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WEEKLY December 2 - 8, 2017

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SPECIAL REPORT

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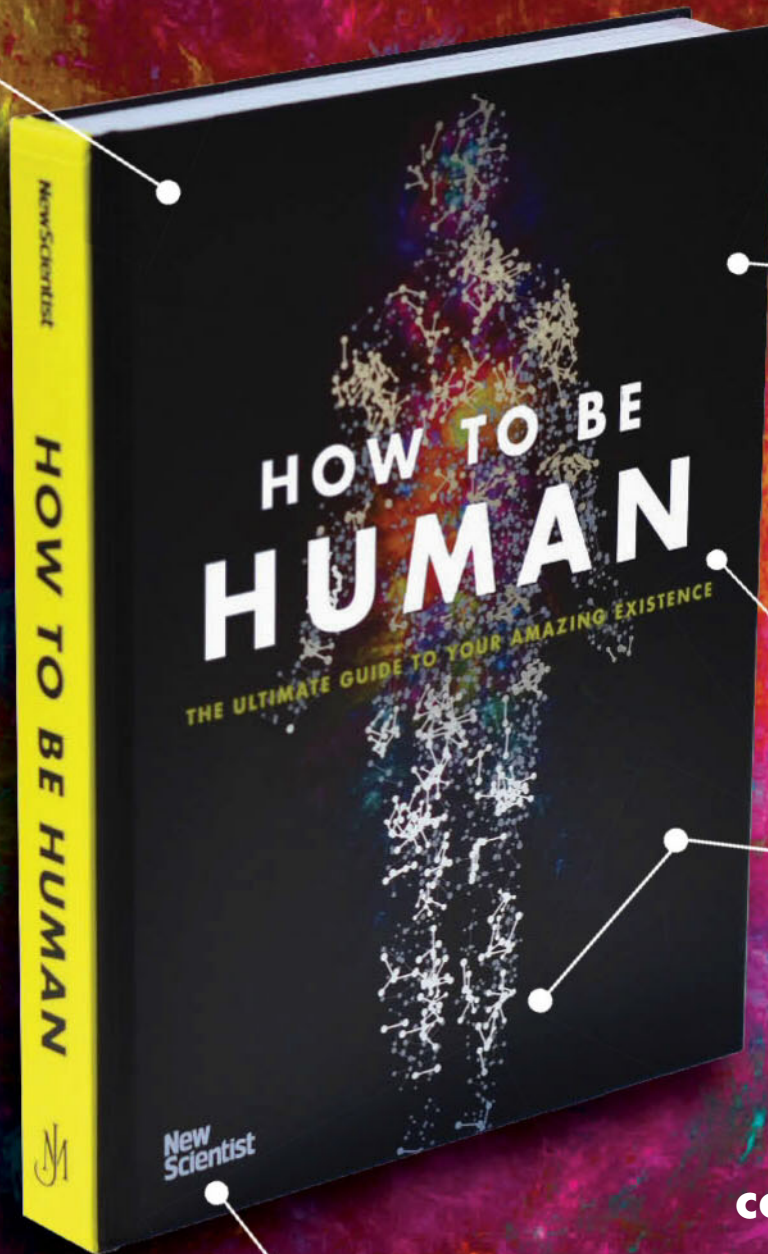
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Raw versus cooked

Humanity will need the equivalent of 2 Earths to support itself by 2030.

People lying down solve anagrams in 10% less time than people standing up.



About 6 in 100 babies (mostly boys) are born with an extra nipple.

60% of us experience 'inner speech' where everyday thoughts take a back-and-forth conversational style.

We spend 50% of our lives daydreaming.

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Whichever way works

Child welfare is a bogus argument against social change

PEOPLE of a certain age may remember school sociology lessons debating the merits of the nuclear family – mother, father and their biological children – versus the extended family, a tight-knit local network of grandparents, parents, children, aunts, uncles and cousins.

That debate is rarely heard nowadays. The discussion – and angst – about the optimal family structure has changed. More than half the children in the UK and US are now being brought up outside a nuclear family, and not because of any great revival of the extended family. Thanks to the rise in reproductive technologies, egg and sperm donation and permissive social attitudes, couples or single people who couldn't previously have started families now can. As our special report starting on page 30 explains, a giant social experiment is under way.

To some people, any deviation from the norm is unacceptable – especially if it involves same-sex relationships. In the run up to Australia's national survey on gay marriage, shocking posters appeared in Melbourne claiming that 92 per cent of children raised

by same-sex parents are abused, 51 per cent have depression and 72 per cent are obese.

There will always be people prepared to spread fake news to further their agenda. But amid the bigotry, they do have one valid point: the welfare of children must always trump the desires of would-be parents.

