better for anyone looking for the next great book or movie.

Like the rest of us, gamers can't keep up with all the new titles constantly being published. "The accumulation is ridiculous," says James Ryan at the University of California, Santa Cruz.

Apple's App Store has around 800,000 games, with several hundred new ones added every day. Even if they're great, many will get lost in the crowd.

So Ryan and his colleagues

developed GameSpace as a better alternative to the algorithms that give us tips like: "People who watched *Breaking Bad* also watched *Better Call Saul*."

These often work well, with one big caveat. "Recommendation systems are self-fulfilling," says

James Allen-Robertson, who researches digital media at the University of Essex, UK. People who rely on them end up in a bubble, with the system only showing them games or films like ones they have already enjoyed.

"We wanted to build a tool that cuts through the morass," says Ryan. "We wanted to capture how people actually talk about games."

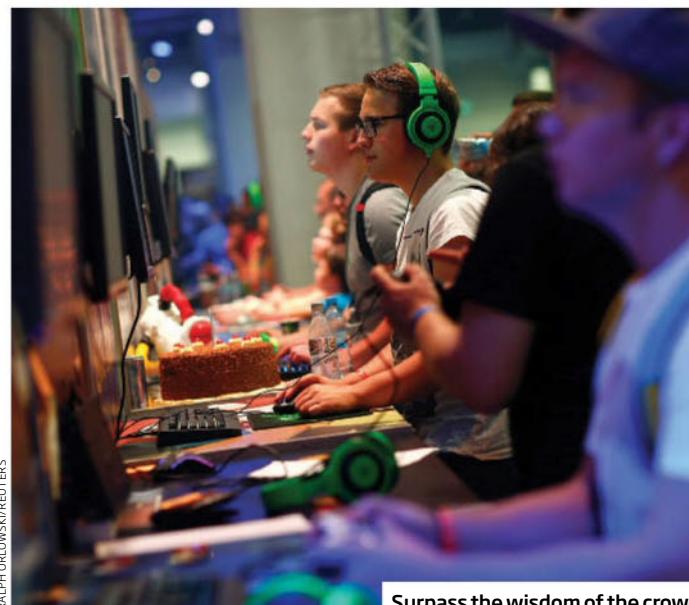
Instead of relying on the opinions of those who might also be trapped in their own filter bubbles, the team turned

to Wikipedia descriptions. They used natural language processing software to scour 21,456 game descriptions there. A machine learning system then generated a similarity score measuring how alike any two games are. This score is what the team used to position the games in the 3D galaxy visualisation.

The tool has already thrown up some surprises. Why was a game about breakfast cereal sitting next to *Doom*, for example? "I thought the algorithm was broken," Ryan says. But it turned out the cereal game was indeed an adaptation of *Doom*. "Not only was it not broken, but it was really cool the way it was bringing up related games," he says.

One shortcoming is that the tool is limited by what people happen to have posted on Wikipedia. Japanese interactive novels are really well represented, for example, but much more popular sports games are not.

The team will present the work at the Foundations of Digital Games conference in Massachusetts next month. Extending it to books and films should be possible for any title with a Wikipedia description, says Ryan. You could even build a tool that let you fly through Wikipedia itself, he says. ■



Surpass the wisdom of the crowd

RALPH OLOWSKI/REUTERS

Blood test spots rare anomalies in fetuses

A BLOOD test can scan a fetus's entire genome for chromosomal abnormalities at 10 weeks of pregnancy. The test may help identify pregnancies in need of closer monitoring, or those at a higher risk of miscarriage or complications.

Chromosomal abnormalities occur in around 1 in 1000 births. The most common are Down's syndrome, Edwards' syndrome and Patau syndrome, which are caused by carrying an extra copy of a

chromosome. These can all be detected by the form of non-invasive pre-natal testing (NIPT) currently offered by private clinics. NIPT works by detecting fetal DNA fragments in maternal blood.

Several teams around the world have now developed whole-genome versions of NIPT that can detect rarer chromosomal anomalies, such as mosaic trisomy 22, which can cause learning difficulties, short stature and webbing of the neck.

Mark Pertile at Victorian Clinical Genetic Services (VCGS) in Melbourne, Australia, and his colleagues are one of the first teams to use whole-genome NIPT, and recently completed 30,000 tests of the technique. Of the 90 cases

of rare chromosomal abnormalities they identified, 70 per cent were associated with pregnancy complications, including miscarriage.

They found that the test was highly accurate – whenever follow-up invasive tests like amniocentesis were used, they confirmed the chromosomal abnormality detected by whole-genome NIPT. Pertile's team plans to publish detailed results from tests of the technique soon.

The idea is that, when a rare abnormality is found, parents can

"Obstetricians have told us this information is useful so they can prepare their patients"

make an informed choice about how to proceed. This may include further tests, such as amniocentesis, or counselling to help them decide if they want a termination, or to prepare them for possible miscarriage or looking after a child with disabilities. "Obstetricians have told us this information is useful so they can prepare themselves and their patients," says Pertile.

In some cases, the findings can also reduce subsequent parental guilt, says Trent Burgess at VCGS. "It's not uncommon for people who have a miscarriage to start wondering what they did wrong," he says. "So knowing there's actually a genetic cause can be reassuring." Alice Klein ■

Hot ice could have seeded life on Earth

JUST add salt to a new form of ice and we may have the recipe for the primordial soup. Such exotic "hot" ice could also have shaped the geology of our solar system.

Ice VII has completely different properties from regular ice. It only forms under intense pressure, and is dense enough to sink in water.

Outside of the lab it exists mostly in the deepest layers of Neptune and Uranus, and perhaps also on icy moons like Europa and Ganymede.

Arianna Gleason at Los Alamos National Laboratory and Stanford University and her team used a laser to compress water between two sheets of quartz. Next, they placed the water next to a diamond, then fired the laser at the diamond. This recreated the effect of a collision between a comet and a large body like a planet and formed the ice (*Physical Review Letters*, doi.org/b9q9).

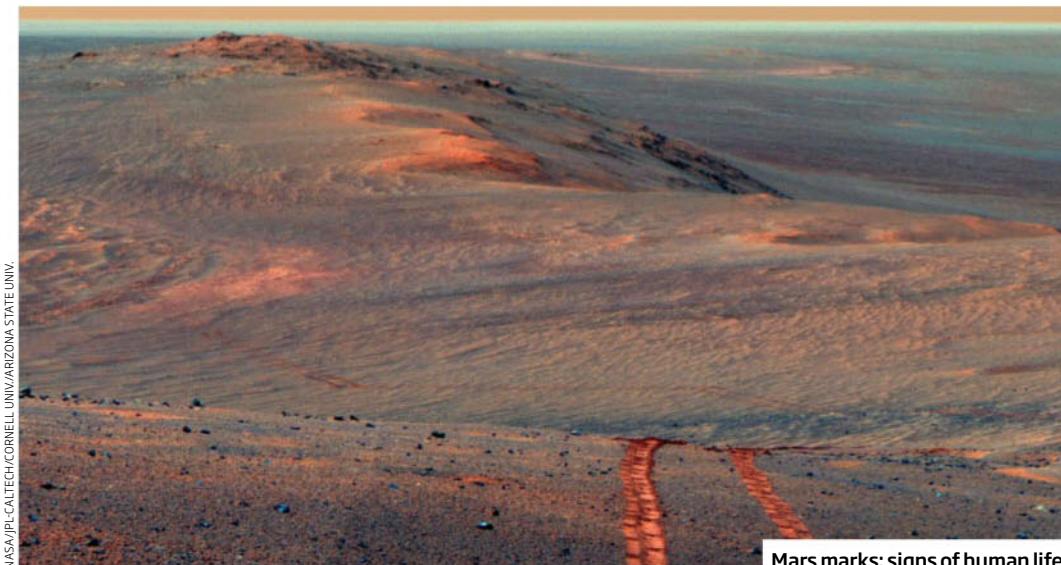
"That diamond immediately turns into a plasma and that goes off like a rocket," Gleason says. "It blows off this shock wave in the opposite direction."

Ice VII formed by this impact could have forever altered the chemistry and geology of moons and planets of the outer solar system, even though it only lasts for nanoseconds before reverting to less exotic ice or water.

This form of ice may have changed the strength and composition of surface materials as they separated and created strata within ice crater layers. Shock waves induced by ice VII may also explain why some impact craters have several ridges.

And that's not all. If you factor in salts, a comet slamming into an icy body could create something like the prebiotic soup that led to life on Earth – and that could exist on Europa, Titan or Enceladus.

Unlike the panspermia scenarios, where a comet carries biotic material to a lifeless planet, it could instead be the catalyst that creates ice VII, which then helps a world explode with life. John Wenz ■



Mars marks: signs of human life

Alien hunters should track ET like an animal

TO DETECT alien life, try to find footsteps. The first signs of life on another planet may not be a complex signal captured by an antenna or images of a scampering creature on the horizon, but a track left in long-dried mud.

On Earth, palaeontologists study traces left behind when an organism interacts with its environment. A team led by Andrea Baucon at the University of Modena, Italy, suggests that astrobiologists should follow suit and search not just for living and fossilised creatures, but also the traces they may have left behind.

"You have a heck of a lot more chance of finding the trace of an organism than you do the actual organism itself," says Lisa Buckley, a palaeontologist at Peace Region Palaeontology Research Centre in British Columbia, Canada. "One animal will leave countless traces in its lifetime, but it's only ever going to leave one body fossil."

Baucon says the odds of finding alien life would be increased by hunting for footprints, infilled burrows, excrement or other signs that something living disturbed

the sediments of Mars, Saturn's moon Titan or other solid surfaces in the solar system.

Evidence of soft-bodied life forms – which lack a skeleton that can mineralise into fossil – can also be preserved in these ways, expanding the types of creatures found in the geological record.

Furthermore, they could reveal the behaviour of extraterrestrial life. On Earth, fossilised footprints

"One animal will leave countless traces in its lifetime, but it can only leave one body fossil"

show the gait of long-extinct dinosaurs and burrows indicate the habits of clams. Traces on other planets could hint at how alien organisms interact with their environments.

Baucon and his team tested the concept by hunting for signs of life in high-resolution imagery of the solid bodies in our solar system (*Earth-Science Reviews*, doi.org/b9nw). They didn't find aliens, but they did discover traces of life: human boot prints on the moon and rover trails

meandering over Mars. However, trace fossils won't always be as easy to identify as footprints in lunar dust.

"Just because an organism leaves the trace, doesn't mean that all traces are beautifully preserved and easily recognisable," says Buckley. "Unless you actually find the animal dead in its tracks or you actually see the animal making the trace, you can never be 100 per cent sure that specific animal made that trace."

It can also be hard to tell if marks have been left by a life form or are merely the relic of a geological process. A simpler organism is more likely to leave a simpler trace that can be confused with something that is not biological, like a squiggle or a crack in the rock, says Buckley.

Geological processes like erosion can also alter the rock, obscuring or altering traces. Definitively identifying traces is tough enough on Earth without factoring in the many unknowns of an alien environment.

But these techniques could open up new ways to discover alien life – if we can spot traces when we find them, that is. Would we recognise a slithering snake's track if we'd never seen a creature without legs?

Mika McKinnon ■



JIM BRANDENBURG / MINDEN PICTURES

Ravens make plans for the future

Anil Ananthaswamy

RAVENS can plot for long-term gain at least as well as 4-year-old humans and some adult, non-human great apes.

The birds planned for future events in tasks they wouldn't encounter in the wild. This means this isn't an adaptation to an ecological niche, but rather a flexible cognitive ability that evolved independently in birds and hominids.

Planning requires the use of long-term memory for some anticipated gain down the line. For many years, it was thought to be a uniquely human trait that develops in young children. But it turned out that chimpanzees, bonobos and orangutans have this ability too, making tools to use later on.

In 2007, researchers at the University of Cambridge showed that scrub jays can cache food in places where they anticipate being hungry the next morning.

This behaviour is flexible and requires planning. But Mathias Osvath of Lund University, Sweden, says some argued that it might merely be an adaptation specific to caching food, which the crow family does habitually.

Osvath and his colleague Can Kabadai wanted to see if ravens could plan for the future in tasks that aren't natural to the birds, such as tool use and bartering with humans.

"Ravens can make an immediate decision for a future that will occur at another place"

In one experiment, the ravens were trained to use a stone to dislodge some dog food from a box. Later, the birds were shown a collection of objects, including the tool, without the box in sight. The researchers let the ravens select an object and 15 minutes later showed them the box with the reward in it. The birds had to drop

the stone into the box to collect the food. The ravens succeeded, on average, in 11 of the 14 trials.

The birds also took part in a bartering test. They were trained to exchange a token for a reward. Later, they had to select the correct token from a batch of objects, hold on to it for 15 minutes, and then swap it with an experimenter to get a reward. The birds picked the correct token 143 out of 144 times, and exchanged 77 per cent of the tokens.

Even when the 15-minute wait between tool or token selection was extended to a 17-hour one, the birds completed the challenges 90 per cent of the time.

Crucially, the ravens were planning from the first trial onwards, suggesting that their success wasn't due to habituation, says Osvath. "They can make a decision in the immediate situation for a future that will occur at another place," he says (*Science*, DOI: 10.1126/science.aam8138).

The study offers evidence that general intelligence has also developed in birds, says Markus Boeckle at the University of Cambridge. "This is very important for understanding how intelligence evolves." ■

Colon cancer gets help from cow bacteria

A TYPE of bacterium normally found in cows can accelerate the growth of colon tumours.

Cancer arises when DNA mutations prompt cells to start proliferating quickly. Sometimes there is a prime suspect - such as cigarette smoke in the case of lung cancer - but often there is no clear cause for these mutations.

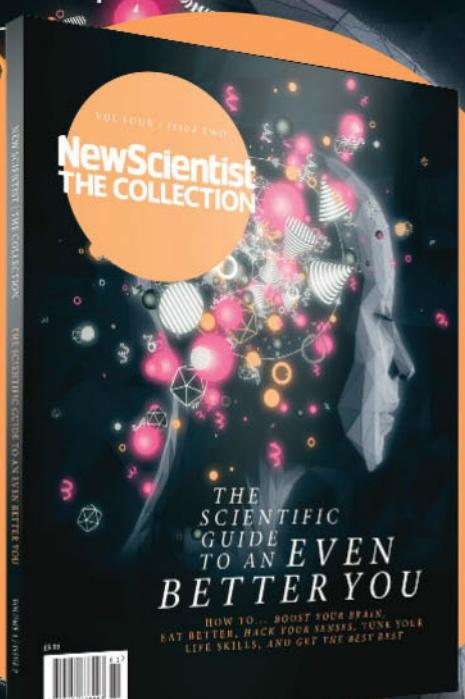
Colon cancer is the third most common cancer in the UK and has been linked with dietary risk factors, such as eating a lot of red meat. But could there also be a role for the bacterium *Streptococcus gallolyticus* (*SGG*), which is present in some colon tumour samples?

To find out, Yi Xu of Texas A&M Health Science Center and her team fed SGG bacteria to mice predisposed to develop colon tumours. Those who were fed SGG developed around twice the volume of tumours as those given a different microbe for comparison. Human colon cancer cells in a dish also multiplied faster in the presence of SGG (*PLoS Pathogens*, doi.org/b9ns). "Somehow it can stimulate pathways that are important in proliferation," says Xu.

When the team tested tumour samples from people with colon cancer, they found 74 per cent had SGG bacteria in them. This suggests the bacteria could play a role in that percentage of colon cancers, says Xu.

We still don't know if SGG is the primary cause of colon cancer. Instead, the bacteria may accelerate the growth of existing small tumours, says Xu. If SGG's role in cancer is confirmed, colon cancers may one day be treated with antibiotics or even prevented with a vaccine, she says.

Around 2 to 8 per cent of healthy people may have SGG in their colon tissue, but how they catch it is unclear. The bacteria also infect cows and a different study found that people in a farming area of Spain are six times more likely to have SGG than those in the city of Barcelona. Clare Wilson ■



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Swiss banks now invest in bitcoin

Timothy Revell

WHAT do you get the person who has everything? As of 12 July, investors at Falcon Private Bank – a boutique investment firm headquartered in Zurich – were able to ask their asset manager to purchase and store bitcoin on their behalf. Despite the cryptocurrency's infamous volatility, this is another indication that bitcoin is here to stay.

"We have various clients that are interested in buying bitcoin for investment purposes," says Arthur Vayloyan, the global head of products and services at Falcon. And now, these customers won't require any specialist knowledge to switch their cash into bitcoin. The Swiss financial authority, FINMA, granted Falcon regulatory approval on 11 July.

Only a few years ago, many conventional banks still thought that bitcoin was doomed to fail. But the price has soared and it has continued to survive, making it too attractive for investors to resist. In 2012, you could buy a bitcoin for less than \$10, last month they were selling for a record high of \$3000. Illustrating

the currency's volatility, it is currently trading at just under \$2500, but overall has tripled in value in the last year alone. Users of Falcon's bitcoin service will have to sign a waiver to show they understand the risks.

But some worry that the risks go beyond standard investing exposure. Traditional banks in possession of large sums of bitcoin will be obvious targets for hackers. "It's a lot easier to steal digital currency than a traditional currency," say Andreas Antonopoulos, host of the Let's Talk Bitcoin podcast.

"This is why decentralisation is so important," he says – a principle bitcoin is ostensibly

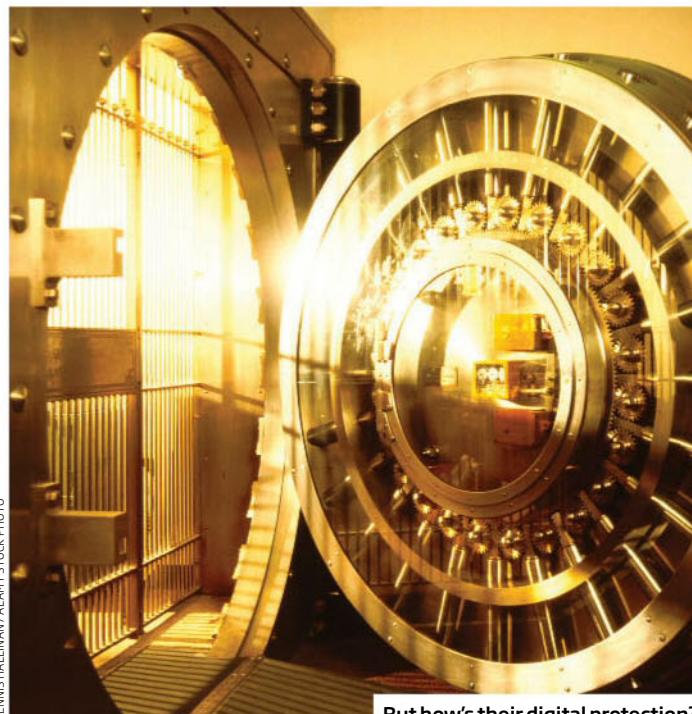
built on. Instead of relying on central banks and governments, bitcoin relies on a network of computers that anyone can join to check the legitimacy of transactions.