So what does the evidence say? The stats on the poster do come from real studies, albeit ones that have been debunked. The scientific consensus is the exact opposite. The near-unanimous

“More than half the children in the UK and US are being brought up outside a traditional family”

conclusion from a body of long-running studies on the emotional and psychological health of children brought up in non-traditional families of all kinds is that there is nothing to worry about, over and above regular concerns about child welfare within any family. Some studies even suggest that welfare is higher in families that have used IVF, simply because of the emotional investment made to start them.

There are other issues around identity and relatedness. Starting a family with the help of a donor raises all sorts of questions: what traits will my child inherit? How will our relationship develop if we know we are not genetically related (see page 33)? Here the research is a little less clear, but the emerging message is the same: there is no extra risk to children brought into the world in this way.

These findings are beginning to feed into legislation. In the UK, for example, same-sex parents can now be the joint parents of children born through assisted reproduction. But progress is slow. In France, IVF was legal only for married couples until 2013. And then, when gay marriage was introduced, the rules were rewritten to specify only married heterosexual couples.

In 30 years time, the debate over alternative family structures will appear as quaint as that over the nuclear and extended families. In the meantime, people who use the “think of the children” argument to promote the status quo ante should accept that we have thought about them, and the kids are doing just fine. ■

Volcano poised to blow

A MASS evacuation has been ordered from a 10-kilometre danger zone around the Mount Agung volcano on the Indonesian island of Bali. Around 40,000 people have already fled.

The volcano began erupting on 24 November. Explosions hurled clouds of white and dark grey ash 3000 metres into the atmosphere, and lava welled up into the crater. Mudflows, caused by the ash mixing with rain, flowed down some valleys. As *New Scientist* went to press, it was feared an even larger eruption could occur.

The ash clouds reached the island's international airport on Monday, forcing it to close and stranding tens of thousands of travellers. Volcanic ash can damage jet engines.

It can also irritate eyes and make

breathing difficult, and heavy build-ups can cause roofs to collapse and smother crops. Soldiers and police distributed masks over the weekend as ash began to settle on villages and resorts around the volcano.

Mount Agung can be a highly dangerous volcano. Its last major eruption began in February 1963 and killed 1100 people. There were two huge explosive eruptions on 17 March and 16 May, and activity continued until January 1964. Most of the deaths were caused by pyroclastic flows.

A large eruption that sends ash into the stratosphere could temporarily cool the planet by 0.1 or 0.2°C, as the 1963 eruption did. However, this cooling effect would be short-lived so wouldn't help stop climate change.



SONNY TUMBELAKA/AFP/GETTY IMAGES

Blasting ash into the sky

Hack the NHS

THE UK's National Health Service (NHS) announced a new central Security Operations Centre on Monday, part of a £20 million project to improve cybersecurity across its trusts.

To monitor for potential threats, the centre will probe the integrity of NHS systems through "ethical hacking". This is the practice of trying to break into a computer system to identify its weaknesses – before malicious attackers can find and exploit them.

"Ethical hacking is about trying to find a system's weaknesses before malicious hackers do"

The NHS hopes that such penetration testing could prevent devastating cyberattacks, like the one that hit in May. Ransomware known as WannaCry, designed to lock down computers and demand a payment, created dire consequences for the NHS. Thousands of appointments were cancelled and five accident and

emergency departments had to turn patients away.

A recent government report found that hospitals had been warned of vulnerabilities. Nearly a year before the attack, the Department of Health was advised to update software in an effort to prevent such a situation.

The NHS hopes the "extra specialist resources" provided by the new centre will ensure timely preparations.

Cybersecurity expert Kevin Beaumont says the new project is "a really good idea". He also points out that most large companies have similar cybersecurity operations teams these days.

But penetration testing across all 250 NHS trusts is likely to be laborious, says Alan Woodward at the University of Surrey, UK. "Hence there are still likely to be windows of opportunity for hackers and attackers," he says. He hopes the scheme doesn't result in NHS managers believing that cybersecurity is something they can outsource: "I fear it could lead to some thinking that unless they have been notified of a problem, none exists."

Obesity rise

AS MANY as 27 per cent of men – and 29 per cent of women – in the UK are now obese, meaning the country has one of the worst obesity problems in Europe.

An analysis of countries across Europe, north Africa and the Middle East suggests that rises in obesity and diabetes could halt the fall in deaths from heart disease in recent decades.

In countries where complete data was available, the prevalence of type 2 diabetes doubled

between 1995 and 2014, from 2 to 4 per cent on average. In high-income countries it now stands at 5 per cent.

Obesity affects 23 per cent of people in high-income countries. The UK has the highest obesity rate in men, and the second highest in women in the study (*European Heart Journal*, doi.org/cgr2).

"The effects of diabetes and obesity will check the decline [in cardiovascular deaths] we've seen over the past 50 years," says Adam Timmis at Queen Mary University of London, who led the study.

Spotlight on NASA's telescopes

ONE of NASA's next big telescopes is facing cuts due to skyrocketing costs.

The budget for the Wide Field Infrared Survey Telescope (WFIRST) has ballooned from a projected \$2 billion to at least \$3.9 billion, according to a recent report by an independent review team.

That is due to an upgraded 2.4-metre telescope and an added coronagraph, which reveals exoplanets by blocking light from their parent stars. As its scope and

scale has crept up, its launch date has slipped to the mid-2020s.

The report recommends cutting costs, noting that removing the coronagraph would save \$400 million. They won't cut that, but will reduce the science mission and alter the telescope to keep it under \$3.2 billion, wrote Thomas Zurbuchen at NASA's Science Mission Directorate in a memo. He says WFIRST remains NASA's highest astrophysics priority after the James Webb Space Telescope.

Measles hits UK

TWO UK cities were hit by measles outbreaks last week. There were 11 confirmed cases in Leeds and eight in Liverpool. All were in children who hadn't been vaccinated against the virus,

ANDREY/GETTY IMAGES/ISTOCKPHOTO



Clinging on

Farewell to lemurs?

CUTE they may be, but ring-tailed lemurs are in deep trouble, says a report listing the world's 25 most endangered primates.

Two decades ago, there were several hundred thousand of these lemurs on Madagascar. But a census in the *Primates in Peril* report shows there are now 2500 to 3000.

"It's so dramatic, we felt we had to highlight it," says lead editor Christoph Schwitzer of

"Two decades ago, there were several hundred thousand of these lemurs. Now there are 3000"

Bristol Zoological Society, UK.

He says there are three major factors driving the rapid decline. One is the desperate poverty that drives citizens to kill lemurs for food: 69 per cent of the population live on less than a dollar a day. This is aggravated by long-standing political instability and corruption, which has led to donor aid being withdrawn.

Next, poverty has forced people to turn to small-scale, subsistence rice farming, which is eating into the lemurs' habitat. "We're seeing very high rates of habitat loss exacerbated by the political instability," says Schwitzer.

The final factor is the pet trade.

Baby ring-tailed lemurs are often captured and sold to hotels and restaurants to amuse guests.

The situation can only be reversed if Madagascar stabilises, says Schwitzer. That, in turn, depends on international help to address the extreme poverty. "Conservation does work, but we need to double or treble our efforts," he says.

Cleaner air

VEHICLE fumes are deadly, but levels of one pollutant, nitrogen dioxide, may have peaked in Europe. "It's not air quality solved or anything, but it is positive," says Stuart Grange at the University of York, UK.

Nitrogen dioxide (NO₂) is blamed for tens of thousands of deaths in Europe each year. A related chemical, nitric oxide (NO), is also released, and changes into NO₂. The two are called NO_x.

Grange's team analysed data from nearly 500 monitoring stations in Europe. From 1995 to 2010, the proportion of NO_x that was NO₂ grew, probably due to extra diesel vehicles, which governments supported as they emit fewer greenhouse gases than petrol ones. Since 2010, NO₂ levels have either stabilised or fallen (*Nature Geoscience*, doi.org/cgr3). But they remain well above recommended levels.

Bitcoin's bull market

The digital currency bitcoin is nearing the \$10,000 mark for a single bitcoin – a 1240 per cent increase from its price of \$730 last year. In early October, a bitcoin cost around \$5000. The jump in price may be spurred by a glut of new buyers. Coinbase, the largest bitcoin exchange in the US, added nearly 100,000 accounts last week.

No asteroids needed

Asteroids have been seen as the best candidates for how life could spread between planets. But it may also be possible for space dust to collide with biological particles in a world's upper atmosphere at high enough speeds to send them into space (arxiv.org/abs/1711.01895).

Big-beaked birds

Evolution usually moves at a snail's pace, but not always. North American birds called snail kites have evolved larger beaks in less than a decade, in order to eat invasive island apple snails that are much larger than the snails they used to eat (*Nature Ecology & Evolution*, doi.org/cgrv).

Teen brains

Adolescents' brains aren't developed enough to adapt to high-stakes situations, which may explain why some engage in risky activities. Brain scans of teens playing a game found that the older they are, the better they adapt their behaviour to high-risk or low-risk situations (*Nature Communications*, DOI: 10.1038/s41467-017-01369-8).

Rocks on the move

Huge, mysterious rocks high on sea cliffs were dumped there by storms and tsunamis. Boulders weighing 30 tonnes each on Annagh Head, Ireland, were carried there by centuries of storms, while similar boulders on the Matheson Formation in New Zealand were probably deposited by a single, massive tsunami (*PNAS*, doi.org/cgrt).

"The number of children in England receiving the vaccine has dropped for the third year in a row"

according to Public Health England.

In order for a population to be protected by herd immunity, 95 per cent of people need to be immunised against a virus. At this level, it is difficult for the virus to spread. But this year, the proportion of children in England receiving the MMR vaccine – which protects against measles, mumps and rubella – dropped for the third year in a row, down to 91.6 per cent.