Whenever currency changes hands, everyone on the network updates their copy of a shared ledger known as the blockchain. Underpinning the whole system is complex mathematics that makes it very difficult to deceive or control without infeasible amounts of computing power.

Instead of bank accounts, anyone can create and store their own bitcoin "wallet" – these too are decentralised. That means there is no central target enticing hackers with large amounts of digital currency.

But if you put lots of wallets in the same place, the system may no longer hold. "By putting in more eggs, you make the basket weaker," says Antonopoulos. You will need far more security to protect the wallets.

Indeed, this problem has plagued exchanges, where people trade different digital and traditional currencies. The biggest of these until 2014 was Mt. Gox, which at the time was handling more than half of all bitcoin transactions. In February of that year, 850,000 bitcoins corresponding to \$450 million at the time disappeared, thought to have been stolen by hackers. ■



DENNIS HALINAN / ALAMY STOCK PHOTO

But how's their digital protection?

Rats know when they forget stuff

MUCH like students doing a test, rats tend to skip questions when they have forgotten the answer. The finding suggests rats share an ability of humans and some primates – they may have metamemory, an awareness of what they can remember.

Victoria Templer at Providence College, Rhode Island, and her team trained rats to sniff samples of

cinnamon, thyme, paprika or coffee, and then go to a dish smelling of the matching scent. If the rats picked the correct dish, they got a piece of cereal.

But there was a twist. Although rats that chose a dish with the wrong scent got no reward, rats that chose a fifth, unscented dish received a quarter-piece of the cereal. This meant that when rats forgot what they had smelled, their best bet was to pick the unscented dish – provided they could tell that they had forgotten the relevant smell.

Nine rats were tested across a range of experiments. In some of

these the unscented dish was not there, forcing rats to choose a scent even if they couldn't remember it.

Without the unscented option, the rats picked the wrong dish 48 per cent of the time. But when it was available, they chose the unscented option 20 per cent of the time, and in those cases where they did choose a scented dish, the rate of picking the wrong one fell to 39 per cent – a drop

'Rats did better when there was an opt-out choice, suggesting they chose it if they forgot the answer'

that wouldn't be expected by chance (*Animal Cognition*, doi.org/b9nt).

Because the rats' performance improved when the unscented dish was available as an opt-out, Templer says this shows the rats weren't simply choosing it for no reason.

In further experiments, the rats chose the unscented dish less often when they were allowed to sniff the sample twice before choosing a match. But making the rats wait longer between sniffing the sample and choosing a match pushed up the number of times they opted out.

Diana Crow ■

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Ghost ponds hide 150-year-old plants

Karl Gruber

WE'RE raising the dead. Well, almost. Plants discovered in "ghost ponds" are being revived after lurking underground as dormant seeds for up to 150 years.

These so-called ghost ponds are formed when agricultural land expansion means that existing ponds are filled in, and buried alive, says Emily Alderton, at University College London (UCL), who led the study.

To expand a field, farmers commonly remove hedgerows then use the uprooted plants and soil to fill up any ponds. This happened at the site Alderton's team studied in Norfolk, UK.

"Small ponds were not drained,

but were filled in while they were still wet. We think this is likely to have contributed to the survival of the seeds buried within the pond sediments," she says.

These buried ponds can often be seen as a ghostly mark on the landscape – a damp depression, change in soil colour, or patch of poor crop cover, where the ground never quite dries out, says Alderton.

"We also suspected that 'ghost' was the right word as it hints at some form of life still hanging on, and this is exactly what we have," says co-author Carl Sayer, director of the UCL Pond Restoration Research Group. "The species that lived in the past pond are still alive,

dormant and waiting."

The team estimates that there are around 8000 ghost ponds in Norfolk alone, and as many as 600,000 more buried across England's agricultural landscape.

To locate these buried treasures, researchers often use Ordnance Survey maps and other historical records, which reveal the location of former ponds that have since been converted into agricultural land.

Once researchers locate a ghost pond, and obtain permission from the farmers, they can use an excavator to dig out the metre or two of soil that usually covers it.

"Life hangs on - the species that lived in the past pond are still alive, dormant and waiting"

So far, the team has dug out three ghost ponds and "resurrected" a total of eight aquatic plant species (*Biological Conservation*, doi.org/b9pt).

These particular plants are commonly found in the landscape, but Alderton thinks that further ghost pond hunting in other areas could reveal surprises.

"Given the range of different seed types that we found capable of germination after 150-plus years, it could be reasonable to expect that ghost ponds could provide suitable reservoirs of rare or even extinct species," says Alderton.

What's more, ghost ponds could reveal dormant animal species. The team found resting eggs from two crustacean species, although they have not yet assessed their viability.

"For plants to grow back after being buried for over 150 years is remarkable," says Christopher Hassall at the University of Leeds, UK.

Sayer is excited about the prospect of resurrecting species that are locally or nationally extinct. "It is a very positive conservation message – a rare positive," he says. ■



Here lies a pond, buried alive

CARL SAYER

AI coach helps chatbots seem more human

LITTLE clues make it obvious that Siri or Alexa are driven by artificial intelligences, but you might struggle to nail what gave the game away.

A new AI can suss out the specifics. Given a snippet of dialogue between a chatbot and a human, the system – developed at McGill University in Montreal, Canada – predicts how convincingly human you or I would rate the chatbot's response. In other words, it automates the Turing test. This could help build better virtual assistants.

Today's chatbots are great for specific tasks – Amazon's voice-operated assistant Alexa can order you a pizza, for example, or check the weather – but try asking if it's enjoying the weather.

To make their chatbots more convincing, companies like Amazon use large teams of human testers as evaluators. But for firms with fewer resources that's prohibitively expensive and time-consuming.

Would it be possible to cut humans out of this process altogether? To find out, Lowe designed an AI that automatically rates how human-like a piece of chatbot-generated dialogue sounds.

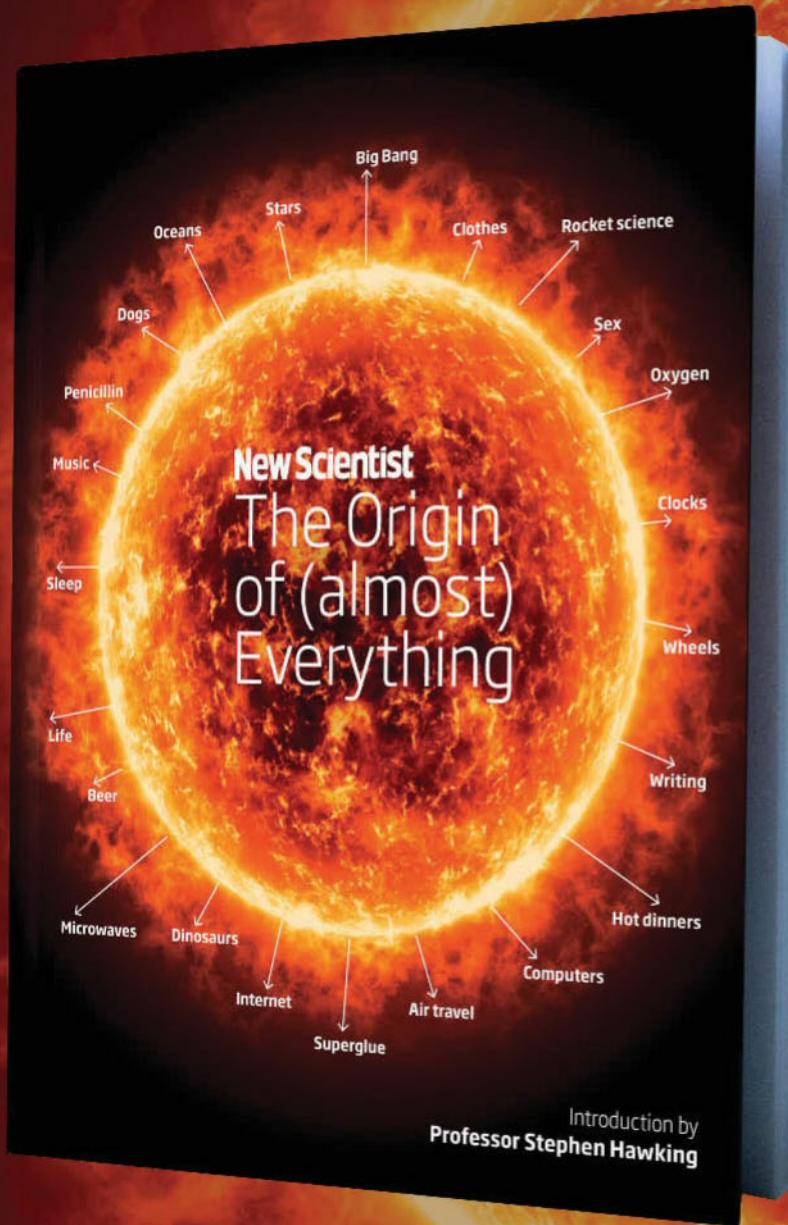
He asked a group of volunteers to rate hundreds of Twitter conversations – some generated by bots, others by people – according to their human qualities. Lowe then trained his neural network on these ratings.

After training, Lowe's algorithm was able to match the judgement of the human evaluators. Crucially, it decided bot or not in a fraction of a second, a vast improvement on the time it now takes to reach consensus.

"This will mean you can create better chatbots," says Oliver Lemon at Heriot-Watt University in Edinburgh, UK.

Lowe plans to open-source his evaluator, so many more researchers can create convincingly human chatbots. Matt Reynolds ■

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Polar bear attacks on humans rising as climate changes

CLIMATE change may be driving more aggressive polar bears to areas where people live, and the consequences could be lethal. With ice freezing later and thawing earlier, polar bears can't stock up on seal meat for as long, leading hungry animals to search for food in populated areas. "You've got bears that are spending increasing amounts of time on land becoming nutritionally stressed, moving into areas of human settlements," says Todd Atwood, a wildlife biologist at the US Geological Survey.

Atwood's team combed through 150 years of records of bear attacks in Canada, Greenland, Russia, the US and

Norway. They drew data from government agencies, news reports and, in the older cases, from ships' logs.

They found 73 cases of polar bears attacking groups or individuals, with 63 people injured and 20 killed. The bears were acting in a predatory manner in most cases, and hungry male bears were more often involved (*Wildlife Society Bulletin*, doi.org/b9m5). Over the 150 years, polar bear attacks averaged eight or nine per decade, Atwood says, but from 2010 to 2014 alone there were 15. "That does lead you to hypothesise that around 2000 we might have hit a shift in the kind of conditions in the Arctic."

Another study found 63 deaths from black bear attacks between 1900 and 2009 in North America alone. "Polar bear attacks are still relatively rare when you compare them to brown bear and black bear attacks," says Atwood.

Bad period pains linked to infertility

EXCRUCIATING period pain can be a sign of endometriosis. Now it seems the degree of pain may also be linked with fertility problems.

Around 10 per cent of women have endometriosis, a poorly understood condition in which uterus cells turn up elsewhere in the body and bleed each month.

Some women with the condition experience a little pain, but for others it can be much

worse. No one knows why the symptoms vary so much, says Mathilde Bourdon at Descartes University, Paris.

To find out more, Bourdon's team found 422 women with endometriosis who had been unable to conceive naturally after a year. When asked to score their pain on a scale of 1 to 10, 289 of them rated it as a 7 or higher. By looking at surgical reports,

the team found that those who reported worse pain had more extensive disease, with patches of endometriosis deeper in the body.

Women who reported being in more pain also took significantly longer to get pregnant, and needed more surgery and more fertility treatment to do so. Bourdon presented the findings at the annual meeting of the European Society of Human Reproduction and Embryology in Geneva, Switzerland, earlier this month.

Giant galaxy supercluster found

THINK big. No, much bigger. At over 650 million light years across, the Saraswati supercluster of galaxies is one of the largest structures in the universe.

It is about 4 billion light years away – much more distant than other superclusters we've seen. It is made up of at least 43 galaxy groups and clusters that contain about 400 galaxies in total, giving it a combined mass 20 million billion times that of our sun.

Joydeep Bagchi at Savitribai Phule Pune University in India and his colleagues discovered it using data from the Sloan Digital Sky Survey, a map of galaxies (arxiv.org/abs/1707.03082v1).

As it was formed relatively early, it could help us probe the tiny fluctuations that later expanded to form the largest structures. "It's like a geographer discovering a new, great mountain range," says J. Richard Gott at Princeton University.

Ancient asteroids were big mudballs

BEFORE asteroids, the solar system was awash with giant mudballs.

Not much is known about the history of the most common asteroids, carbonaceous asteroids, which may have delivered water and organic molecules to Earth. Philip Bland at Curtin University in Australia and Bryan Travis at the Planetary Science Institute in Arizona modelled the formation of these rocks and found when ice, dust and mineral grains came together, they wouldn't have been compacted straight away (*Science Advances*, doi.org/b9p6).

Radioactive atoms would have melted the ice, making a sludgy mud that became rock, perhaps aided by gravitational pressure once the asteroid got big enough, or impacts with other objects.

Lioness adopts a leopard cub

A LIONESS has been spotted nursing a leopard cub. The never-before-seen behaviour between two natural enemies was photographed in the Ngorongoro conservation area in Tanzania on 12 July.

Estimated to be only 3 weeks old, the leopard cub suckled on a 5-year-old lioness that is collared and monitored by KopeLion, a conservation NGO in Tanzania supported by Panthera, the global wild cat conservation organisation.

Normally, the two felines kill cubs of the other species to eliminate future competition for food and raise the chances that their own progeny will survive to adulthood.

Pumas sometimes adopt members of their own species, but cross-species adoption among big cats remains rare. "This is a truly unique case," says Luke Hunter, Panthera's president and chief conservation officer.

The fact that this lioness recently gave birth is a critical factor, Hunter says. The lioness, named Nosikitok by KopeLion's Maasai lion scouts, is thought to have given birth to her second litter of cubs in mid to late June, although they are no longer with her. The leopard cub is almost exactly the age of her own cubs.

Hunter doesn't think the odds are in the leopard cub's favour, however. "It is very unlikely that the lioness' pride will accept it," he says.



Hairs across the body tell each other when to grow

HAIRS all over the body use the same two chemical signalling pathways to communicate with each other – a finding that might help treat baldness.

Hair doesn't constantly grow. Each hair follicle goes through a cycle of growing, dying and resting. There are two chemical pathways called Wnt and BMP that are known to help regulate this for the hairs on the backs of mice.

Now Maksim Plikus at the University of California, Irvine, and his team have used mathematical modelling to see

if Wnt-BMP signalling might play a role across the whole body.

They found that waves of Wnt and BMP signalling accurately explain the growth cycles of all mouse hairs. Waves of Wnt signalling spreading from hair to hair activate follicle growth, followed by waves of BMP signalling that shut down the stem cells in these follicles, halting growth.

The team based their model on observations of signalling in smaller areas, and extended it to cover the whole body. The model

predicted certain patterns of growth that the team were then able to identify in real mice (*eLife*, doi.org/b9m3). This is the first time a model of many hair follicles has accurately predicted growth across an entire mouse.

Plikus hopes models like this will inform efforts to regulate the Wnt-BMP system with drugs – an approach that may spread waves of growth back into balding areas. "We now have a road map to optimise the levels of activators and inhibitors to achieve desired hair growth," says Plikus.

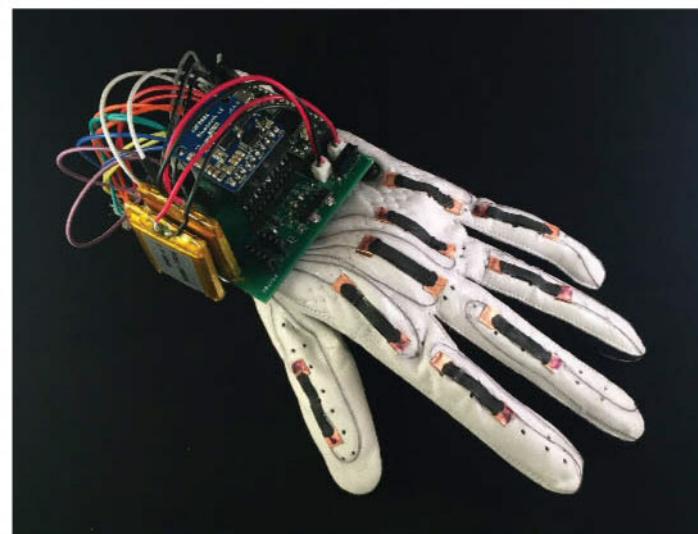
Breast implants slow down bullets

CAN breast implants really protect against gunshots? It has previously been claimed that implants have saved women from gunshots, stabbings and even kangaroo attacks.

To test if there's any scientific credibility to this, Christopher Pannucci, a plastic surgeon at the University of Utah, and his team analysed bullets shot through saline breast implants into ballistics gel – a substance designed to mimic human tissue.

Using a handgun, they fired shots at 300 metres per second into blocks of gel 2.5 metres away. When these blocks were placed underneath large saline breast implants, the distance the bullets travelled into the gel was reduced by an average of 8 centimetres, or 20 per cent (*Journal of Forensic Sciences*, doi.org/b9m2).

An analysis of the gel showed that the implants seemed to flatten the bullets and make them wider, increasing their drag force and slowing them down. This decelerating effect could mean the difference between life and death in some cases, says Pannucci. "But it would depend on the bullet velocity and the size and type of the implant," he says.



DARREN LIPOVIC/UC SAN DIEGO'S DEPARTMENT OF NANOCHEMISTRY

Glove lets phones read sign language

HANDWRITING will never be the same, thanks to a glove. Developed at the University of California, San Diego, it allows the alphabet as signed in American Sign Language to be turned into text on a smartphone.

"For thousands of people in the UK, sign language is their first language," says Jesal Vishnuram at the UK charity Action on Hearing Loss. "Many have little or no written English. Technology like this will completely change their lives."

Unlike existing systems, which are bulky and inconvenient, the new device simply consists of a standard

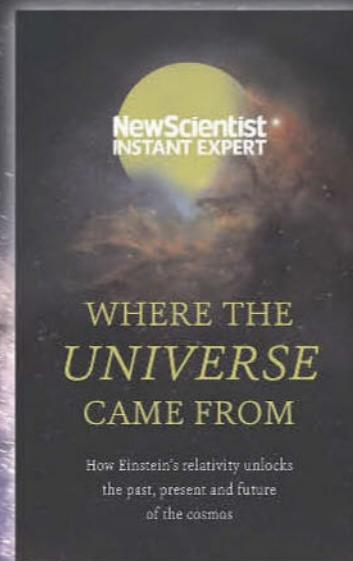
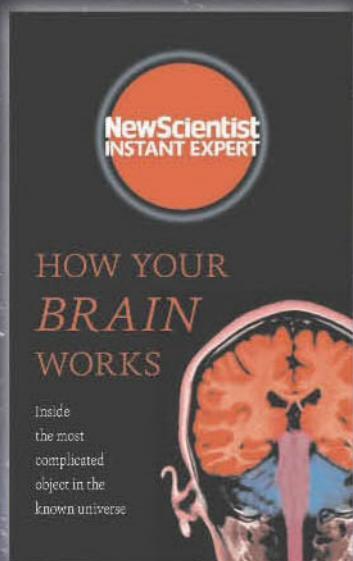
sports glove, with lightweight strain and motion sensors that allow software to work out what letter the wearer is signing (*PLoS One*, doi.org/b9pw).