In the US, 120 people are reported to have caught measles so far this year. Although it was declared "eliminated" in the US in 2000, many people pick up the virus while travelling.

An investigation by the US Centers for Disease Control published last week found that two outbreaks related to unvaccinated people catching the virus abroad cost public health agencies more than \$68,000 to monitor, treat and control.



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Will it take off?

'Virgin birth' stem cells get test run

A new kind of treatment sidesteps the ethical issues of embryonic stem cells

Clare Wilson

A NEW type of stem cell has been tested in people for the first time. Derived from "virgin births", the cells have been injected into the brains of people with Parkinson's disease, and will soon be tried out as a way of fixing physical brain injuries.

Like embryonic stem cells, these cells could be a powerful treatment for a range of diseases. Embryonic stem cells can theoretically be used to make or heal any part of the body, but they come from fertilised and discarded human embryos, which some people believe is unethical.

However, the virgin birth stem cells come from unfertilised eggs, so no life is created or ended. This means they could be seen as morally equivalent to cells made from sperm, according to Daniel Brison at the University of

"Because the cells can be created years in advance, they can be given extensive safety testing"

Manchester, UK, who wasn't involved in the work. "An unfertilised egg doesn't have any potential for human life."

Virgin births occur in a range of animals from aphids to worms, and occasionally in larger species like sharks and Komodo dragons. Through a process called parthenogenesis, females of these species can make eggs divide to form embryos without the eggs needing to be fertilised by sperm.

But this doesn't happen in mammals. If unfertilised human eggs are coaxed into dividing in the lab, they die after a few days. However, stem cells extracted from these balls of cells before

they die seem, like stem cells taken from embryos made using fertilised eggs, to be able to become any type of cell.

People with Parkinson's disease have previously shown improvements when given transplants of fetal nerve cells that release the chemical dopamine. This probably helps because the condition is caused by the death of cells in the brain that normally make dopamine, leading to symptoms like tremors. But these transplants come from aborted fetuses, meaning the supply of such cells is limited.

Now, instead, Russell Kern of US firm International Stem Cell

Corporation and his team are giving people with Parkinson's disease transplants of neural stem cells developed in the lab from parthenogenetic stem cells. Work in animals suggests that some will develop into neurons that release dopamine several months after injection.

Unknown power

Preliminary results show that, of the six people treated so far, there have been some improvements in symptoms, such as a shortening of periods when they are unable to move, the team told the Society for Neuroscience meeting in

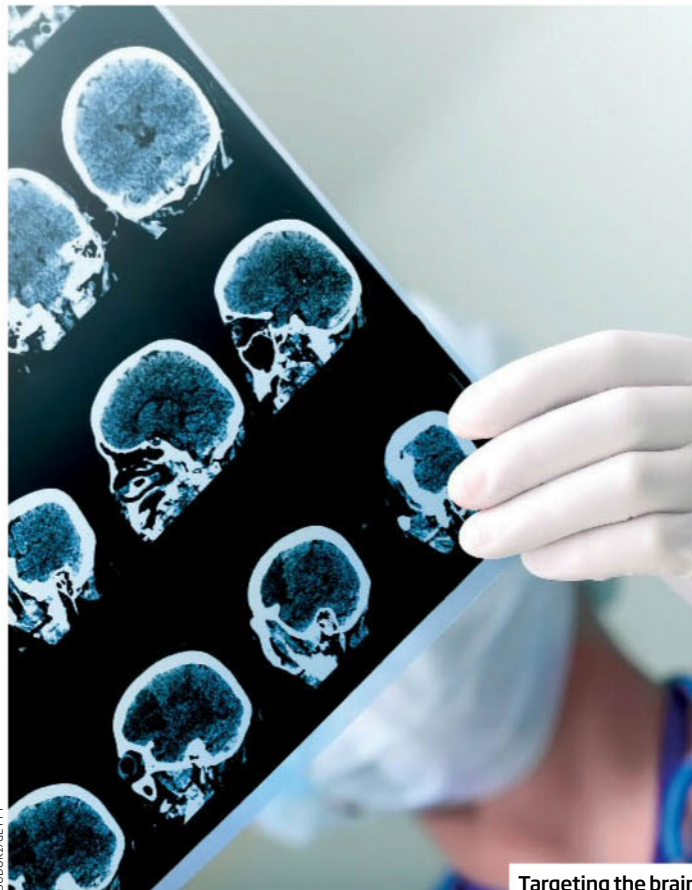
Washington DC in November.

However, it will take a larger, placebo-controlled trial to know for sure if the cells are effective, partly because Parkinson's disease seems particularly susceptible to the placebo effect.