Since the glove can interpret the alphabet only, it requires users to spell out words letter by letter. To become truly convenient, it will need to be able to translate whole words and phrases too.

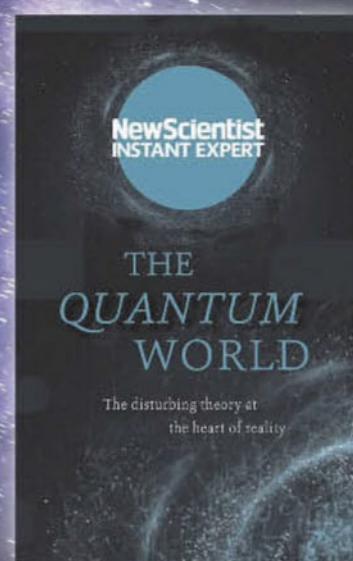
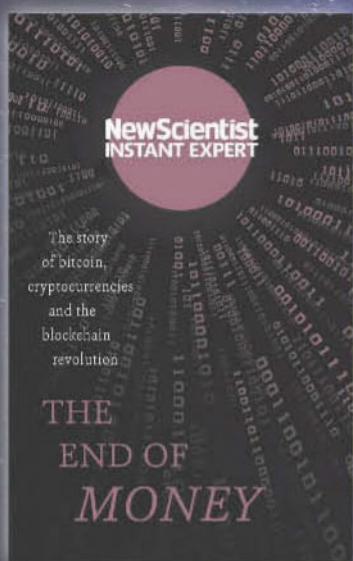
The developers also want to use the technology with robotic hands, allowing fine movements to be mirrored remotely – useful for surgery or for bomb-defusing robots.

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MARCH 2017



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Towards the sound of silence

Unwanted noise is a scourge of modern life. But an extraordinary material from BASF's research labs is restoring a bit of peace

The impact of noise can be profound. Many office workers believe poor acoustics undermine their ability to do their jobs. And in 2005, researchers found that long-term exposure to noise at home or at work significantly increases heart attack risk.

This problem is set to get worse as the number of people living in cities increases. Today, around half the global population lives in cities and the UN believes that will reach two-thirds by 2050. The types of noise society is generating is changing too. It's easy to imagine that processes such as urbanisation will increase our exposure to unwanted sound. But researchers at the German chemicals giant BASF beg to differ. The ability to absorb sound is an engineering challenge that the company has long held dear. And it has developed a range of sound absorbing materials that can do the job.

Innovative software brings the acoustic effects of Basotect® to life

BASF has a long history of innovation. The company was set up more than 150 years ago in Mannheim, Germany, to produce chemicals for the dye industry. Today it has annual global sales of €58 billion and employs more than 110,000 people.

Its expertise in sound insulation began with a serendipitous discovery. During the 1979 oil crisis, a team at BASF's R&D centre in Ludwigshafen began looking for thermal insulators that would cut energy use. In the process, they discovered a material which turned out to have sound absorbing properties too.

This material is made from the chemicals melamine and formaldehyde which usually react to form a hard plastic. But BASF's chemists added a "blowing agent" that turns to gas and creates bubbles inside the polymer.

This process usually forms closed spheres of gas within the resulting foam. In this case, BASF's chemists allowed the bubbles to grow until neighbouring

bubbles began to combine. The result was an open cell structure with cavities measuring between 50 and 150 micrometres in diameter, bound by slender polymer strands. The company called this material Basotect® and it has some interesting properties.

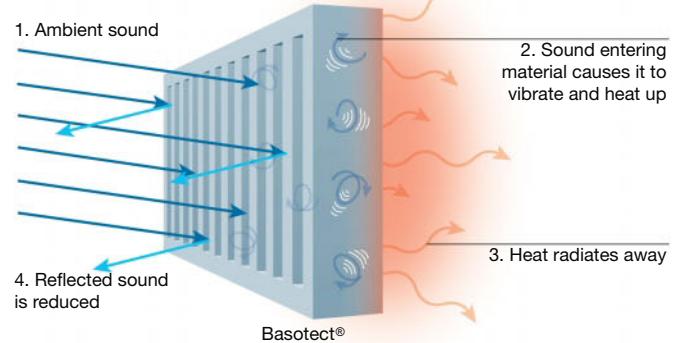
As well as being a thermal insulator, it has the remarkable ability to turn sound into heat. The mechanism is simple. Sound waves are better able to enter its open cell structure than a closed cell. Inside the material, the waves set the polymer strands vibrating, heating them up. This heat then radiates away (see diagram).

By contrast, the poor acoustics in offices, sports venues and bars usually results from sound waves reflecting off hard materials such as glass, concrete or metal. Even foams with a closed cell structure reflect a fair bit of sound.

Basotect® is most effective at damping sound waves in the 500Hz to 4,000Hz frequency range — with a wavelength of approximately 70 cm to 10 cm. This



Absorbing sound





corresponds closely to the frequencies of human speech and to the frequencies our hearing is most sensitive to.

The applications are many. Designers and architects have used Basotect® to improve acoustics in sports centres, theatres, restaurants, music studios, hotels and offices. Basotect® helped improve the sound quality in Beijing's swimming stadium built for the 2008 Olympics. The Solomon R. Guggenheim Museum in New York utilized it to create an immersive installation called PSAD *Synthetic Desert III* by artist Doug Wheeler where visitors can escape the sounds of the city – it runs until 2 August.

The material is easy to retrofit.

"Acoustics is often forgotten when rooms and other spaces are being designed," says Peter Wolf, global marketing director

for Basotect® at BASF. "Correcting such problems is where our strength lies." BASF says customers report sound reductions of up to 45 decibels relative to background noise of 50 to 60 decibels.

The material is also light, easily moulded and highly flame and heat resistant. It maintains its structure at temperatures up to 240°C. As a result, it is also widely used in the transport sector where resistance to engine heat is important.

Car designers use it to absorb engine sounds and transmission noise. Passengers on a wide range of buses, trains, aeroplanes and even yachts have Basotect® to thank for the relative peace and quiet of their journeys.

And BASF researchers hope to make the material even better. Their current challenge is to make it not just flame-

Virtually quiet

EVEN the best architectural drawings reveal little about the acoustics of a building or room. This can be a big problem if the premises are intended to house a lot of people who want to talk with each other.

That's why BASF has developed a virtual reality audio simulation tool called Envision Mobile that allows users to hear the difference that Basotect® can make in different scenarios.

Designers and building managers using the tool wear a virtual reality headset to explore an open plan office, a restaurant, a children's nursery and a swimming pool with a joystick.

Through headphones they can hear people talking, footsteps, background music and children playing in these virtual environments with and without melamine foam sound absorbers.

The system was developed by Inreal Technologies, a company in Karlsruhe, Germany, that provides similar systems to large property developers. "It allows you to hear the acoustics of a room even years before you build it, allowing for better planning and decision-making," says Enrico Kürtös, CEO of Inreal.

BASF hopes to eventually provide tailored simulations of the acoustic benefits of Basotect® based on designs provided by individual customers.

retardant but non-flammable. Success could allow the foam to be used in components that must comply with more stringent standards such as those for underground trains and high rise buildings.

There are other challenges too in the changing soundscape of city life. For example, engine noise is almost entirely absent in electric cars.

This looks set to reveal new opportunities for Basotect®. "The noise from internal combustion engines currently covers up a variety of smaller sounds generated by other moving parts," says Wolf. "Our understanding of the acoustics of electric cars is still developing, however it may be that drivers will be more sensitive to these other sounds, which could create a demand for new Basotect® components."

More at: www.basotect.com



In decline

Stubbed out

The long decline of smoking in the West means some are eyeing its eradication. Is it possible, asks **Clare Wilson**

MOST of us in the West are an unhealthy lot: we eat junk food, drink too much alcohol, exercise too little and generally ignore medical advice designed to help us live longer.

But there is one thing we are listening to our doctors about. Smoking rates have been slowly falling, year on year, in most Western countries for decades. This month saw the 10-year anniversary of England's ban on smoking in enclosed workplaces – including bars and restaurants – a change that once would have seemed inconceivable. The UK

government is due to announce new tobacco control strategies for the next few years.

The decline of smoking is emboldening some public health officials to plan for what is sometimes called the tobacco endgame – stubbing out smoking completely. But several strategies to reach this goal have potential pitfalls, and some could even be counterproductive. So is a smoke-free future ever going to happen, and what could we do to bring it about?

Smoking was a minority pursuit until the late 19th century

and the arrival of one of the deadliest inventions in history: industrially produced cigarettes. Their popularity soared during the first world war, as soldiers were given cigarettes with their rations. Celebrities, athletes and even doctors endorsed the habit. At its peak in the mid-20th century, around half of all adults in the UK and the US smoked.

But the evidence was building

"In the UK, adult smoking rates are now down to about 16 per cent, in the US, 15 per cent"

that smoking causes lung cancer, as well as heart attacks, strokes and other diseases. The risks were denied by tobacco companies for decades, but the tide of public opinion was turning. As governments brought in an increasing array of tobacco control measures, from health warnings on cigarette packs to advertising bans and restrictions on where people can light up, smoking rates have slowly declined.

A long-standing fear, however, has been that the fall would stop because of a hard core of smokers impervious to all health advice. "People always used to say you can never get below 25 per cent," says Martin Dockrell of Public Health England.

But this hasn't happened. In the UK, adult smoking rates are now down to about 16 per cent, in the

US, 15 per cent. So how long could this trend continue?

Some think there is practically no limit, including Stanton Glantz at the University of California, San Francisco, a long-time tobacco control crusader. He says that while smoking will never be completely wiped out, the habit could be eliminated "as a public health problem of substantial consequence" – in other words, smoking rates could be reduced to just a few per cent.

Some countries already have this goal in sight. New Zealand, which has long had some of the world's strictest tobacco control laws, aims to get adult smoking down to below 5 per cent by 2025. Finland is aiming for this by 2030, including the use of chewing tobacco and e-cigarettes.

A plan to ban

But is this goal enough?

Despite all the health warnings, some argue that people assume cigarettes can't be that bad if you can still buy them everywhere. Perhaps a full ban is the only way to get the message across.

To date, only one country has dared go this far. In 2004, the Himalayan nation of Bhutan outlawed the sale of all cigarettes and chewing tobacco. People can buy them legally abroad, but there is a limit on what they can bring into the country.

Western nations probably shouldn't look to Bhutan's ban as a guide, though, as even before it came in, the country's smoking rate was estimated at just a few per cent. It is also very different culturally. The main religion is Tibetan Buddhism, which encourages people to keep a clear mind so they can meditate, says Michael Givel at the University of Oklahoma. "Tobacco hasn't been as big a cultural thing as elsewhere."

Aside from the question of whether it is ethical to stop people doing something they enjoy, this kind of ban may also backfire. History tells us that prohibition

fuels criminal suppliers. This happened in the 1920s when alcohol sales were banned in the US, and still goes on today with illegal recreational drugs such as heroin.

"There are all sorts of scary unintended consequences that could come along with prohibition," says Dockrell. Use could even increase, he says, as illicit cigarettes would be much cheaper and lack health warnings.

"You're much more effective at regulating products if they're legal," says Deborah Arnott of UK anti-smoking group Action on Smoking and Health.

It's hard to know the effect of the ban in Bhutan as there is no reliable data, but seizures of smuggled tobacco in the country rose more than three-fold between 2005 and 2008. "If anyone claims they can get rid of smoking based on the Bhutan model, the evidence is fairly to the contrary," says Givel.

There are other strategies on the table. One sometimes floated is the introduction of a minimum age for buying cigarettes that rises each year. Existing smokers could carry on, but youngsters wouldn't legally be able to start.

Such a law has been debated in the Tasmanian parliament in Australia, although it has never been introduced anywhere, partly

because it raises the same problem of fostering a black market for those under the age limit.

Others have suggested forcing the tobacco industry to alter the make-up of cigarettes, such as making them slightly more alkaline to deter deep inhalation. This would make them more like the harsh old-style "gaspers", as

In 2004, the nation of Bhutan outlawed the sale of all cigarettes and chewing tobacco

cigarettes used to be known in the UK. But again, milder, black-market cigarettes would win out.

The best approach, says Glantz, is to continue raising taxes, and further restrict advertising and where people can smoke in public. The next target should be cutting out smoking in movies and other media, he says, perhaps by giving any films that contain smoking a high age rating. Studies show that the more that teenagers see smoking on screen, the more likely they are to take it up. "It's a bigger effect than conventional advertising," says Glantz.

And what about those who really don't want to give up smoking? They may be able to wean themselves off using e-cigarettes. Since they were first mooted, these devices,

which vaporise nicotine without producing smoke, have divided public health experts. In most of the West, particularly the US and Australia, the mainstream view is that they are almost as dangerous as ordinary cigarettes.

In the UK, on the other hand, vaping is increasingly seen as a useful aid to help people quit smoking, like nicotine gum. Public Health England says e-cigarettes are 95 per cent safer than smoking, and that we should consider letting people vape in places where smoking is banned – sometimes even indoors.

"There's no evidence of harm to bystanders, and by prohibiting vaping you might undermine people's attempts to give up smoking," says Dockrell. He would even like to see doctors be able to prescribe e-cigarettes on the NHS.

Another argument against e-cigarettes is that they might tempt more people to take up smoking. Research suggests that teenagers who vape are more likely to go on to smoke – but that doesn't prove one causes the other. It could just be that the type of teen who chooses to try under-age vaping is more likely to carry out other "bad" behaviours.

The latest UK figures also seem to contradict the idea that e-cigarettes are a gateway to smoking. Vaping took off around 2010, and since that time the rate of decline in smoking has, if anything, slightly steepened. On the other hand, smoking rates are falling in the US and Australia, where vaping is more frowned on. Perhaps in a few years' time, we will know which approach is right.

Glantz predicts that as smoking continues to fall, it will become less socially acceptable to light up when among non-smokers or even just out in public. Studies suggest that smoking bans in indoor workplaces help people to keep their own houses smoke-free, even if they smoke themselves. "The current policies are working," he says. "We just need to do them more." ■



Can vaping help people quit?

How to spend it

Some doubt the idea that buying experiences makes you happier than buying things. Is materialism back, asks **James Wallman**

AH, THE joys of (social) science. You've been saying something for years, as publicly as possible, and then new research comes along that suggests you might have been wrong all along.

A few years back, I bet the proverbial farm on writing a book about what I believe is one of the most important social trends of our era: the move from materialism to experientialism. Instead of looking for pleasure, identity and status in material things, we're increasingly seeking them in experiences instead.

One core reason is that if you spend your cash on experiences you're more likely to be happy. This advantage was shown in 2003 by psychologists Leaf Van Boven and Thomas Gilovich. At least seven studies since have backed that up, via both small-scale experiments and nationally representative surveys. Eight



Fry harder

Backstreet fast food slipped through the net in the war on killer fats, says **Anthony Warner**

DEMONISING food choices is not usually my thing, but I'll make an exception for the horror show that is partially hydrogenated vegetable oils (HVOs). These are high in trans fats, which are very damaging to heart health.

The US, ruling them unsafe in any amount, will ban them next year. Their downsides have been

well known since the 1990s, and efforts to get them out of food have by and large worked. In the UK, average trans fat intake is below the 5 gram daily limit the NHS advises. This is due to voluntary removal by food firms, so a ban was deemed unnecessary.

Despite the success, average intake can be misleading. You may

struggle to find HVOs on shop shelves, but cheap independent takeaways are a different story.

Lack of control over the sale and use of HVOs means many small fried chicken shops still cook with them, and high levels of trans fats are served up every day, often in socially deprived areas.

To see the probable impact, look to New York. It banned these fats in eateries in 2007. The result? 6.2 per cent fewer heart attacks and strokes. Yet in London, studies

"New York banned trans fats in restaurants and takeaways. The result was fewer heart attacks"

show that some chip portions can have around 15 grams of trans fats.

Cooking with HVOs is pointless. Improving the nutritional quality of fried chicken and chips can be done with no impact on quality, cost or taste. Continued use is largely due to the inertia of some shop owners and misguided beliefs about taste and shelf life.

It doesn't help that these oils are still marketed, often directly at chicken shops, or that there is no requirement to declare that foods have been fried in HVOs.

If we are to resist a ban, then oil makers must step up, educating shop owners, ditching the most harmful oils and offering practical

anxiety and depression, it strikes me as essential to know how to spend in order to be happier.

What people need is simple guidance rather than nuances. So, stuff or experiences? Despite the recent doubts, the overwhelming evidence is that materialism is bad for you and bad for the planet, and that experientialism is better for happiness. The Hungarian study? Correlation, not causation. To truly find out if Hungarians are happier spending on experiences, we would have to randomly assign some to spend more on experiences and others more on material goods – like the design of the bulk of experiments that found experiences triumphed.

Those other recent studies? There's no doubt some material things are good, and some are better than some experiences. I'd rather have a TV than spend five years in jail, or a new sofa than see some of the experimental theatre my wife takes me to.

But I'm not persuaded materialism deserves a come back. When the facts change, my opinion changes. Yet when the core facts remain, I'll keep saying it: to be happy, spend less on stuff and more on experiences. ■

James Wallman is the author of *Stuffocation* (Penguin)

alternatives. With public health bodies so obsessed with dietary choices, it is curious there is not more pressure for this to happen.

I hope this is not a result of prejudice about the choices of the young people who mainly use these takeaways. Because from the outside it can seem as if those who fail to live up to puritanical, pleasure-free choices of health diktats are not worthy of the simplest protection from harm.

This is one health inequality that could be easily avoided. ■

Anthony Warner is a food industry development chef. His first book, *The Angry Chef* (OneWorld), is out now

INSIGHT Net neutrality



At risk of being throttled

Web firms are right to demand net freedoms

Matt Reynolds

PEOPLE visiting some of the world's most popular websites, including Amazon, Netflix and Twitter, on 12 July saw pop-up messages saying that the site had been blocked or slowed down.

The pop-ups were fictional, all part of an online protest supporting the principle of net neutrality. Its backers believe that internet service providers should not be allowed to prioritise some types of web traffic over others. ISPs should not be able to accept payment from Amazon, for example, to make sure that its website loads faster than competing sites.

The protest arose because the US Federal Communications Commission – the government agency that regulates the country's ISPs – wants to overturn rules, dating from Barack Obama's presidency, that uphold net neutrality. In May, the FCC voted to repeal an earlier ruling that defined broadband as a public utility, meaning that ISPs are obliged to make their services available to the public at a reasonable price.

The move was widely interpreted as a direct attack on net neutrality.

The internet, normally a place of endless squabbling, has been near-unanimous in its response. At the time of writing, over six million people had submitted comments on the FCC's "Restoring Internet Freedom" proposal, which would prohibit the agency from introducing net neutrality rules similar to the Obama-era ones.