Because the brain is relatively shut off from the immune system by the blood-brain barrier, the parthenogenetic cells don't need to be immunologically matched to each person for the treatment of Parkinson's disease and brain injuries. Patients are taking a modest, one-year course of immune-suppressing medicines, though, to be on the safe side, says Kern. Long-term immunosuppression would be needed if the cells are implanted elsewhere in the body.

Unlike some types of stem cell treatment, parthenogenetic stem cells aren't tailored for their individual recipients. One advantage of this is that they can be created years in advance and given extensive safety testing, says Kern. This means the cells might avoid the risks of induced pluripotent stem cells, which can be personalised by making them from a patient's skin cells, but are created in a way that can induce potentially cancer-causing mutations.

On the other hand, we still don't know if the virgin birth stem cells really have the same capacity for regeneration as embryonic stem cells. Sperm and egg cells have different patterns of chemical "imprinting" that affect the activity of different genes, so stem cells derived solely from eggs may have unusual imprinting patterns. Kern says tests show that this doesn't affect their ability to turn into dopamine-making neurons, however. ■



Targeting the brain

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Crab nebula's mystery flashes solved

WAVES of charged particles slamming into gas and dust may be responsible for unexpected super-bright flashes in the Crab nebula.

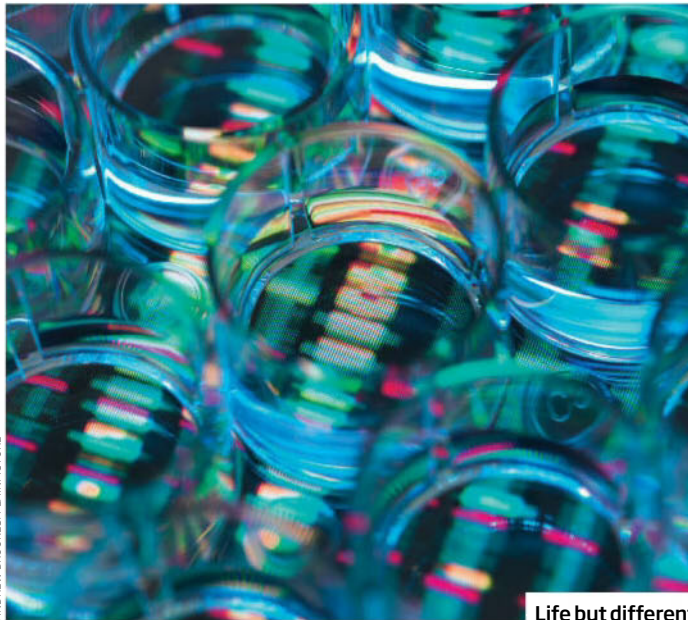
At the heart of the nebula is an ultra-dense neutron star - a pulsar whose magnetic field generates intense beams that, as the star spins, shine like a lighthouse. Pulsars are some of the most regular objects in the cosmos; the Crab nebula's spins 33 times per second and produces steady electromagnetic radiation.

In 2011, telescopes observed unusual short-lived gamma-ray bursts in the Crab hundreds of times brighter than its normal emissions. But the source of the flashes was a mystery. Now, Gwenael Giacinti and John Kirk at the Max Planck Institute for Nuclear Physics in Heidelberg, Germany, have pinned the bursts on charged particles such as electrons and positrons that flow from the pulsar at near light speed, like a constant breeze.

"We propose that at some moments you have pockets inside this wind" where the density of electrons and positrons drops, says Giacinti. Lines of an electromagnetic field usually keep a constant current. When they hit these lower density pockets - where charged particles contain more energy per particle than in higher density regions - that current is disrupted.

At this point some of the particles' energy converts into kinetic energy, causing electrons and positrons to accelerate and smash into the nebula's gas and dust (*Physical Review Letters*, doi.org/cgqc). The effect is similar to the behaviour of a circuit containing an inductor. Should the current in the circuit suddenly drop, the inductor - which acts to smooth out the electric current - will try to rapidly counteract the loss with a huge pulse, often resulting in a spark.

Giacinti and Kirk calculated that this phenomenon should produce bursts in the Crab nebula with almost exactly the same energy as the observed emissions. Adam Mann ■



ANDREW BROOKES/FLANPICTURE

Life but different

Two new letters added to the genetic alphabet

THE genetic alphabet just got 50 per cent bigger. A bacterium has been engineered not only to have two more "letters" in its DNA, but to use them to make new proteins that have never existed in nature.

The genes carried on DNA are instruction manuals for making proteins, which do essential jobs like digesting food and fighting infection. The letters that make up the genetic code are molecules called bases. All known living things use the same four letters: A, C, G and T.

The new bacterium has two more synthetically engineered bases, called "X" and "Y".

Floyd Romesberg at the Scripps Research Institute in La Jolla, California, and his team have been working on X and Y for 13 years. In 2014, they moved them from a test tube into an *E. coli* bacterium. The cell was able to copy the DNA with X and Y in it, and pass that DNA to its daughter cells.