As part of the so-called Battle for the Net, Google, Airbnb and Spotify joined dozens of smaller websites in a day of protest timed to encourage millions more to express their views to the FCC before the 17 July deadline for comments. The protest follows similar,

"ISPs should not be able to accept payment from a company to make sure that its website loads faster"

successful campaigns in 2012 against the proposed Stop Online Piracy and Protect IP Acts.

Protesters are right to be worried. Deregulation of ISPs would be bad for online competition and for the internet.

Left to their own devices, ISPs have a history of violating net neutrality.

For example, between 2011 and 2013, Verizon, AT&T and T-Mobile blocked the rollout of payment service Google Wallet across their networks, because they were backing a competing service called Isis.

Loosen the leash and you can be sure that telecoms companies will happily violate net neutrality again – one firm has admitted to exactly that. In a 2014 court case, Verizon's attorney said the company would already be exploring the possibility of offering preferential internet speeds to certain websites, were it not for net neutrality rules.

The protesters want to secure "Title II" classification for ISPs, meaning they would be governed by the FCC just like telephone companies under the Communications Act of 1934. Both the ISPs and the FCC see such a move as too heavy-handed.

Actually, on this they are right. This decades-old law is so broadly worded that it would give the FCC powers over all aspects of an ISP's operations, something no one wants.

Last week's protest, then, should be seen as about much more than a piece of legislation drawn up in a bygone era. It should be the start of a conversation about how the internet is run. If we believe in net neutrality, then the US Congress must pass a new law that specifically upholds it. Only then will online freedoms truly be – to use the FCC's favoured term – "restored". ■

Future proofing

As it enters its third century of business, the science and sustainable technologies company Johnson Matthey has ambitious plans for the future

The half-life of big businesses is about 75 years – that's the time it takes for half the companies started at a particular time to die away. So a company that survives for 200 years is highly unusual. Johnson Matthey, which is celebrating its 200th anniversary this month, is one of these enduring businesses.

That raises an interesting question: how is it planning for its third century in business? The answer is with a powerful focus on researching and developing innovative science-led products and sustainable technologies.

Take clean air. A large part of Johnson Matthey's business involves reducing toxic emissions to enable a cleaner world. This is one reason the company stands out: it embraces the kind of emissions legislation that most others would see as a burden.

"Much of what we do in terms of research to enable cleaner air is driven by emissions regulations," says Jill Collier at Johnson Matthey's Technology Centre in Berkshire, UK. As a senior principal scientist in the emissions control lab, she spends much time anticipating clean air rules and helping to create technologies to comply with them.

As a result, Johnson Matthey has almost certainly had an impact on your life. Around a third of all cars are fitted with the company's catalytic converters. Johnson Matthey also makes the active ingredients in many drugs. Its technologies optimise the production of many chemical building blocks. For example, it has made fertiliser production more efficient, allowing its customers to make more with less energy and raw material. Recently the company developed a methanol manufacturing process that dramatically reduces greenhouse gas emissions. And on top of this, it engineers electrodes for cardiac pacemakers and brings cutting-edge chemistry to a plethora of everyday applications.

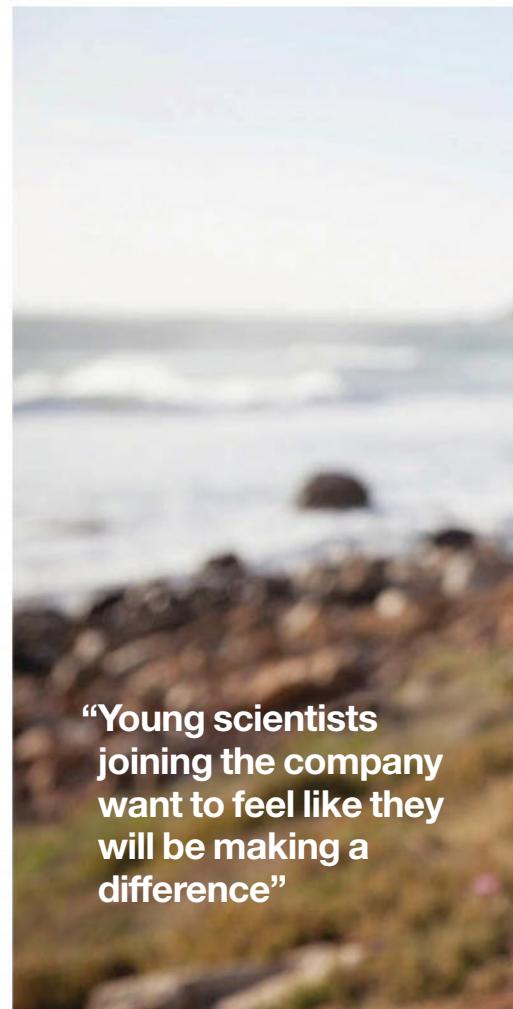
Johnson Matthey's reach is broad, yet the

common theme is clear. It is using science to make the world cleaner and healthier, and to help its customers make sustainable use of the planet's natural resources. More than 90 per cent of its sales come from products and technologies that benefit the environment and people's health in some way.

This would please Percival Norton Johnson, who founded the company in 1817. Johnson was a gold assayer, analysing the composition of precious metal ores and removing impurities. After George Matthey joined in 1838, Johnson and Matthey became official assayer and refiner to the Bank of England. Today, both founders would recognise the modern company's ethos – precious metals and recycling are still part of the business but its technological breadth is now much expanded.

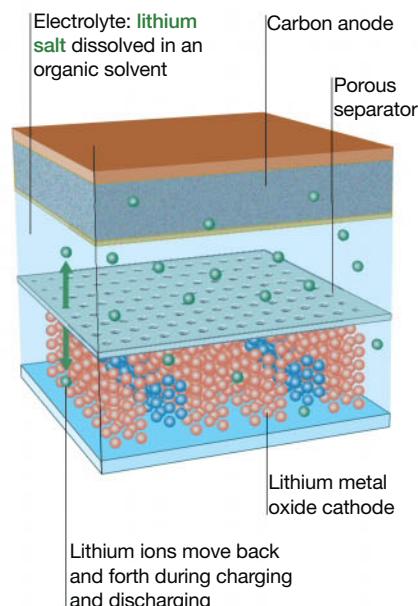
Johnson Matthey's battery technology operation is a good example of how it is bringing cutting-edge chemistry to important everyday challenges. Lithium-ion rechargeable batteries are fast becoming the preferred source of rechargeable power in the automotive industry, a sector Johnson Matthey is familiar with from its work in emissions control and fuel cells. Compared with lead-acid, nickel-cadmium and other traditional battery types, lithium batteries are more efficient, longer lasting and less toxic. They also have higher energy density.

One R&D focus is on improving the material used in the cathode electrodes, an important limiting factor on battery performance. Some of the most promising materials are lithium nickelates and lithium iron phosphate. More work is needed to develop next generation materials for automotive applications, which deliver improved range, cycle time and safety. All this plays neatly to two of Johnson Matthey's major strengths: expertise in advanced materials and a deep understanding of the automotive industry.



"Young scientists joining the company want to feel like they will be making a difference"

Inside a lithium ion battery





To support this work, Johnson Matthey's researchers have an enviable suite of state-of-the-art equipment. An X-ray diffractometer lets them study the crystalline structure of catalysts under realistic operating conditions. A scanning electron microscope helps them study the topography and composition of a material's surface while X-ray photoelectron spectroscopy determines surface chemistry.

Next door is a transmission electron microscope, which can map a material's composition at the atomic level. That's useful for studying supported catalyst particles and determining dispersion, alloying and core-shell properties. Johnson Matthey also uses synchrotron, neutron and laser sources at the Harwell Science Campus.

Johnson Matthey uses this impressive analytical power to support its healthcare business where it manufactures an extensive list of active ingredients for pharmaceuticals.

One of the challenges is that modern drug molecules are getting bigger and more complex and this makes them less soluble. Johnson Matthey specialises in finding the salt form of the drug that allows it to be absorbed into the bloodstream. "We're helping the pharmaceutical industry make

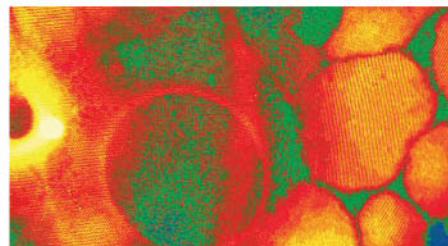
these more complex, more targeted drugs effective as treatments by making sure they can be administered properly and reach the point of action," says Nicholas Johnson, strategic marketing director for the company's health sector.

Meanwhile, plenty of challenges remain in Johnson Matthey's clean air activities. In the emissions lab, researchers are working out how to meet new vehicle emissions standards in Europe and the US by catalysing the reduction of nitrogen oxides at low temperatures. Another team is working on purifying the air inside cars, which can often contain more pollutants than the air outside.

Liz Rowsell, director of the Technology Centre, says that young scientists joining the company frequently remark that they want to feel they will be making a difference in the world, that they will be doing something worthwhile. "It's important to them."

Perhaps this is why they applied in the first place: at Johnson Matthey, there is no shortage of world-changing opportunities. And that should keep the company busy for the next 200 years. ■

More at: www.matthey.com



SUSTAINABILITY TARGETS

At Johnson Matthey, sustainability is central not only to its processes and use of resources, but also to the ethos of its business. Most of its products and technologies are designed to reduce the impact of harmful substances on the planet.

That's why, in 2007, the company set itself six sustainability targets for 2017. They were challenging goals: stop sending waste to landfill; halve the use of electricity, natural gas and water relative to sales; halve carbon dioxide emissions by the same measure; eliminate workplace accidents; reduce occupational illness to zero; and double underlying earnings per share.

The company hasn't hit all of these, but it has come pretty close, particularly on its environmental goals. For example, it has cut its carbon intensity by half and significantly reduced the waste it sends to landfill each year, compared with 2007.

Some targets are still further away, but as Johnson Matthey's sustainability director Sean Axon, says: "We knew at the time that we were setting highly aspirational goals, but this was really about engaging and educating our employees, so they know how their day-to-day jobs connect to those high-level goals."

With a view to this, the company aims to set targets for the coming years that will reach beyond its operational boundaries and reflect the way it sees its role and purpose in the world. That includes how it contributes to the UN's Sustainable Development Goals for 2030. "It's about what we need to do for the future of our planet," says Axon.

One of the original sustainability goals the company has hit is to more than double underlying earnings per share. Clearly, sustainable development is highly profitable. By doing this, they can make a real difference to the world and improve business performance.

APERTURE



White gold rush

IN THE far north-eastern reaches of the Siberian wilderness, a new industry is booming. The frozen soil hides treasures from an earlier era of our planet's history: perfectly preserved woolly mammoth bones and tusks. The discovery of this ivory has turned many local men to "tusking" in the hopes of striking it rich by selling their prehistoric loot to enthusiastic Chinese buyers.

These mammoth mining sites are far off the beaten track. The nearest village is a 4-hour speed boat ride away. The nearest city, Yakutsk, is a 4-hour flight from there. Last summer, Amos Chapple, a photojournalist with Radio Free Europe/Radio Liberty, spent three weeks at one of these isolated outposts, shedding light on the tusking lifestyle with this set of pictures.

There's serious money to be made. The 65-kilogram tusk in the top left image sold for \$34,000. Some tuskers can earn \$100,000 cash in eight days, so jockeying for territory is a point of tension. "Each site belongs to a village," says Chapple. "The law of the land is, if you're not from that village there's no way you'll get into that site. If your face is known, you can come."

Tuskers use high-powered water pumps, which they often carry on their backs, to melt away the permafrost and bore tunnels that can be 60 metres long. Inside, there are sometimes non-mammoth prizes to unearth. The top right photograph depicts a fossil hunter emerging with the skull of an extinct woolly rhinoceros, which is at least 11,000 years old.

The industry and its water pumps have had a devastating environmental impact - muddy run-off ends up in the rivers, clogging up waterways and killing off wildlife.

And the tusking life isn't easy. These men spend the entire summer away from their homes and families. And most of them will end up walking away having lost money – turning up only worthless bones as they buy expensive petrol for their water pumps. Aylin Woodward

Photographer

Amos Chapple/RFE/RL

rferl.org



Alone in the crowd

Loneliness affects us all, but knowing how it changes the body as well as the mind can help us overcome it, finds **Moya Sarner**

IMAGINE you are a zookeeper and it's your job to design an enclosure for humans. What single feature would best ensure the health and well-being of the animals in your care? Appropriate access to food and water? Shelter?

The thought experiment has only one answer, according to social neuroscientist John Cacioppo who proposed it. The enclosure, above all else, must take into account our need for connection with other humans.

We are an "obligatorily gregarious species", in Cacioppo's words. Yet if so, this is not how many of us live today. We are often far from our families, in homes where we are the sole occupant, socialising, working and shopping online.

This can have a serious downside: a gnawing feeling of loneliness to which most of us can be prone, regardless of age or stage of life. We're just beginning to understand what serious consequences that can have. Loneliness changes the brain, taking hold of our thoughts and behaviours in ways that are likely to make us feel even more isolated. But its effects are not just psychological; they are also physical. Left unchecked, loneliness can have a physiological impact as detrimental to longevity as smoking or obesity.

"I'd always thought of loneliness as a nuisance, not one of the most toxic environmental conditions we can possibly encounter," says Steve Cole at the University of California, Los Angeles, who studies the effect of the environment on our genes. If that sounds gloomy, the new insights also offer perspectives on how to tackle this notoriously intractable social phenomenon –

and make each of us less lonely, too.

Loneliness is often assumed to be a problem of social isolation, one that predominantly affects the elderly, or vulnerable people with no friends and family who rarely leave home. Perhaps the most well reported statistic is that nearly half of people aged 65 and over say the television is their main source of company.

Yet loneliness may have very little to do with being on our own, or having few friends, even if this is how it is often defined. "It's not social isolation; it's feeling socially isolated," says Cacioppo of the University of Chicago, who has spent 25 years studying the subject.

"Loneliness may have very little to do with being on our own, even though it is often defined that way"

Loneliness arises from a mismatch between expectations of our social interactions and the reality. A lonely person will not feel less so simply by being surrounded by other individuals. Similarly, a socially enfranchised person won't feel lonely just because they have spent some time alone.

We have known for a while that being physically alone is bad for our health. Only now, though, is it becoming clear that just feeling isolated can be equally damaging.

Lonely people are at increased risk of "just about every major chronic illness – heart attacks, neurodegenerative diseases, cancer," says Cole. "Just a completely crazy range of bad disease risks seem to all coalesce





around loneliness.” A meta-analysis of nearly 150 studies found that a poor quality of social relationships had the same negative effect on risk of death as smoking, alcohol and other well-known factors such as inactivity and obesity. “Correcting for demographic factors, loneliness increases the odds of early mortality by 26 per cent,” says Cacioppo. “That’s about the same as living with chronic obesity.”

One apparent reason is that loneliness lowers willpower, so we are more likely to indulge in self-defeating behaviour. We may take risks and make bad decisions – from choosing unhealthy food, to avoiding exercise. Feeling socially isolated also increases the risk of mental health problems such as anxiety, stress, depression and eating disorders, all of which can have a knock-on effect on our physical health.

Screaming signal

But perhaps the biggest effect may be on the genes that control the immune system. In their first study together, Cacioppo and Cole compared gene expression in the white blood cells of two groups. In one group were six persistently lonely middle-aged adults and in the other were eight who ranked as consistently socially enfranchised. In the lonelier people, the activity of genes responsible for inflammation was ramped right up. “The signal was screaming loud – it could not have been more clear,” says Cole.

Inflammation is the body’s first line of defence against injury and bacterial

SOCIAL, ANTISOCIAL?

To those who champion social media, it is an antidote to loneliness, helping people to connect more, even when deprived of the time or ability to meet up in person. Others cite it as a cause of loneliness, especially in young people.

What's the truth?

To investigate the link between the rapid proliferation of social media and the increased perception of loneliness today, Brian Primack at the University of Pittsburgh surveyed more than 1700 people aged 19 to 32. He compared time and frequency of social media use with feelings of social support or emotional isolation. Primack was expecting to find more

feelings of loneliness at both extremes of social media use, but it wasn't so. "We found a straight line: if a person was a heavier user of social media they generally were more lonely."

So does high social media use provoke loneliness, or do lonely people use social media more? Ethan Kross at the University of Michigan sent smartphone users texts five times a day for two weeks asking about their Facebook use since the previous text, and how they felt at that moment. "We found that feeling bad doesn't lead to more Facebook usage," he says. "The more you use Facebook, the worse you feel."

But there is a good way and bad way to use Facebook: "What seems to be particularly damaging is when people passively use the site, scrolling through their newsfeed, looking at other people's pages," says Kross. This is probably because people curate their pages to make their lives seem better than they are, provoking more negative feelings in people who passively consume that information than those who use the site to chat and connect. He has also found that the more friends you have in your online milieu that you have never met in person, the higher the risk for emotional problems.

infection, but too much inflammation has been linked to cancer, depression, Alzheimer's disease and obesity. The lonely people in the study also had less activity in genes that regulate the immune response to viral infections, "Just the way you really wouldn't like for our long-term well-being", says Cole. Such findings lend weight to Cacioppo's thought experiment: failing to allow the human inhabitants of the zoo the chance to form social bonds could have dire consequences for their health.

But if loneliness is so bad for us, why have we evolved to feel this way? That's possibly not such a mystery. A short pang of loneliness probably helped us to survive in our evolutionary past. Social primates like us live in groups as a means of protection. "Loneliness is part of a biological warning machinery, just like hunger, thirst and pain," says Cacioppo. So we need to listen to that painful, empty feeling of disconnection that we call loneliness and change our behaviour, seeking out safety in numbers.

This evolutionary interpretation of loneliness also helps to explain the immune system changes that Cole and Cacioppo saw. Ramping up inflammation and dampening other immune function is what's called the conserved transcriptional response to adversity. It means that the fight or flight response suppresses our default immune function, which tends to protect us against viral infection. This happens so the immune

system can shift towards a more effective response to bacterial infection, "which are the kind of microbes that tend to follow the wounding injuries you might get if a sabre-toothed tooth tiger bites you," says Cacioppo.

Once that acute mortal terror has passed, we would normally shift back into antiviral mode, to protect us against socially transmitted pathogens. But chronically lonely people's bodies are constantly primed for the sabre-toothed tiger attack that never comes.

Too much inflammation changes the brain, too, triggering behaviours that prime for threats. "Inflammatory biology makes the brain a little more suspicious, vigilant and

"The bodies of chronically lonely people are primed for a sabre-toothed tiger attack that never comes"

irritable," says Cole. In one study, Cacioppo and his team measured people's brain activity while they looked at either threatening or neutral pictures and found that lonely people tuned in to social threats faster. Similarly, hyper-vigilance could explain the correlation between loneliness and poor sleep quality (see "One eye open", right).

Inflammation also dampens down brain areas involved in motivating you to interact with others. This probably evolved in part as a spontaneous social quarantine for sick people,

says Cole. But in the modern world, these kinds of behaviours create a vicious cycle towards increased loneliness.

So it is easy to see why, left unchecked for too long, loneliness can spiral out of control. But this doesn't get to the bottom of why some people feel lonely in situations where others would be fine. Here the answer is complex: studies of twins suggest a genetic component predisposes some people to a greater need for strong social connections, but environmental factors clearly play a vital part.

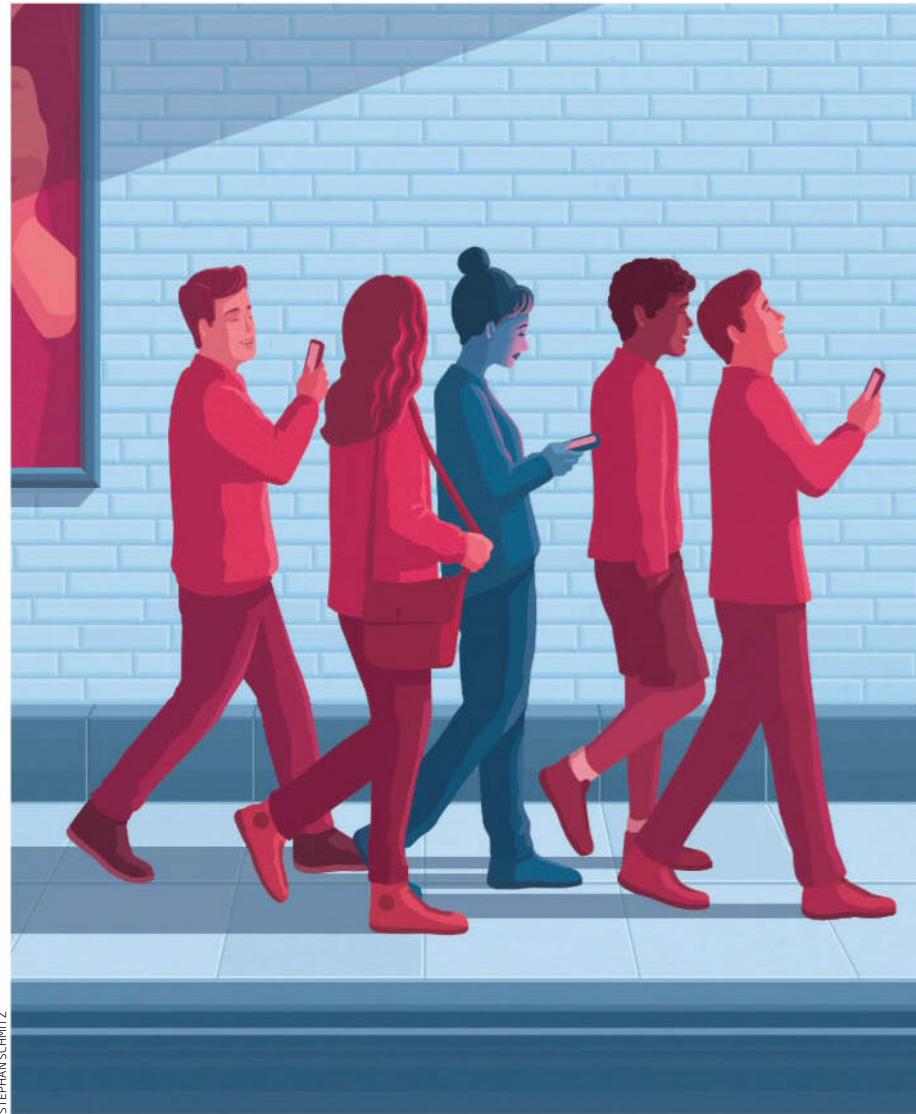
You're not alone

That can help explain why young people today seem particularly vulnerable (see "Understanding loneliness", page 34). For instance, says Jean Twenge, a psychologist at San Diego State University and author of *Generation Me*, there's been a drop in the number of young people in committed relationships. According to one poll, the proportion of young adults in the US who say they are single and not living with a partner rose from 52 per cent in 2004 to 64 per cent in 2014. "That doesn't necessarily mean they're lonely, but certainly having a stable romantic relationship in modern life in particular is one of the key sources of social interaction and social support."

Many young people also don't stay in the same city long enough to take root, Twenge says. Previously, it was generally married couples moving with their kids; now people are moving while they're still single, for a job and so on, ending up by themselves, without as many close relationships. The use of social media to bridge the gap seems to compound the problem (see "Social, antisocial?", above).

If there's one factor that stands out in alleviating loneliness, then it is the quality, rather than quantity of relationships. This too fits our evolutionary past, according to Robin Dunbar at the University of Oxford. "For you to live, survive, work and function well depends on you having a set of very intense close friendships, or family relationships. It turns out that this core group numbers about five close friends and family – and this is very consistent across primates, including humans."

To maintain those crucial five or so relationships, there's an easy formula, says Dunbar – you need to dedicate 40 per cent of your total social effort to them, "and that means seeing them on a very regular basis". Small changes like pruning random acquaintances from social media, setting



STEPHAN SCHMITZ

ONE EYE OPEN

As if feeling lonely weren't bad enough, it can keep you awake at night too. People who rate themselves as lonely are more likely to sleep badly, feel tired and have trouble concentrating during the day,

This is true regardless of social isolation - actual or perceived - and mental health problems. "There's something unique about this association between loneliness and not sleeping

well," says Louise Arseneault at King's College London, one of the study's authors.

Stress hormones play a part. But Arseneault's team found that people who were lonely and had been exposed to violence in the past were especially prone to sleep problems. They concluded that loneliness adds to existing feelings of threat. This would make sense considering the evolutionary roots of loneliness making us

seek safety in numbers (see main story).

"If it's dangerous to fend off wild beasts by yourself with a stick, imagine how dangerous it is to put that stick down and lie to go to sleep... You cannot afford to sleep soundly, and your brain responds accordingly," says John Cacioppo at the University of Chicago, who also found that lonely people experience more micro-awakenings during the night.

notifications for updates from real friends, and spending time with a core group could all act as a buffer against loneliness.

But what do you do once it has taken hold? It seems the best approach is to start with the mind, rather than trying to expand your social network. A meta-analysis of interventions to reduce loneliness found that the most successful dealt with the psychological aspects of loneliness using cognitive behavioural training. The heightened sense of threat lonely

"Knowing loneliness can strike anyone, regardless of social situation, can help dispel the stigma"

people feel means they are more likely to pay attention to and remember negative details and events, and behave in ways that confirm their negative expectations, perpetuating the vicious spiral of loneliness.

Similarly, early-stage research by Cole, who is investigating what factors might make people less likely to succumb to the negative health effects of loneliness, hints that finding a sense of purpose and meaning in life can overcome the negative effects of loneliness. "If you think of lonely people as having a world view of threat and hostility, this study suggests that you can attack this underlying psychology by becoming engaged in helping others, trying to make the world a better place," says Cole. "I'm kind of excited about that as an oblique attack on loneliness." He is also looking at whether anti-inflammatory medication could interrupt some of the biological mechanisms behind this negative feedback loop.

Ultimately, knowing loneliness can strike anyone, regardless of their social situation, might help dispel some of the stigma.

Cacioppo recalls an experiment where he hypnotised people to make them feel lonely and found that their personality instantly changed too – back and forth as they were hypnotised and brought round. Prior to that study, the story was about non-lonely people vs lonely people. "None of that was true," he says. Rather, this is a story about how and when all of us can feel lonely, and how we can best avoid it. We can forget about the stereotype of a house-bound elderly person with only a TV for company, or the Instagram addicted teenager: it could be any of us. ■

Moya Sarner is a freelance writer based in London

Understanding loneliness



What is loneliness?

Loneliness is often inaccurately defined as being without friends or companions.

But while being unintentionally alone or cut off can make someone more likely to become lonely, loneliness is actually a subjective feeling of social isolation.

It might be cold comfort at such times, but loneliness probably evolved to make sure we seek out others for our own protection, and has come to be a deep-rooted

part of the human experience. Why do some people feel lonely in situations where others don't? Genetic predisposition seems to play a part. And new research suggests different personality types are more or less resilient.

There is also a distinction to make between introversion and loneliness, says Steve Cole at the University of California, Los Angeles. "Introverts are people who are happy being

alone, or at least with a small number of interaction partners. Lonely people want lots of social contact and at the same time can't get it, often because they're afraid and feel threatened, and they're sensitive to social rejection."

It's clear that loneliness is not determined by the number of friends we have, either in real life or online. And it can affect us all – loneliness, like death, is one of life's great levellers.

How lonely are you?

To measure loneliness, researchers commonly use the UCLA Loneliness Scale, first developed by Daniel Russell and colleagues at the University of California, Los Angeles, in 1978. The full version is 20 questions long, but Russell has created a shorter one in case too many people become familiar with the test used by researchers and skew future results.

Answer the questions using a scale from 1 to 4, where 1 = never, 2 = rarely, 3 = sometimes and 4 = always, then calculate your total score.

Source: Daniel Russell, UCLA

- 1 How often do you feel unhappy doing so many things alone?
- 2 How often do you feel you have no one to talk to?
- 3 How often do you feel you cannot tolerate being so alone?
- 4 How often do you feel as if no one understands you?
- 5 How often do you find yourself waiting for people to call or write?
- 6 How often do you feel completely alone?
- 7 How often do you feel unable to reach out and communicate with those around you?
- 8 How often do you feel starved of company?
- 9 How often do you feel it is difficult for you to make friends?
- 10 How often do you feel shut out and excluded by others?

HOW YOU SCORED

20 Is the average score on this survey
25 or higher Reflects a high level of loneliness
30 or higher Reflects very high levels of loneliness

Loneliness in numbers

48%

of people in the UK believe we are getting lonelier

Mental Health Foundation

1 in 3

people in the UK would be embarrassed to admit loneliness

Mental Health Foundation

4000

calls to the UK Childline helpline by "lonely" children last year

Childline

31%

of people surveyed in the US feel lonely at least once a week

American Osteopathic Association

15

cigarettes a day – equivalent health impact of feeling lonely

Age UK

Types of loneliness

ACUTE VS CHRONIC

We can all expect to feel lonely from time to time, especially during life-changing events like moving home, the birth of a child, or the death of a loved one. But chronic loneliness changes the way we think and behave. It makes us worse at reading social situations. It also affects the brain in ways that make us less likely to seek out others. Because of this, loneliness begets loneliness.

"Chronic loneliness is really what we worry most about," says Steve Cole from the University of California Los Angeles. Advances in genomics, neuroscience and psychology are bringing fresh insights on the noxious

impact it has on our physical and mental health. It affects the immune response and puts us at an increased risk of conditions like neurodegenerative disease and cancer.

"You're locked in a world view, you're locked in a lifestyle, and you're perpetually running a body that's a little bit more at risk of these diseases because of this chronic inflammatory biology," Cole says.

Because people with chronic loneliness are more likely to push others away, it's also harder to treat. But understanding these negative thought patterns also offers a route for intervention.

SOCIAL VS EMOTIONAL

Social isolation can be defined as the absence of relationships with family or friends on an individual level, and with society on a broader level, according to the UK Mental Health Foundation. It is determined by the strength of a person's actual social network.

Emotional loneliness refers to the objective feelings of isolation a person has, regardless of their social network. Importantly, both types have negative effects on our health.

It seems odd that some of us can spend much of our time alone but suffer

no ill effects, whereas others can be lonely even in relationships. According to John Cacioppo at the University of Chicago and co-author of *Loneliness*, we all need different amounts of social contact. It is this, rather than the objective amount of social contact we have, that determines how prone we are to emotional isolation.

The environment plays a large role too. Some people, such as teenagers and those with certain mental health problems, may be especially prone to loneliness because they can tend to misread social cues.

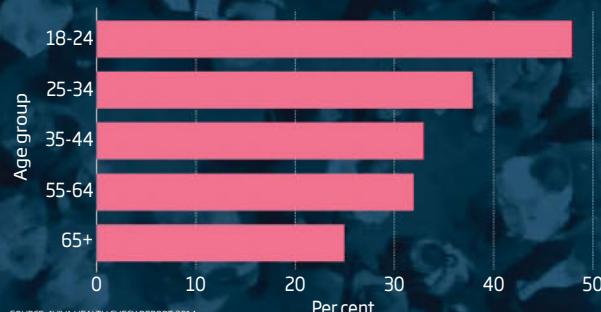
Who's feeling lonely?

YOUNG, FREE... AND LONELY

Most of the campaigns against loneliness focus on the elderly, but surveys show it's a big problem for the young. A study of 1000 teenagers, for instance, found that only 58 per cent feel they always have a close friend to turn to. The UK's Mental Health Foundation has found that the younger

you are, the more likely you are to often feel lonely. This could be down to changing work and living structures, expectations of connectedness generated by technological advances, or the quality of relationships that are maintained more through technology than face to face.

We feel less lonely the older we get, challenging widely held assumptions



SOURCE: AVIVA HEALTH CHECK REPORT 2014



ONLINE TOO MUCH?

More young people than older people think they spend too much time communicating with family and friends online rather than in person.

31%
18-34 **9%**
Over 55s



ARE YOU AT RISK?

There are times when all of our resilience to loneliness is put to the test, such as...

- Moving home or job**
- Bereavement**
- Divorce or separation**
- New baby or departure of older child**
- Unemployment**
- Poverty**
- Mental illness**
- Disability**
- Drug or alcohol addiction**
- Caring for a relative**
- Being a lone parent**

WORRY ABOUT LONELINESS

Younger people are more likely to worry about feeling lonely.

36%
18-34 **17%**
Over 55s

Mental Health Foundation, 2010



The eyes have it

What first persuaded our amphibian ancestors to walk on land? New fossils are suggesting a fresh view, says Brian Switek



Mudskippers could shed light on how fish made the leap to land

sparse, but when one of the most significant transitions in life's history was taking place. This was the era in which fish-like things hauled themselves out of the water for new life on land, setting the stage for the rise of amphibians, reptiles and mammals like us.

Tiny isn't the only recent discovery challenging our view of this transition. Where once we imagined that a few sturdy pioneers exchanged their fins for limbs, took a gulp of air and never looked back, now we see a haphazard process that relied as much on shifty, swelling eyes as the anatomical prototypes of limbs.

So far, we've uncovered a number of flagstones on the evolutionary path from fish to four-legged land animals, or tetrapods. In rocks dating from 375 million years ago, the end of the Devonian period, palaeontologists have found a fossilised shoal of fishy creatures that document the evolution of fins into the limbs and fingers that would eventually carry them onto land. Fleshy-finned fish related to today's lungfish mark the start of the transition, with fossils like *Panderichthys* from Latvia and the 375-million-year-old *Tiktaalik* from Ellesmere Island, Canada, demonstrating how fin bones were modified into the rudiments of our own appendages.

Fast forward about 10 million years and vertebrates seem even better suited to wandering ashore. There was *Acanthostega*, roughly salamander-shaped and 60-centimetres long, with well-defined limbs and eight fingers on each hand, and the larger *Ichthyostega*, with its seven digits. Although recent studies suggest it would have been more comfortable in water, *Ichthyostega* was capable of dragging its body along the mud banks. At this point, early tetrapods had limbs, fingers and the ability to breathe air, inherited from their lungfish-like ancestors. Life seemed perfectly poised to crawl onto land for good.

But that's where the fossils disappear. For the first 15 million years of the Carboniferous – between 360 and 345 million years ago – the descendants of the first tetrapods seemed incredibly scarce. Where palaeontologists had expected an explosion of tetrapod species, there were fewer than they could count on their fingers. When the fossil record picks up again, there is a riot of amphibian life at the water's edge, including the first creatures to fully abandon the water for life on land.

This vast hole in the fossil record is known as Romer's Gap – after US palaeontologist Alfred Romer, who first called attention to it – and it has long been a mystery. What happened in the period between *Ichthyostega* pushing its way through weed-choked

swamps and the early amphibians making themselves comfortable further ashore? And why so few fossils?

Palaeontologist Peter Ward at the University of Washington in Seattle and others thought the answer might be oxygen. They noticed that for tens of millions of years prior to Romer's Gap, arthropods like the early arachnids had thrived on land, only to struggle during those mysterious millennia. This led people to argue that the hiatus in the fossil record was down to a severe drop in atmospheric oxygen levels. With less O₂ in the air, breathing would have been difficult, creating a barrier to animals taking anything more than brief forays out of the water.

But the fossil record has a habit of surprising us. The first hints came in 2002, when Jennifer Clack at the University of Cambridge and her colleagues looked more

Bigger eyes and better eyesight revealed the bounty of prey on land

closely at the bones of *Pederpes finneyae*, previously identified as a fish that lived just within Romer's Gap, about 348 million years ago. Clack identified *Pederpes* as a tetrapod with five functional toes on feet that were much less paddle-like than those of its predecessors. It was not fully terrestrial, she says, but its limb anatomy suggested *Pederpes* was more capable on land than any previous vertebrate. More than that, it was a hint that Romer's Gap might not be so barren, after all.

Encouraged, palaeontologists returned to long-neglected rocks dating from Romer's Gap for a closer look. And they were shocked by what they found. In 2015, Jason Anderson at the University of Calgary, Canada, and others drew from a collection of fossils found at Blue Beach, Nova Scotia, to argue that a diverse array of tetrapods had lived there at the time.

The following year, Clack and a team of colleagues returned to a riverbed not far from Chirnside to discover a bumper crop of new fossils – not one but five new tetrapod species.

The reason they were missed for so long is that the rocks from Romer's Gap do not contain commercially exploitable resources such as coal, limestone or iron ore. "[The rocks] were considered barren and that meant no one looked," says Clack. "Simple as that."

Closer inspection revealed hidden treasures. Among them was *Aytonerpeton microps*, given the name Tiny thanks to its diminutive head, just 5 centimetres in length. That really ➤

SEEN through the right geological lens, the bucolic countryside near Chirnside, a village in south-east Scotland, becomes a tropical swamp. The rocks divulge a picture of a sweltering and soggy landscape, tangled with all manner of tree ferns, horsetails and 30-metre-high clubmosses that look like giant scaly asparagus spears.

Here, 350 million years ago, off the edge of a muddy bank, a pair of eyes poked above the water. They belonged to a newt-like creature with a broad head, a wide mouth full of needle-sharp teeth and a long tail. It also boasted four limbs, with which it shuffled awkwardly onto the bank.

This amphibious vertebrate, nicknamed Tiny by its discoverers, might be the most important fossil you've never heard of. It lived through a time for which our records are

is small compared with the other amphibious creatures of the time, and it is part of what makes *Tiny* so special: it suggests that tetrapods had evolved a range of body sizes by this point. Indeed, although *Tiny* and its ilk are unlikely to become household names, they have been lauded by palaeontologists because they close Romer's Gap.

Fossilised charcoal from the same period revealed the presence of fire, giving the lie to the idea that oxygen levels had dropped severely. In circuitous fossil trackways, too, there were clues that invertebrates were not suffering as badly as researchers had previously assumed. It wasn't that the environment during Romer's Gap was hostile to life moving ashore: palaeontologists just hadn't found the fossils.