Now they have gone a step further and used the altered DNA to make new proteins (*Nature*,

DOI: 10.1038/nature24659).

"Every protein ever translated has been decoded using a four-letter alphabet, but now we've decoded proteins using a six-letter one," says Romesberg.

Cells make proteins by stringing together smaller molecules called amino acids. They do this in factories called ribosomes, which use the letters

"Every protein ever made was built using a four-letter alphabet. We're using a six-letter one"

from the DNA as instructions.

The letters are read in groups of three, such as "ACG", called codons. There are 64 possible codons, which is more than enough to specify the 20 amino acids used in nature. But Romesberg's bacterium is far more versatile. Thanks to the extra two letters, the number of possible three-letter codons jumps to 216.

The 152 new codons can be assigned to amino acids beyond

the original 20. New amino acids mean new proteins, which might be able to do different things from their counterparts found in nature.

"Work such as this shows that the genetic code... is malleable and subject to expansion," says Farren Isaacs at Yale University in Connecticut.

It is a "landmark development", says Alex Deiters at the University of Pittsburgh in Pennsylvania. It is doubly significant because the new bases are linked by a different type of chemical bond not previously used in DNA.

In the short term, Romesberg says it could lead to new protein-based drugs, improving therapies used to treat cancers and autoimmune disorders. But in the longer term, he wants to make new types of life that can do things that natural organisms can't. He suggests creating microorganisms that can target specific cells or organs in our bodies for therapies, or clean up oil spills by breaking down pollutants into safer chemicals.

"What proteins can do must somehow be limited by the building blocks they can use," says Romesberg. "If we give them new building blocks, there must be something new they can do."

Romesberg says the study is also evidence that life could have evolved in many ways, and that life on another planet could be genetically different to anything on Earth. "It's been a question for hundreds of years: are we the way we are because we're the only solution, or a solution?" he says. "In the smallest possible way, but for the first time, we have data that suggests we are merely a solution."

Romesberg's study is the latest to expand the existing genetic code. Last year, another team reported they were part way through recoding an *E. coli* bacterium with an alternate genetic code, so that it could make proteins with up to four artificial amino acids. Aylin Woodward ■

Political chat really has got dumber

Douglas Heaven

IN THE US, critics have drawn attention to what they call the “Trump effect”: a shift in norms since Donald Trump became a serious presidential candidate. Anecdotal reports say it has made racism and sexism more acceptable in public conversation. Now a study of online political discussion groups over the past 10 years shows that conversations have indeed become less sophisticated and more offensive.

Rishab Nithyanand at Data & Society, a research institute in New York, and his colleagues at the University of Massachusetts wanted to see if they could find evidence that discourse had worsened. They looked at Reddit, a social network built around discussion groups with specific topics, known as subreddits. More than 230 million people use the site each month, making it the fourth most visited in the US.

Reddit is particularly useful for finding out what people really think, says Nithyanand. Compared with Twitter, which only lets you post very short messages, Reddit supports longer and more

complex discussions. And unlike Facebook, it does not require you to disclose your identity.

The team analysed 3.5 billion comments from 25.3 million people between 2007 and 2017. They sorted the comments into two groups: one non-political, the other comprised of things posted

to politics subreddits. Noting the frequency of offensive words and phrases gave a measure of how civil the discussions were.

The non-political comments were fairly civil. The political comments were not. People were 35 per cent more likely on average to use offensive language in political than nonpolitical discussions. Political discourse was more offensive between May 2016 and May 2017 than in any other 12-month period in Reddit’s history.

To analyse the complexity of the comments, the researchers used

the Flesch-Kincaid readability test, which ranks language use on a US grade-school scale. They found that discourse in political groups had dropped on average from seventh-grade (age 12) to first-grade (age 6) levels since 2007 (arxiv.org/abs/1711.05303).

What accounts for the changes? Nithyanand and his colleagues identified a large influx of new users to Reddit’s political groups, which may have lowered the average level of linguistic complexity. Also, there were many users who had previously been active only in extremist groups, who now posted regularly in mainstream groups. Such users can take control of the tone or direction of conversations.

Another growing group of Reddit users is likely to be bots – accounts that post automatically. Nithyanand is now looking into the exact role bots may have played in lowering the quality of discourse and hopes to have results early next year.

“I wouldn’t be surprised if bots were involved,” says Julio Amador Diaz Lopez at Imperial College London’s Business School. Plenty of recent evidence suggests they played a role both in Brexit and the Trump election.

Lopez thinks we should block fake or offensive material on social media automatically, just as we block spam emails. ■



REUTERS/ROBERT GALBRAITH

Bots don't talk so good

‘Underground’ flower mimics mushrooms

THERE is a plant whose flowers bloom almost underground – and that might be how it lures in its favourite pollinators, mushroom-eating flies.