With the latest discoveries, we're getting a clear view of this long-standing evolutionary blind spot. Far from suffering in a repressive atmosphere, these early limbed vertebrates were thriving and diversifying rapidly. "This was when tetrapods really began to exploit the land," Clack says. "The conditions of varying environments seem to have promoted the ability to feed and shelter on land, while still living primarily in the water."

But why? It is one thing to know that vertebrates were shuffling back and forth between water and land, trialling various

anatomical innovations; it's quite another to know what drove them. Maybe it was the threat of predators in the water, or the lure of new food sources on land?

Malcolm MacIver, a neuroscientist at Northwestern University in Illinois, brings fresh perspective to bear on such questions. He had previously studied how black ghost knifefish detect prey in the water using electrical current, and got to thinking about how the first terrestrial vertebrates perceived their environment. It led him to look deep into their eyes – or at least into the empty spaces of their fossilised eye sockets.

Visions of plenty

MacIver and his colleagues measured the eye sockets of 59 tetrapod skulls from between 390 and 260 million years ago. They found that eye sockets grew dramatically over that period, tripling in size, and gradually migrated to the top of the head. Take *Tiktaalik*, for example (see image, below). This was still a fishy, water-bound animal, but the size and position of its eyes suggest it at least paid attention to what was going on above the surface. What surprised MacIver the most, though, was that these changes occurred before the early tetrapods acquired limbs capable of carrying them onto land.

Eyes at the top of its head: *Tiktaalik* was made to see above water



ANNE RYAN/POLARIS/EYEVINE

In biological terms, eyes aren't cheap. It takes a great deal of resources to grow and maintain them. So what benefits did they bring? To find out, MacIver and his colleagues used experimental data from living creatures to model what these prehistoric eyes could have seen, both above and below the waterline. Enlarged eyes aren't necessarily helpful underwater, they found. But once those bigger peepers poke above the surface, it's a different story: in air, larger eyes lead to a proportionate increase in how far you can see.

And what was there to look at? Lots of crunchy arthropods, all naive to the threat of predators like these. So here's what MacIver is suggesting: bigger eyes and better eyesight created "an informational zip line to the bounty of invertebrate prey on land", perhaps drawing those early tetrapods farther and farther from the water to snaffle up the arthropod buffet. He calls it the "buena vista" hypothesis.

Merely seeing farther was not enough to drive the surf-to-turf transition, of course. But MacIver thinks that once the tetrapod ancestors could catch a glimpse of all that helpless food, those with certain anatomical quirks – like limbs and ribs capable of supporting bodies on land – would have had an advantage that natural selection favoured.

Anderson welcomes the hypothesis, and the creative approach that spawned it, even if he has reservations about how closely eye socket size correlates with eye size. "It's definitely an idea to follow up on," he says.

Such is the nature of palaeontology. Every discovery and novel hypothesis raises more questions – and there is still a great deal to learn, not only about Romer's Gap but also the first slippery steps onto land it has obscured for so long.

At the top of Clack's wish list is more detail on the reproductive strategies of the creatures making the first forays into a drier world. Were their breeding habits still tied to the water, like those of modern amphibians? When did the first egg capable of surviving on land evolve? "You'd need an [exceptional fossil] showing soft body preservation to stand a chance of that," she says. Likewise, we still don't know why five fingers became the standard for tetrapods.

Having exposed Romer's Gap as nothing more than a sampling problem, we know the answers are out there in the fossil record, says Anderson. Just a few more tiny discoveries could mean a giant leap in our understanding. ■

Brian Switek is a writer based in Salt Lake City, Utah

Waste not...?

Like altruism, The Beatles and chocolate, recycling is universally acknowledged as a good thing. For many of us, it is a way of life. Recycling rates have been rising since the 1970s, and in some places, including Germany, the Netherlands and California, more than half of all domestic waste is recycled. But now some people are challenging the received wisdom with difficult questions. How do non-recyclable styrofoam coffee cups compare with paper or ceramic ones, when all the costs of manufacturing are included? Is it worth recycling materials such as glass and plastic that yield only small environmental benefits? Might landfill be a greener option for plastic, much of which is trucked to seaports and shipped to China for recycling? If you've been left wondering whether it's worth it, here's what you need to know to make up your mind. *Words by Bob Holmes*



1

Which materials are worth recycling?

From the most basic environmental point of view, all materials are worth recycling, because this reduces the need for energy-intensive mining and smelting of virgin materials. That makes a huge difference for some things – notably aluminium – but even recycling glass leads to a small energy saving and consequent reduction in greenhouse gas emissions. Recycling can also provide a reliable, non-imported source of scarce resources such as the rare earth metals that are crucial parts of touchscreens and other high-tech devices.

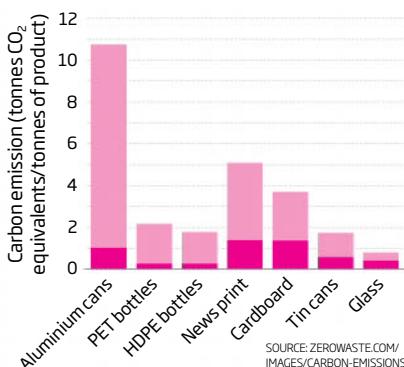
However, the answer gets muddier when we consider economics. The price of recycled material fluctuates wildly, and some often aren't profitable to recycle, especially if the recovered material has to be shipped long distances to a reprocessing plant. Waste managers often have to pay recyclers to take glass off their hands, for example. That can make virgin glass look like a better deal – but only because we often fail to include the environmental costs of mining sand and the carbon emissions from glassmaking furnaces. Similarly, plastics are often reprocessed in China, so proximity to a seaport may dictate whether it is profitable to recycle them.

Other low-value materials such as wood and textiles need to be clean to be recyclable. The extra effort and expense required to separate them from general waste means they often end up in landfill.

Wasted opportunities

Greenhouse gas emissions from the production of various materials reveal that recycling is always greener than using virgin resources

■ CO₂ from recycling ■ Additional CO₂ from virgin resources



3

Why do I have to separate my recyclables?

Keeping recyclables separate from the rest of your rubbish reduces contamination and makes recycling more effective. Recycling companies like it if we also segregate different types of recyclables because then they don't have to incur the extra expense of doing this.

Separate collections of organic waste, recycling and other rubbish can make waste-handling more efficient. Kitchen waste is dense and self-compacting, so organics can be collected frequently with simple vehicles. With the stinky organics gone, recycling and other rubbish can be collected less often – even once a month or two – which makes more efficient use of expensive compactor trucks.

But the more complex the household sorting task becomes, the more likely householders are to give up and simply pitch something into the rubbish. As a result of this trade-off, local authorities often lump all recycling into a single bin, or just separate paper and cardboard from plastic, metal and glass.



"In the US, landfill accounts for 18 per cent of methane emissions, making it the third largest source"

4



CULTURA/REX/Shutterstock

What if my carefully segregated load is contaminated?

Everyone makes mistakes, and recyclers accept a certain amount of contamination. But too much of it can downgrade the quality of the batch and reduce the price reprocessors will pay. In practical terms, that means you should take reasonable steps to rinse and sort your recyclables according to your waste-management system's protocol, but don't obsess over every last decision.

Pay particular attention, however, to instructions on how to handle plastic wraps and plastic bags, because these can clog up the shredding and sorting machinery in some systems. If your local authority asks you not to put them in the recycling bin, don't.

5

Does recycling keep plastic from polluting the ocean?

Most of the plastic that ends up in the oceans is "leakage" – the stuff that gets tossed out of car windows, dropped on the street or otherwise escapes the waste management system. That accounts for 32 per cent of global plastic packaging. So, if plastic is recycled – or even sent to landfill or burned – it should stay out of the ocean.

6

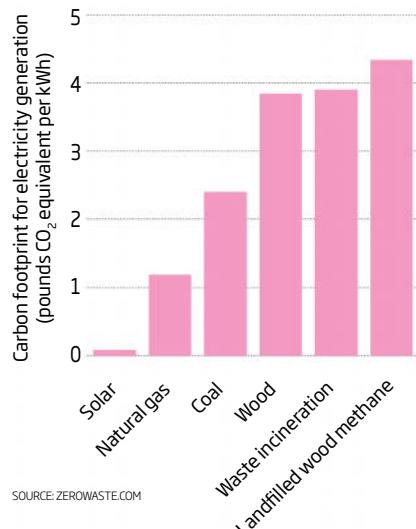
Is burning rubbish in incinerators better than dumping it?

Incinerators reduce the volume of waste that might otherwise be dumped into landfill sites, and most also generate heat for electricity or heating homes. Modern waste-to-energy incinerators are very clean, so toxic emissions aren't generally an issue. But then modern landfill sites generally don't leach toxins into their environment either. Incinerators do, however, release a lot of carbon dioxide for every kilowatt-hour of electricity produced – more than many coal-fired power plants, in fact. And as the electricity grid shifts more towards renewables, burning trash to generate electricity is likely to look increasingly less attractive.

Another consideration is that burning waste may reduce levels of recycling. Cities that rely too heavily on incineration can find themselves trapped by the system's demands. "These things are hungry," says Thomas Kinnaman, an environmental economist at Bucknell University in Pennsylvania. "They need lots and lots of fuel to stay efficient, and they're increasingly looking at that recycling pile."

Going up in smoke

The carbon footprint of electricity generated from garbage incineration and landfill is more than from most coal-fired powerplants



7

Is there any point to composting?

Composting is one of the most useful things you can do. Compacted, airless landfill sites are the perfect breeding ground for anaerobic bacteria called methanogens that feed on organic waste. For every kilogram they digest, they produce about 2 kilograms of the powerful greenhouse gas methane. That doesn't happen in a compost bin. Yet households in the UK binned 7.3 million tonnes of food waste in 2015, two-thirds of which could have been composted. Separating kitchen scraps, garden waste and other organic waste from the rest of the rubbish stream means they can be used to generate high-quality compost to increase soil fertility for crops and gardens. Organic waste contaminated by household chemicals, glass, metal fragments and the like may only produce compost fit for restoring industrial sites and roadsides.

8

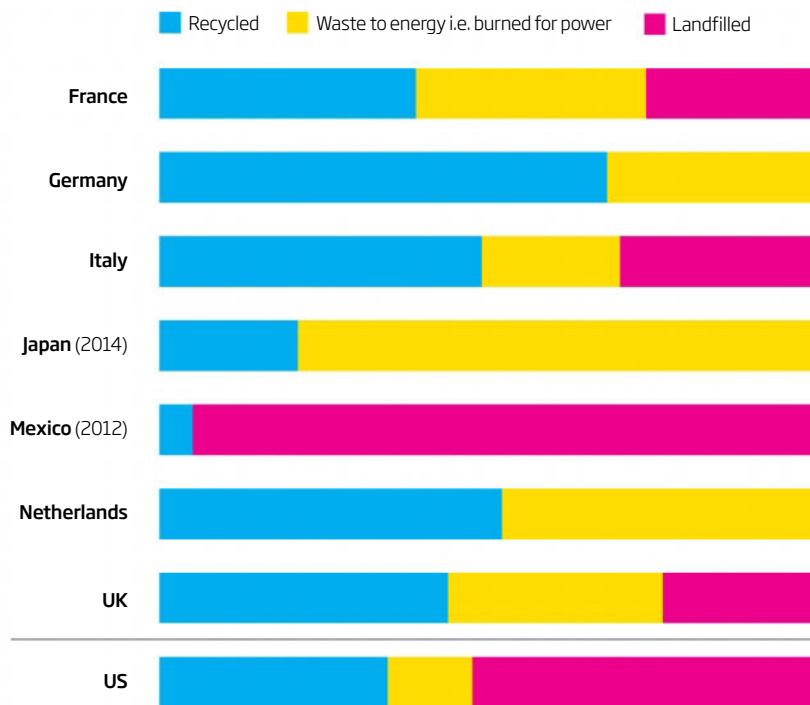
Isn't "recycling" a misnomer?

Some materials, such as glass and aluminium, can be melted and recast into new products that are just as good as those from virgin material. But others can only be "downcycled" into products of lower quality than the original. Each time paper is recycled, for example, its fibres break into shorter lengths so it can be used only for increasingly low-quality papers such as newspaper and toilet paper. Most plastics are downcycled into products that cannot themselves be recycled. In fact, only about 15 per cent of recycled plastics end up in products of similar quality. Researchers are working on finding new ways to chemically break down plastics into their component molecules so that they can be rebuilt into high-quality material.

There is a move to redesign products and packaging to minimise waste. In the meantime, environmentally aware consumers can reduce, reuse, avoid disposable items and repair broken ones instead of throwing them away.

Global disposal

Here's how various countries disposed of their municipal waste (in 2015, unless otherwise indicated)



81
MILLION
TONNES

of US municipal waste was recycled or composted, reducing CO₂ emissions by 181 million tonnes - comparable to the annual emissions from 38 million cars.

30
MILLION
TONNES

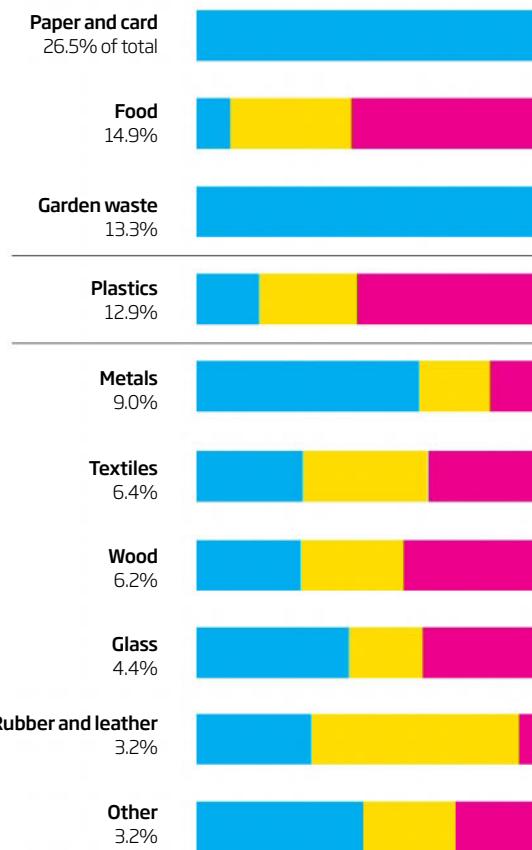
Less than 13 per cent was burned to produce power.

123
MILLION
TONNES

More than half went to landfill. Food, plastics and paper were the largest contributors.

US breakdown

The US is one of the most prolific producers of household waste in the developed world. Here's what Americans threw away in 2014



SOURCE: [HTTPS://STATS.OECD.ORG/INDEX.ASPX?DATASETCODE=MUNW](https://stats.oecd.org/Index.aspx?datasetCode=MUNW)

Towards zero waste

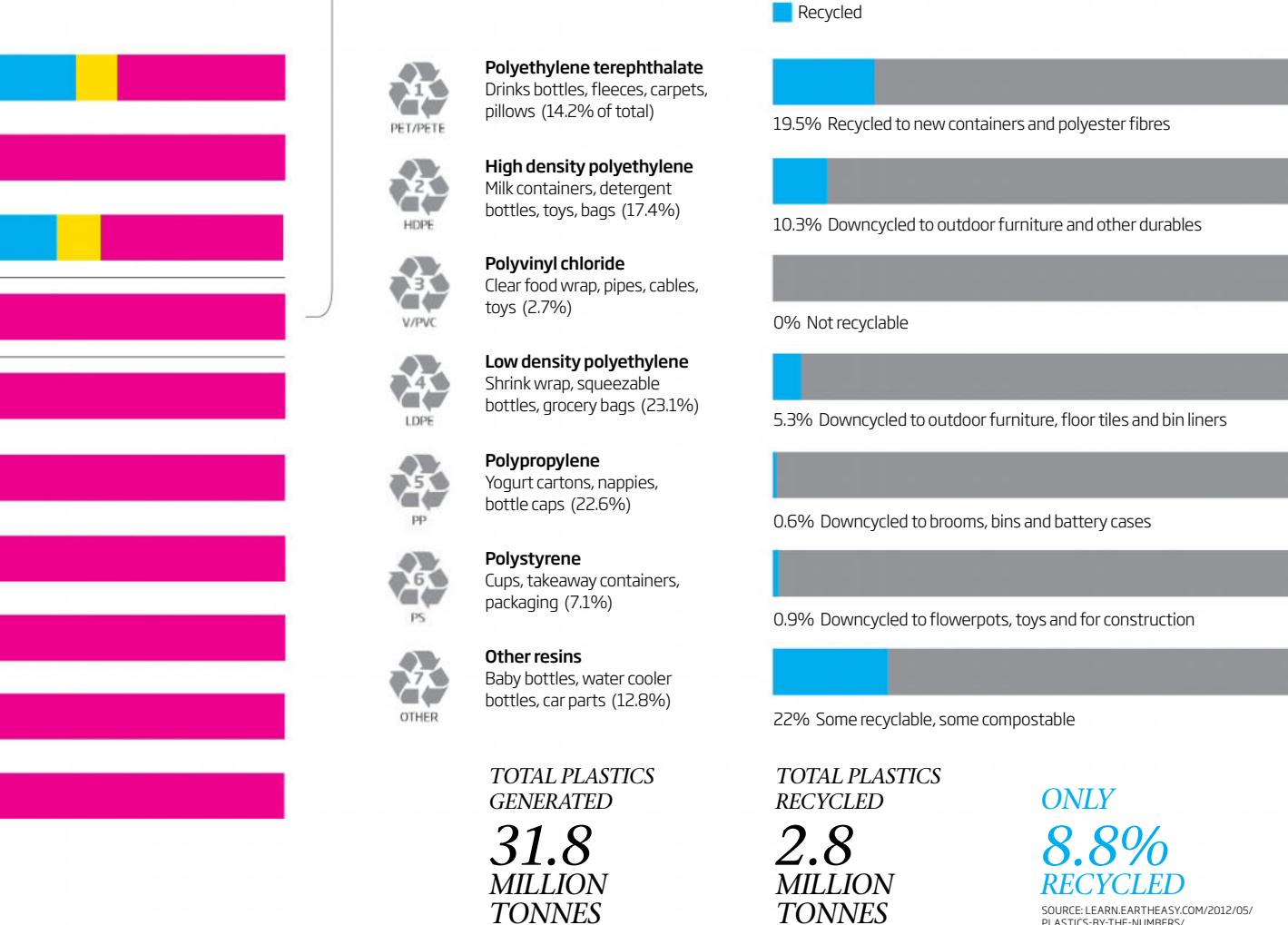
Can we create a world without rubbish?

One of the big impediments to recycling is products made of mixed materials that can't easily be separated – but solutions are on the way. Sachets are a prime example. People living in poorer countries often purchase single-use sachets of things like ketchup and detergent because they cannot afford to buy in bulk. These sachets need to be durable as well as impermeable, so they are often made of layers of different materials. Hundreds of billions are produced annually. Unilever, a major manufacturer of sacheted products, pledged earlier this year to make all of its packaging recyclable by 2025, and is developing new ways to dissolve the polyethylene out of used sachets so that it



US plastic breakdown

Seven different categories of plastics are distinguished for recycling, yet very little is actually recycled



can be reused. Others are developing ways to separate mixed plastics by shredding them and automatically sorting the millimetre-sized fragments.

Such efforts are part of the “new plastics economy”, which recognises that plastics can have environmental benefits as well as costs. “We don’t want to eliminate plastic, we want to eliminate plastic waste,” says Joe Iles, a spokesperson for the Ellen MacArthur Foundation, which is leading the initiative. That will require coordination as well as innovation. For example, there’s a new generation of biodegradable plastic made from corn starch that can be used to make drinking bottles. But we need an easy way

to distinguish them from bottles made from polyethylene terephthalate (PET), says Iles, because even a few can contaminate and ruin a batch of recycled PET.

Another way to encourage recycling is to require manufacturers to take back and recycle the products they sell at the end of their useful life. This extended producer responsibility is increasingly being applied to products like electronics and batteries. It encourages manufacturers to think about the disposal of their products, possibly redesigning them to make that easier. Japan, one of the leaders in this approach, adds the price of recycling to new products and has seen an associated 27 per cent increase in

recycling rates for containers and packaging.

Initiatives like these are pushing society towards a “circular” economy, in contrast to today’s “take, make and dispose” economy. We have a long way to go and, even with the most advanced technologies and best intentions, zero waste is an impossible dream. But that shouldn’t stop us dreaming. “I sometimes equate it to zero deaths in the emergency room of a hospital,” says Jeffrey Morris, a waste consultant at the Sound Resources Management Group in Olympia, Washington. “Any other goal makes no sense.” ■

Bob Holmes is a consultant for *New Scientist* based in Edmonton, Canada

How am I feeling, machine?

Now that technology is finally getting emotion-savvy, could machines give us the benefit of their new-found wisdom? **Rosalind Picard** thinks so

WHEN Rosalind Picard announced to the world that computers needed to understand emotion, many scoffed. But her book, *Affective Computing*, published 20 years ago, seeded a new field. It's now clear that computers will serve us better if we can help them understand what matters to us – using changes in our physiology, movement, facial expression and tone of voice to discern our emotions.

Affective computing is enjoying quite a few real-world applications. What kinds of ideas are you working on at the moment?

Something I'm excited about are wearable systems that help people see their stress levels and mood changing. In the early days of affective computing, a "wearable" computer might have weighed 50 pounds – totally impractical. Today, I've got this lightweight device on my wrist, the Empatica Embrace. Its sensors record my skin conductance, motion data and skin-surface temperature 24/7 – information linked to my mood, stress and activity levels. It's connected to a smartphone app. Using our latest tech, this set-up is around 85 per cent accurate at predicting a person's mood, stress and health tomorrow night based on their data from today.

What's the appeal of this system?

People have huge differences in their ability to gauge their own emotions and how those feelings change over time. People with autism in particular have difficulty with this but it is by no means limited to them. I've had computer scientists pull me aside, usually privately, and say "I don't understand what you mean by 'feelings'." It can be a terrible handicap that affects women as well as men.

So we have an opportunity to help people learn more about their feelings. Turning on cameras to see how much someone smiles and frowns, and listening for the emotion in their speech could also be beneficial. Personally, I've learned a lot about my stress using the wrist sensor – about what activates it, what calms me down.

How might this sort of technology help us deal with stress?

In the heat of the moment, you don't want your phone to act like the HAL 9000 computer in the movie *2001* – "Hey Dave, take a stress pill." But imagine that you're someone who isn't aware of stress until it suddenly becomes overwhelming – that's true for lots of people – and that you have a wearable device that gently warns you well before the stress level

"I want people to be aware of a looming emotional storm before it hits them"

gets high, giving you the chance to change what you're doing. What I'm working on is raising a person's awareness of subtle changes before they would naturally become aware of them, and certainly before a looming emotional storm hits that affects them and everybody around them.

What will affective computing's killer app be?

People often think of a killer app as the thing that everybody sees and names and recognises. But if we succeed in putting the emotional intelligence in our different smart interactive systems, you probably won't notice it explicitly. You'll just feel that you had an

PROFILE

Rosalind Picard runs the affective computing group at the Massachusetts Institute of Technology Media Lab. She co-founded Empatica, which makes wearable sensors and analytics for healthcare, and Affectiva, which develops tech to measure and communicate emotion

intelligent interaction that made you feel good, and understood. That's hard to pull off, even for another human.

A simple example would be your GPS system. You don't want a happy, upbeat voice telling you to make a U-turn when you've driven the wrong way and are feeling frustrated. In fact, in controlled experiments, we see that accidents happen more often when the driver is stressed and the GPS voice sounds happy. If these systems perceive our state, and respond appropriately, it makes the entire experience better – whether it's driving or any other augmented system.

You have said that face-reading systems could help politicians better understand the feelings of their constituents. How would this work?

Many years ago at Affectiva, we started using face-reading technologies while people watched politicians speak. We hit a problem: all the facial expression analytics imposed symmetry on the tracking, but we realised people were smiling lopsidedly, smirking in scepticism at what the speakers were saying. We had to develop a smirk detector. I've since left Affectiva, but last year they measured smiles, smirks, looks of disbelief and other expressions in people watching the US presidential debates online, and got some really nuanced feedback about what people



liked and didn't like. Giving people the power to communicate their emotion in an objective way to elected officials offers an opportunity to influence them in a powerful way.

How might that work in practice?

Imagine people watching a politician giving a talk on their smartphones, while the system watches their facial expressions and then aggregates relevant smiles, smirks and frowns across all the viewers. The team surrounding that politician might tell her, "Great job, your message really connected!", but then facial-expression data show them that in fact 60 per cent of viewers exhibited negative expressions during that message. Such direct-to-leader data could be very powerful in helping voters communicate with their representatives effortlessly and accurately.

Social media thrives on content that angers or delights users. What would happen if these sites had unfettered access to facial reactions? I don't see everyone turning on their cameras all the time, giving "unfettered access". But if social media sites did respond to your facial expressions, they could become much better recommenders for you by noting not just what you watch – which already happens – but also what you smile and laugh at, and helping you find more of that. Some people could get addicted to just watching things that make them smile.

On the other hand, you might choose settings that offer you a more diverse emotional diet. Good film-makers know that the best experiences involve a range of emotions – you have better highs when there are also lows.

You've said that part of affective technology is actually about developing the next generation of humans. Can you elaborate on that? Affective technologies can augment our innate ability to understand feelings – our own and those of others. People are manipulated emotionally all the time, by fake news, by friends, advertisers, teachers... While some of this is bad, some of it is also good, and technology can help us measure, understand and manage how emotions influence our choices. We can create a better future by finding engaging ways to communicate with one another – and learning what people really want. ■

Interview by Kayt Sukel
Rosalind Picard will be speaking at New Scientist Live in September (live.newscientist.com)



Fantastic voyage: music takes us on a mysterious "emotional journey"

he asserted that music had to have sufficient variety to be interesting while also having enough consistency to be intelligible.

Through playing games with the young Paravicini, Ockelford came to understand that the significance of repetition in music is that it occurs with perceived intent; music seems to the listener to be imitating itself. Each note, interval or motif appears to be derived from, or is perhaps controlled by, what went before, as though there was agency within the music itself.

This is Ockelford's "zygonic conjecture", which doesn't merely define a structural element of music, but claims to define a universal characteristic of all music from across the world. The exceptional expressive beauty of "great music" is achieved by this fusion of content and structure.

Ockelford argues his case by a comparative analysis of Mozart's piano sonata K.333 with J. C. Bach's sonata for piano/harpsichord Op. 5, No. 3. He declares the former a work of genius, the latter as merely demonstrating talent. Elsewhere he makes similarly profound analyses of *Twinkle, Twinkle, Little Star* and *Hickory Dickory Dock*.

The zygonic conjecture, its name derived from the Greek prefix "zygo-", which refers to a union, is used to explore a diverse range of musical phenomena that are all ultimately connected in the human mind. That, after all, is the only place where any piece of music can be said to exist.

Ockelford explores the processes of composing ("one of the most mysterious of human pursuits"), performing and listening. In the latter, our enjoyment of "sweet anticipation" ultimately derives from our subconscious attribution of imitation and agency to successive musical sounds.

The zygonic conjecture also

Sweet anticipation

The odd thing with music is that it makes sense, says **Steven Mithen**

Comparing Notes: How we make sense of music by Adam Ockelford, Profile



WHEN Derek Paravicini was 8 he had thousands of pieces of music at his fingertips on the piano, playing each with fluency in any key.

Whether Bach or Beethoven, the blues or the Beatles, he played with a joyous vitality, adding notes to melodies, enriching harmonies and filling out textures. He still does so at the age of 37.

Celebrated as a musical genius, Paravicini was born prematurely, blind and with severe learning

difficulties. Adam Ockelford, now professor of music at the University of Roehampton in the UK, patiently honed Paravicini's musical skills from the age of 5, and weaves his story, along with those of other musical savants, into this outstanding book about music. Ockelford's 40-year intellectual journey is intimately connected with Paravicini's story: it was when they were playing copying games on the piano that Ockelford gained a critical insight into the nature of music.

He begins with a swift tour of 20th-century theories of music. Heinrich Schenker believed a single deep structure underpinned all music. Arnold Schoenberg taught conventional music theory, all the while

developing a radical atonal music. Positivist and postmodern approaches include Susan McClary's phallic interpretation of Beethoven's 9th symphony, and the Chomsky-influenced theories of Fred Lerdahl and Ray Jackendoff. Ockelford extracts the core ideas from music theory that are notoriously difficult for non-specialists, and demonstrates just how accessible they can be in the right hands.

A recurring theme from Schenker onwards has been that music depends on repetition. Schoenberg took up the idea when

"Music seems to be imitating itself. Each note appears to be derived from what went before"

underpins Ockelford's account of how musical ability develops, throws light on the significance of absolute pitch (which usually accompanies, but doesn't explain, musical savantism) and helps explore the challenge of atonal music.

According to Ockelford, music works by taking us on an emotional journey in which we imbue the stream of abstract sounds with agency. The obvious next question is, why? Why are we compelled to compose, perform and listen to sound streams that have these particular qualities?

Here Ockelford is hesitant; he makes occasional references to our evolutionary past, seeming to appreciate its significance but leaving this ultimate question unanswered. I will be bolder: what the zygomatic conjecture has brilliantly identified is how our minds remain attuned to a human world prior to the invention of spoken language.

This is the human world I described in my book *The Singing Neanderthals*, one which existed up until the emergence of *Homo sapiens* less than 200,000 years ago. It was a world in which communication was achieved through musicality alone, by sound streams that varied in pitch, rhythm, timbre and loudness to express emotions and induce emotions in others, leading to high level of cooperation and trust between individuals. What Ockelford has shown us is that our minds today remain ready to listen to that world of pre-linguistic utterances, which were rich in imitation and agency because they were made by multiple voices.

The genius of Mozart, J. S. Bach and Beethoven is that they found the means to transport us into our evolutionary past and lifted, for a while, the cognitive burden of living with spoken language. ■

Steven Mithen is an archaeologist and the deputy vice chancellor at the University of Reading, UK

The joy of science fiction

In Arthur C. Clarke's centenary year, **Lydia Nicholas** reads his heirs

The winner of the 2017 Arthur C. Clarke Award will be announced at a ceremony at Foyles bookshop on Charing Cross Road in London on 27 July

THE first Arthur C. Clarke Award for best science fiction novel went to Margaret Atwood's *A Handmaid's Tale* in 1987. It's a book which many commentators still refuse to call "science fiction" because it doesn't grapple with the shiny stuff we might get in the future. Instead, it deals with how lines of power and identity might be redrawn and society restructured along the lines of a nightmare.

Reflecting the UK's own fractured, unstable identity, all of this year's nominees share an interest in the relationship between person, system and machine.

Ninefox Gambit by Yoon Ha Lee (Solaris) is a space opera. Here, faith and culture are designed to

Floating an idea: sci-fi remains as politically relevant as ever

warp reality and soldiers are programmed to obey. A religious calendar reshapes physics and permits epic, uncanny fights involving fast-paced battle mathematics and startlingly original forms of carnage.

Colson Whitehead's *The Underground Railroad* (Fleet) is a work of historical fiction that sneaked into this shortlist on the back of choosing to make the metaphor of its title a real, dark, hand-dug network of tunnels. A stark, beautiful depiction of what we have done and what we can be, it should be taught in schools.

Tricia Sullivan's *Occupy Me* (Gollancz) follows an angel on a hunt across higher dimensions and geological ages. It's uncanny and ambitious, if uneven in tone. It's impossible not to like its hero, as she falls ever more in love with everything.

A Closed and Common Orbit by Becky Chambers (Hodder) reflects its central character's earnest

sweetness in light, joke-filled prose, even while alternating the stories of an enslaved clone and an AI struggling to adjust to a new body and a society which considers her an object.

A fractured set of interwoven stories, groggy with author Lavie Tidhar's love for a future Tel Aviv, *Central Station* (Tachyon) reflects the city's crowded, chaotic setting. But through the chaos runs a hunger for faith and connection,

"This year's collection offers grounds for hope. People still reach out for loved ones in these worlds"

as characters suck data or neck pills in an attempt to achieve a consensus reality.

Emma Newman's *After Atlas* (Roc) is a hard-boiled detective story, but our investigator is no hard-living swaggerer in a trench coat; no, Carlos is an indentured servant whose every word and movement is monitored by the owners of his contract. Newman depicts his traumas and precious small triumphs – a good meal, a smile of kindness – with as much care as she unveils a plot that reaches from a bloodied hotel bedroom to the stars, weaving in faith, family and brutal betrayals.

If individually the novels cover a thrilling range of horrors and monsters, as a collection they offer grounds for hope. In these worlds of chips, nodes or artificial assistants, people still reach out to loved ones. Even owned and tortured characters find fragments of joy, and the will to fight for more. ■



LEEF MARTIN / MILLENIUM IMAGES

Lydia Nicholas is a researcher in data and culture

A very British coup

Major Chinese fossils take the UK by storm, finds **Graham Lawton**

Dinosaurs of China: Ground shakers to feathered fliers, Wollaton Hall, Nottingham, UK, until 29 October

THE city of Nottingham knows a thing or two about punching above its weight. In 1979, Nottingham Forest won the European Cup – possibly the greatest feat in the history of English football. In 1980, they did it again.

The story of a hitherto-unfashionable Nottingham institution pulling off a major coup has just repeated itself. Landing Dinosaurs of China is possibly the greatest feat in the history of English natural history museums. It is the first time many of the world's most important and iconic dinosaur fossils have travelled outside China. Some have never even been seen by the public before. When it is over, they will return to Beijing. Nottingham 1, The Rest of the World 0.

It is not a large exhibition – just 23 specimens in four galleries – but what it lacks in size it makes up for in impact. *Sinosauropoteryx*, *Microraptor*, *Mei long*, *Gigantoraptor*: these feathered dinosaurs have changed our understanding of prehistoric life.

The first to be discovered was *Sinosauropoteryx*, which came to the world's attention in 1996. It was found in early Cretaceous deposits in Yixian, north-east China. Yixian is a lagerstätte: a site of exceptional fossilisation where soft tissues are often preserved alongside bones and teeth. Around 120 million years ago, it was a forested wetland next to a volcano. Frequent eruptions and

toxic emissions killed the local fauna, covering them in ash or sending their corpses to the bottom of lakes where they were rapidly buried. "That's the reason we've got soft tissue preservation, which is what makes them so special," said TV presenter Chris Packham, who opened the exhibition.

The *Sinosauropoteryx* – a small, predatory theropod – is so finely preserved that a halo of soft tissue is visible around its skeleton. Palaeontologists interpreted this as a coat of downy feathers, probably used for display or insulation. The specimen in the exhibition is the original fossil, a piece of dinosaur royalty.

To me, it was like seeing the *Archaeopteryx* in Berlin's natural history museum: familiar from magazines and books, but unexpectedly vivid in the flesh. No amount of studying reproductions quite prepares you for the original.

Sinosauropoteryx was quickly

followed by other downy dinosaurs, including the velociraptor-like *Sinornithosaurus* and tyrannosaur *Dilong*. Both are represented here by replica specimens. There is also the genuine holotype specimen of *Caudipteryx*, which had long feathers on its arms and tail. A holotype is a unique specimen defining a new species. "These are

"It is the first time that many important dinosaur fossils have travelled outside China"

the pieces of evidence that prove beyond any doubt that dinosaurs have feathers, and that birds evolved from dinosaurs," said the exhibition's curator, Adam Smith.

Another butterflies-in-the-stomach moment is seeing the holotype of *Microraptor gui*, the four-winged dinosaur first described in 2003. Though probably a glider rather than a flier, it had well-developed flight

feathers on its arms and legs. This adds weight to another controversial hypothesis: that the evolution of flight went through a four-winged stage.

The bird-dinosaur link is made even clearer by a 3D-printed model of the exquisite *Mei long*, the sleeping dragon, its head tucked under its forearm like a sleeping bird. There are also fossils of early birds themselves.

The mover and shaker behind the show is Wang Qi, an assistant professor of architecture at the University of Nottingham. He started work with the Institute of Vertebrate Paleontology and Paleoanthropology in Beijing in 2011, just as it was renovating its own museum.

This is a once in a lifetime opportunity. Nottingham Forest will probably never win the European Cup again. These rare research specimens may never be put on public display again. If you're a fan, you need to be able to say: I was there. ■



Take a good look: China's important finds are unlikely to travel again

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Questions regarding this position can be addressed to alvarez@wjh.harvard.edu. The committee will consider completed applications starting immediately on a rolling basis through October 1. Interviews will be conducted in late September and continue in October.

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Further information about the Scholarships and application forms as well as links to the individual Departments and Institutes and their research themes may be obtained through the Academic Programs section of the WHOI web pages at:

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John E. Burris, Burroughs Wellcome Fund

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Up to 25 institutions will receive a \$30,000 planning grant, and will be invited to develop full proposals for the \$2.5 million awards.

"The low and declining number of physician-scientists is a serious issue, if we are to improve the health of all citizens," says **John E. Burris, PhD**, President of the Burroughs Wellcome Fund.

We need to increase the number of MD's who enter careers in biomedical research. That personal experience of caring for patients can bring a novel and necessary perspective to the discovery of new treatments of diseases. So, we want to jumpstart innovative programs and help create more opportunities for medical doctors to pursue and remain in biomedical research."

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Application Requirements

- Degree-granting institutions in the United States or Canada are eligible to apply.
- Proposed programs must account for how MD-only researchers will be engaged and trained, in addition to MD-PhD pathways. They must also describe plans for encouraging and recruiting student participants.
- Institutional commitments must be outlined, including plans for continuation after BWF funding concludes.
- Pre-proposals for the \$30,000 planning grant are due on **28 September 2017**. For full RFP and details, please visit www.bwfund.org.



John E. Burris, Burroughs Wellcome Fund

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EDITOR'S PICK**Consciousness and intelligence are different**

*From Anthony Castaldo,
San Antonio, Texas, US*

I agree with Quentin Macilray that the brain constructs predictive models of everything, and that consciousness is a consequence of building a model of one's self (Letters, 1 July). This allows planning, which can benefit survival more than moment-by-moment

reactions, even if the "plan" is for just a few seconds into the future.