The cast-iron plant (*Aspidistra elatior*) has drab flowers that are often buried in leaf litter. Biologists have long been puzzled about how these subterranean flowers are pollinated. Slugs, small crustaceans

and insect-like springtails have all been named as possible candidates.

To find out, Kenji Suetsugu at Kobe University and Masahiro Sueyoshi at the Forestry and Forest Products Research Institute in Tsukuba studied wild cast-iron plants. “No one had conducted direct observations in the natural habitat,” says Suetsugu.

The pair went to Japan’s Kuroshima Island, where the plants are common. Over two years, they noted the visitors to flowers, and counted how many became fruit each autumn.

While many species visited, fungus gnats were the best pollinators. These

small, mushroom-eating flies adeptly navigated the flower’s petals and the flowers they visited made the most fruit (*Ecology*, doi.org/cgp7).

“The gnats were observed on multiple occasions departing from *Aspidistra* flowers with a lot of pollen grains on their bodies,” says Suetsugu.

The cast-iron plant’s flowers may have evolved to mimic mushrooms, luring hungry fungus gnats to what

“The drab flowers are often buried in leaf litter, which may be to make them look more like fungus”

looks like their favourite food. The flowers are fleshy and have a “musty” smell, similar to other plants that con fungivorous insects, like the mushroom-imitating *Dracula* orchids. If that is true, Suetsugu says, it could explain why the flowers are near-subterranean – it would make them look more like mushrooms.

The flowers look like the only other underground flowers, Australia’s *Rhizanthella* orchids, says Anne Gaskett at the University of Auckland. This may imply convergent evolution, in which unrelated species find similar solutions to problems. Jake Buehler ■

Not-so-missing galaxies were there all along

THERE ought to be more small satellite galaxies around the Milky Way than we have seen - and now, at last, they've been found.

The main explanation is simple: they were there all along, we just missed them. Stacy Kim at Ohio State University in Columbus and her team pored through data from the Sloan Digital Sky Survey. They found that extrapolating from the number of galaxies in the survey area - about one third of the sky, thus far - we should be able to detect about 200 satellite dwarf galaxies.

This number agrees with what models of how dark matter clumps together tell us we should see (arxiv.org/abs/1711.06267). "As simulations get better, they predict fewer dwarf galaxies, and as observations get better, they find more dwarf galaxies," says Paul Sutter, also at Ohio State University. "What used to be a factor of 10 - or worse - mismatch has been reduced to a factor of 2 in the past few years, and this latest work may close the final gap."

The work may also add constraints to models of "warm" dark matter, in which the huge amount of unseen matter in the universe is made of fast particles that don't interact with light. Most models of dark matter assume it is "cold" - that the particles aren't very energetic and therefore clump together more readily.

These models predict a lot of small halos: clumps of dark matter that should form galaxies. In this case, some galaxies might be "missing" because many of these halos were too small to ever attract enough matter to make stars, says Joshua Simon at the Observatories of the Carnegie Institution for Science in Pasadena, California.

Warm dark matter would lead to fewer halos and fewer dwarf galaxies. "But you can't make it too warm or too strongly interacting, or you would end up with fewer dwarf galaxies than we actually see," he says. **Jesse Emspak** ■



WELCOME TRUST.

Therapy comes to a head

Hearing voices? Giving them a face can help

FOR people who hear voices, interacting with virtual avatars that embody the voices might be key to a speedy reduction in the distress they cause.

Between 5 and 28 per cent of people will at some point hear voices that no one else hears. Not everyone is bothered by such experiences, but 70 per cent of people with a schizophrenia spectrum diagnosis have auditory verbal hallucinations (AVH) that cause severe distress.

Medication only works in about 75 per cent of cases. A form of cognitive behavioural therapy (CBT) can be helpful, but takes several months. In 2013, a pilot trial with 16 people suggested avatar therapy may give similar results, but faster.

Now a team led by Tom Craig and Philippa Garety at Kings College London has tested another version of this. They gave six sessions of emotional counselling or avatar therapy to 150 volunteers with AVH that hadn't improved with drugs.

The avatar group built a digital

representation of the entity they believed was the source of their main voice, choosing its gender, vocal characteristics and facial features. From another room, a therapist could speak to the participant in their own voice or via the avatar.

At first, therapists had the avatar say derogatory things

"I don't have guilt any more, because I could explain to the voices why their accusations were wrong"

but encouraged the participant to stand up to it. In later sessions, the therapist shifted the balance of power, making the avatar more conciliatory, for example, by having it acknowledge the person's new-found assertiveness.

The experience could be extremely frightening, says Garety, with some people initially whispering or unable to look at the computer screen. As the sessions went on, most people's anxiety eased. One participant said "Before [the sessions] I felt

passive, afterwards I felt in control. I don't have a sense of guilt any more, because I could explain to the voices why their accusations were wrong."