Many creatures, including apes, corvids, dolphins and elephants, show signs of consciousness and an ability to solve novel problems – in the short term. My dog is clearly conscious of himself, but he isn't intelligent enough to use a stick as a weapon, though he can hold one quite firmly. It is an error to conflate consciousness with intelligence.

Humans seem to be unique in their ability to consider abstractions of abstractions to nearly any level. This gives the ability to solve problems requiring thousands of steps and create plans spanning decades. It has apparently evolved only once. Alien life may be common in the galaxy, but with intelligence limited to levels analogous to non-human earthly animals.

Mixed responses to kidney donation

*From Richard de Solderhoff,
Edinburgh, UK*

Clare Wilson describes clearly the situation in the UK for altruistic kidney donation (24 June, p 36). I donated my left kidney six months ago. Some prefer to call this non-directed donation (as opposed to an act directed to a family member).

In one of the many interviews in the screening and assessment process I was described as "typical" of kidney donors. What factors affected my decision? I know someone who had been on dialysis and had a transplant, so I know the life-changing result for the recipient, family and friends. And I am aware that I can function perfectly well with one kidney.

A life in a caring profession, involvement in volunteering and

being fit and active with no history of significant illness made me a more likely candidate. Other relevant factors were being retired and having time to go through the lengthy process, and living within easy access of one of the 24 UK transplant centres.

And the consequences? The first two days after surgery were, admittedly, rather uncomfortable. But I was climbing a Scottish peak with my walking club in less than four weeks. An unexpected, anonymous letter from "your grateful recipient" confirmed that this "miracle" of modern medicine was achieved. We donors all say the same: it's the best thing we have ever done.

*From a reader,
Newbury, Berkshire, UK*
I've changed my mind about donating a kidney after discovering that rapists and

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"No, the solution is empowering women to fully own their reproductive agency"

Zola answers the question of whether we should impose population controls in the face of our impact on Earth (8 July, p 28)

murderers are on the organ waiting lists.

Also, the UK's National Health Service Blood and Transplant organisation promotes kidney donation with examples of recipients with type 1 diabetes and other "not-your-fault" conditions. Yet most kidneys are needed for type 2 diabetes, linked to lifestyle choices. However you feel about conditions linked to lifestyle, this is an advertising-type appeal by the NHSBT.

*From Peter Seligman,
Brunswick West, Victoria, Australia*
You focused on purely altruistic transplants. Another scheme, in use in Australia and at Johns Hopkins hospital in the US, involves people who would like to donate to a family member or friend but are incompatible.

These donors are "pooled" so that a donor can give to a

compatible person, not just to the recipient with whom they have a connection.

Brains automatically make consciousness

*From Norman Bacrac,
London, UK*

Anil Ananthaswamy seems to dismiss Thomas Henry Huxley's view that consciousness is an "epiphenomenon" – a mere side effect of the brain's workings (1 July, p 8). He accepts the assumption of cognitive psychologist Eoin Travers that a brain process accompanied by consciousness must be caused by that conscious experience.

However, the experiments he describes don't seem to distinguish between simultaneous neural and experiential processes. Were the neural events of no consequence, then, while the

conscious events were present? Isn't it more likely that the "rapid learning" so admired by Thomas Metzinger was due to the evolved brain processes themselves?

Consciousness surely evolved as an automatic consequence of novel, large-scale brain activity. It is only we humans who may choose to affirm its supreme value and give it a point – and who strive to diminish its all-too-often unpleasant manifestations in the human world.

Relational reasoning in other animals

*From Virginia Lowe,
Ormond, Victoria, Australia*

Freddy Jackson Brown and Nic Hooper say chimps can't do relational reasoning (3 June, p 38), and artificial intelligence struggles with it (17 June p 12). It is probably the basis for human language. But

surely seeing and using a thing as a tool would count as relational reasoning. Are we meant to believe that no animal recognises bigger or riper fruits? What about a chimp cuddling a log as a "doll"?

I would like to see more tests devised for chimps, dolphins, elephants, crows, octopuses and other species.

Geoengineering, forests and power engineering

*From Helena Kettleborough,
Manchester, UK*

Thank you for your excellent update on climate change (24 June, p 28). On the question of geoengineering, I would suggest considering bioengineering.

This would involve planting billions more trees globally and preserving the trees we already have in endangered forests. Communities are already doing ➤

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this, for example in the Green Belt Movement in Kenya. Planting trees empowers communities.

From Perry Bebbington, Kimberley, Nottinghamshire, UK
You show installed fossil fuel and renewable generating capacity on one graph as if they are interchangeable. But fossil-fuelled capacity can generate at any time demand requires it. The output of renewable capacity, in particular wind and solar, depends on the weather rather than demand.

So how should government work?

From Tony Richardson, Ironbridge, Shropshire, UK
Pam Manfield considers how democracy operates, or how it should (Letters, 17 June). Such scrutiny is particularly necessary today. As never before, we need democracy underpinned by scrupulous objectivity and rational thought and action.

It may be argued that our society is more complex than in Athenian times. As former UK

prime minister John Major said in a recent BBC interview, the issues around Brexit were poorly understood by the electorate.

This is why we have representative democracy, and why holding a referendum was such a serious error.

In principle, we are led by those who have greater expertise and time than the general electorate to debate and to make decisions in society's interests. But too often MPs vote to support their own and their electorates' prejudices.

In the UK, rationality is ranged against newspapers' resources, combined with massive inputs of money and the secretive use of big data by doctrinaire and selfish interests. The effect is to return us to levels of irresponsible and unaccountable influence on our democracy that far exceed those of the Rotten Boroughs abolished in 1832 by the Great Reform Act.

From Bryn Glover, Kirkby Malzeard, North Yorkshire, UK
I am a little surprised that no one seems to have mentioned that for several hundred years we in the UK have been applying sortition

to an important feature of our way of life – the selection of juries. It seems to work OK.

From David Nichols, Wareham, Dorset, UK
Pam Manfield doesn't mention the majority of Athenian residents who were unable to participate in democracy: slaves. The so-called source of Western democracy was based on slavery.

We need sound fisheries management and data

From David Ardill, Vacoas, Mauritius
In her interesting article on seeding oceans with iron to boost fish stocks, Olive Heffernan says that "fisheries... could be exhausted by 2048" (10 June, p 24). This is based on a simplistic extrapolation of catch reductions recorded in the UN Food and Agriculture Organization "nominal catch" database.

As executive secretary of the Indian Ocean Tuna Commission for six years, I support the view that although some fisheries are overexploited, many are well

managed. I was previously responsible for the FAO database and maintain that these data cannot be used in this way.

Sound fisheries management is obviously extremely important, in particular for populations for which fish is the only source of animal protein. Please don't devalue the efforts of the many scientists and managers working to ensure that we will have fish to eat in the future.

From Tim Parsons, Brentwood Bay, British Columbia, Canada

Heffernan says that "there was no firm evidence of benefits to the salmon population" from the iron addition made with funding from the Haida community. Definitive proof may be lacking, but the run of Fraser river sockeye salmon was reported to be at least 10 million in the three-year period following the addition – a large increase.

Gongs all round again

New Scientist Live continues to collect prestigious awards, winning the Association of Exhibition Organisers' Best Consumer Show Launch and Marketing Campaign of the Year (Consumer), and then polishing off the awards season with the coveted Professional Publishers Association Event of the Year (Consumer Media). Congratulations also to event sales executive Laura Giddings, who was named as one of *Exhibition News'* Thirty Under 30 for 2017.

For the record

■ The spokesperson for the Royal College of Psychiatrists who we quoted is Mark Salter (8 July, p 28).

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TOM GAULD



MAKE

Do try this at home



RUSSELL COBB

Digital buddy knows when you're too tipsy to tweet

Better than a breathalyser – build a clever coaster that keeps you off social media when you've had one too many

"I enjoy a quiet drink at home," says Michael Bacchus. "Trouble is, a few beers in I find myself tweeting *Game of Thrones* spoilers. Can you help me avoid upsetting my friends?"

Embarrassing tweets happen to us all: that's why every 28 April we celebrate Ed Balls day, and every time I've had some wine I wax lyrical about Patrick Stewart. Could a digital drinking buddy keep me in check?

First, I needed a way to measure my drinking. A reed switch inside a coaster could detect when I raised my glass, but would require magnets to be glued to my glassware. With visions of tumblers stuck to the sides of my dishwasher, I settled on a force-sensitive resistor to measure pressure.

Tracking the total weight of booze didn't work: topping up my glass convinced the coaster I'd drunk a negative amount of wine. Counting sips was simpler. Now, what to do once the coaster knows I'm buzzed?

I added a Feather, a tiny, Wi-Fi-enabled circuit board made by Adafruit, to my

coaster. Having it access a parental control app to lock my phone proved error-prone. With an internet-linked power socket, I could trigger the nuclear option and cut power to my router, but this would also take out Netflix – unacceptable collateral damage.

So I turned to If This Then That (IFTTT), an online service that allows thousands of apps and devices to interact. My coaster could now send warning tweets on my behalf, but this was more damage limitation than protection. Then I hit on the purr-fect solution.

Twitter limits how many tweets you can send in an hour. Going over triggers a temporary ban. If my coaster could tweet enough cat pictures to put my account on lockdown, I couldn't post anything embarrassing. In hindsight, one cute cat every 100 milliseconds might have been overkill. But it definitely landed me in Twitter jail. Result: a super-effective coaster – although my digital cat cannon may prove more annoying than *Game of Thrones* spoilers.

Hannah Joshua ■

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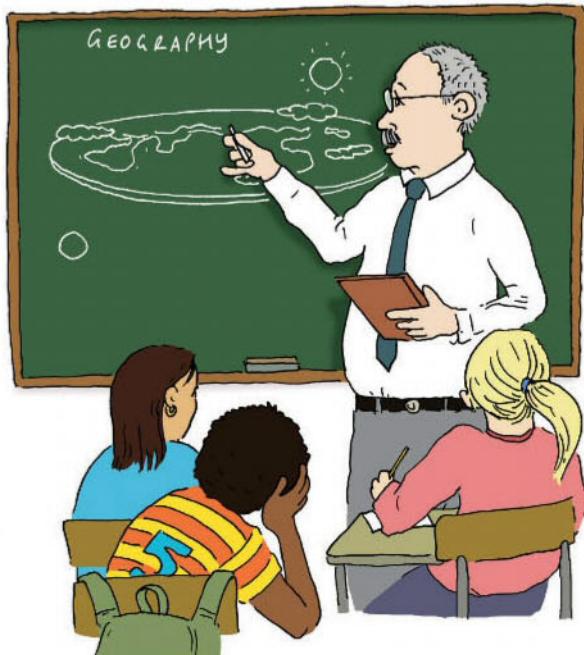
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MANY British readers may be feeling uneasy that their government has formed a coalition with Northern Ireland's DUP, whose anti-science positions include one assembly member's call for creationism to be taught in all schools to counter the "peddled lie" of evolution.

The US has long been pioneering efforts to rejoin church and state. A recent innovation is found in Florida, where state governor Rick Scott signed into law legislation allowing any resident to challenge educational material used in public schools. Passed under the auspices of empowering parents, critics warn that the bill will allow people to target the teaching of evolution and climate change in classrooms.

Feedback can only assume that the Sunshine State's mathematics professors will soon have to find a way to make π equal 3, sex educators teach the controversy over stork deliveries, and rockets blasting off from Cape Canaveral recalibrate for a geocentric model of the cosmos.

PAUL MCDEVITT

Gloucestershire Live informs Eugene Doherty that resurfacing a local road will use 770 tonnes of material, "equivalent to 855 adult kangaroos in weight". Well, that clears that up.

sonograph. Yes, it seems no niche is too small to be defended these days, though how the fetus feels about this public debate over his private moment remains unknown.

THERE are very strange goings-on with the timekeeping of Andy Bebbington's timekeeper (8 July), says Jan Meulendijk. "By my reckoning, using Central European Time would make the man show up an hour early rather than late, unless of course he had managed to set his clock back by 2 hours when he arrived on UK soil."

PREVIOUSLY we scratched our head over the scentless perfume offered by Josie Maran (3 June). Stuart Gillies writes "the bigger puzzle is the widely available perfumed deodorant, which by definition cannot be".

OUR search for units of measurement named after women, and related eponyms, has borne little fruit. Mary Hancock asks: "Would you count Lazy Susan and Spinning Jenny as science or engineering eponyms relating to a woman's name?"

Both of these are named for a woman, yes, but sadly neither seems to be a real one. A scan of the history books reveals no evidence that Susan or Jenny existed in corporeal form.

BAD news for those expecting a happiness boost from lithium-laced water (1 July). Retired GP Ian Dunn tells us: "Lithium tends to limit the range of mood, reducing the risk of being too high or indeed too low. As far as I am aware it would do nothing to someone whose mood moves within the normal range."

He also notes that lithium is toxic and patients using it require close monitoring. We think we'll stick with tap water: it might not make people happy but it's rumoured to turn people gay (17 June).

JUMPING a bit further along the periodic table, the opening of a new children's hospital in Perth, Australia,

has been delayed, owing to the high levels of lead found in the water supply. David Curtis sends a clipping from *The Weekend West*, which reports that despite treatment, 74 per cent of samples contained safe levels of lead, 21 percentage points below the legal threshold.

Previously the treasury had claimed that compliance was at an impressive 92.5 per cent. "Shades of *Yes Minister*", says David, as the chief health officer Tarun Weeramanthri put the discrepancy down to "a rounding error".

THE road is long, and drivers can often find packs of mysterious supplements for sale in service stations to fuel their wakefulness. Jeremy Dean spots an example in Portland, Maine, more questionable than most, as each selling point only leaves us with more questions.



"Over 2000 mg of energy in every bottle," it proclaims, "0 sugar, 0 carbs, 0 calories", and adding for good measure – given the target market – "No crash!"

Jeremy wonders what form of energetic substance would be sold in grams, and why it doesn't contain any calories if it's meant to be consumed. He says: "Maybe this is where the universe is hiding all that dark energy?"

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Remote scenting

How far away can flies smell potential food? We see very few flies in our garden, yet by the time a sparrowhawk had finished his breakfast on our lawn a few days ago, the remains were covered with flies. Do they hold a record for keenness of sense of smell versus their size?

■ There is no particular limit; a gentle breeze can carry aromas of guts and flesh for hundreds of metres.

Flies, like polar bears, will follow such a scent upwind for as long as they can detect it, covering surprising distances within minutes. If they lose the scent, they veer back and forth across the wind until they relocate the trail or give up and try elsewhere.

During a sparrowhawk's meal, a light, steady breeze could attract flies from perhaps a kilometre downwind to join the party. However, the flies you notice in your garden are a minority of those present. More flies of more species than you realise pass through all the time, seeking opportunities to dine or lay eggs.

*Jon Richfield
Somerset West, South Africa*

■ Insects detect odours with their antennae, which are densely covered in hair-like structures containing olfactory sensory nerve cells. Flies arrive at a carcass within minutes of death, but they will generally be attracted to the strongest odour, which depends on the size of the

body, the wind direction and local topography. The carcasses of a herd of cows could attract flies from 7 kilometres away, but because it could take a fly days to reach them, a closer target might be chosen – a dead pigeon nearby, for example.

Volatile molecules called apeneumones escaping from a dead body attract insects. Decomposition generates gases such as hydrogen sulphide and ammonia. Research done more than 70 years ago found that the sulphur-based compounds attracted flies, but egg-laying was triggered by the ammonium-rich compounds, released slightly later.

Flies of different species deposit their eggs in a cadaver at well-defined times following death. Identification of the

"Flies of different species deposit their eggs in a cadaver at well-defined times following death"

resulting maggots allows forensic entomologists to estimate the time of death.

The Washing Away of Wrongs by Sung Tz'u describes how insects were used to investigate after a farmer was found dead in a field in 13th-century China. All the suspects were asked to lay down their sickles, and the one that attracted the blowflies was deemed to be the murder weapon. Its owner later confessed.

*Mike Follows
Sutton Coldfield, West Midlands, UK*

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Never bettered

During a recent cycle ride I was passed at some speed by an ancient Rolls-Royce car, which was far and away the quietest vehicle I encountered all day. Given the huge advances in engineering, materials and design techniques in the 60 or 70 years since that car was built, why can't today's car manufacturers get close to crafting a car with such a quiet engine, so little tyre noise and a lack of discernible wind noise?

■ Your questioner was impressed by the silence of the ancient Rolls-Royce, but perhaps it's first worth mentioning the car's fuel consumption or its wet-weather handling.

That old Rolls-Royce is propelled by a woefully inefficient, low-revving petrol engine with huge cylinders. The pressure generated by the exploding fuel-air mix in these big cylinders is quite low. This makes it very quiet because there are fewer exhaust pulses per minute, and the exhaust pressure is low. An old Rolls-Royce is also a big car with room for a big exhaust silencer.

Modern car engines have smaller cylinders and run faster, and the exploding fuel produces higher pressure in the cylinders. More exhaust pulses, a higher exhaust pressure and a smaller silencer make it noisier, but it gets far more miles per gallon.

Modern tyres are noisy, too: this is a by-product of tread

designs calculated to pump water away from the interface between tyre and road. As long as tyres have a legal amount of tread on them and are properly inflated, however, this provides predictable and safe handling on wet roads.

The modern car is also better built where it matters than the old Rolls-Royce. The Rolls-Royce engine will need an overhaul every 30,000 to 50,000 miles, whereas a modern car engine, built for a fraction of the cost, should manage 150,000 miles with only routine maintenance.

*Richard Ellam
Bristol, UK*

This week's questions

SNAP, CRACKLE, POP

I can usually make sense of my kitchen radio, even if someone else is talking or the phone is ringing. This isolation of a single noise among others is known as the "cocktail party effect".

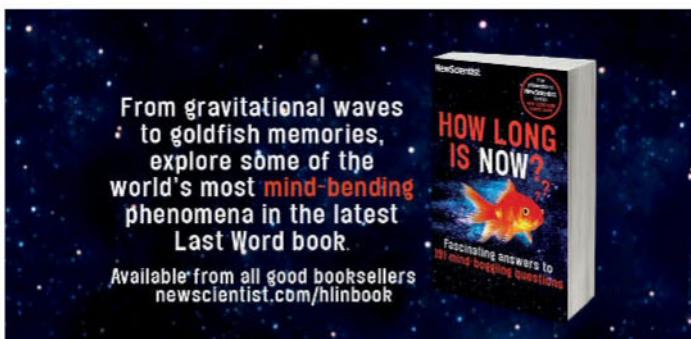
However, just crumpling the bag inside a cereal packet renders any other sound unintelligible. Why?

*Duncan Hutchinson
Newton Abbot, Devon, UK*

YOU MUST BE YOLKING

My wife recently broke three eggs into the frying pan in quick succession, and all were double-yolked. Does this mean there would have been three sets of chicken twins?

*Dave Hulme
Stockport, UK*



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