The participants received a recording of each session that they could listen to. Those in the counselling group recorded a positive message each week.

A few weeks after the sessions ended, the voices heard by the avatar therapy group were reported to be significantly less upsetting compared with people who had received counselling. They heard voices less often, and felt these were less powerful and distressing. The improvement was greater than that reported for CBT, and the effects lasted when the participants were reassessed three months later (*The Lancet Psychiatry*, doi.org/cgrp).

People previously thought it was counterproductive to interact with hallucinated voices, and that there was nothing to be gained by understanding what they said and how they made people feel, says Ben Alderson-Day, a psychologist at the University of Durham, UK. "This shows it is possible to have that interaction and have some kind of therapeutic change as a result," he says. **Jessica Bond** ■

Coral larvae revive Great Barrier Reef

Alice Klein

THEY are the sea's seed banks. Hubs of coral in Australia's Great Barrier Reef could help rebuild damaged areas by spreading their larvae via ocean currents. Saving these areas could be key to the future of the ecosystem.

The reef is threatened by coral bleaching, outbreaks of coral-eating crown-of-thorns starfish, choking sludge from farms on land and cyclones. Surveys from April showed that two-thirds of the reef is now badly degraded.

But there is still hope, says Peter Mumby at the University of Queensland in Australia. His team has identified 112 of 3800 coral reefs in the Great Barrier network that are relatively safe. These reefs could restore their neighbours.

The researchers looked for reefs with the best chance of surviving future stressors, and which could seed new reefs if conditions improve. They needed to be in areas with low risks of bleaching and starfish outbreaks, based on historical records. They also needed to be connected to other reefs by currents, so they could spread their coral larvae.

The refuge reefs were mainly towards the south and away from the mainland. This area is flushed with cool water from an ocean current called the South Caledonian Jet. Most of the coral here survived the heatwaves of 2016 and 2017, which devastated northern parts.

The ocean current partially protects the southern offshore reefs from crown-of-thorns starfish: it acts as a "headwind" slowing them down.

The cool jet also facilitates the spread of coral, pushing coral larvae from healthy offshore reefs to less robust ones near the coast. The researchers calculated that the "mother reefs" can supply up to 47 per cent of the Great Barrier with coral larvae after a single spawning (*PLOS Biology*, DOI: 10.1371/journal.pbio.2003355). "We call them 'super-spreaders,'" says Mumby.

Coral larvae do get around. In August, a study revealed coral larvae being swept 280 kilometres across the Red Sea in two weeks.

Mumby believes the 112 reefs identified by his team should be targeted for extra protection. "Imagine you have a reef that's



Still not beyond saving

just been damaged by a cyclone," he says. "Then you can focus some of your management efforts on preserving intact reefs that you know are going to resupply the damaged one." This might involve removing any crown-of-thorns starfish and tightening fishing restrictions in the area, he says.

Surviving corals could bring others back, says Justin Marshall at the University of Queensland. "It's like a forest: if most of it dies but you still have a few trees left, they can spread seeds and multiply." Nevertheless, he says

even the most resilient reefs will die if we don't rein in our greenhouse gas emissions, since the ocean will become too hot and acidic. "It doesn't matter how much conservation or reseeded or genetic engineering or other fancy things we do. If we don't act on climate change now, there won't be a reef in 50 years' time."

Mumby agrees the threat is severe, but is more optimistic. "I haven't given up all hope for the Great Barrier Reef yet," he says. "Nature has surprised me too many times for that." ■

The protein that makes pregnant women feel sick

MORNING sickness has been blamed on many things - from female fetuses to multiple pregnancies. But a UK study of nearly 800 pregnant women suggests that a protein is the real culprit.

It has long been known that pregnant women produce high amounts of a protein called GDF15 in their liver and placental tissue. The

protein is normally involved in inflammatory processes associated with tissue injury. But it was recently found that high levels of GDF15 put mice off eating their meals.

Stephen O'Rahilly at the University of Cambridge and his colleagues have now analysed the levels of this protein in the blood of 791 pregnant women. After delivery, the women completed questionnaires about the morning sickness they had experienced throughout the pregnancy.

Those who reported vomiting mid-pregnancy had around 1000 more picograms of GDF15 per millilitre

of their blood than women who were sickness-free. And those who said they took anti-sickness tablets had nearly 3000 picograms per millilitre more than women with no sickness. Because these women took medication, the team assumed they experienced the worst morning sickness (*bioRxiv*, doi.org/cgm4).

O'Rahilly and his colleagues suggest that the placenta may have

"We currently only have medications treating the symptoms, not the cause, of vomiting in pregnancy"

evolved to use GDF15 to put mothers off food that could harm the fetus, especially at sensitive stages of the pregnancy.

"Nausea and vomiting in pregnancy can be devastating for women," says Kristine Heitmann of Haukeland University Hospital in Norway. The team's findings suggest that targeting GDF15 may be a way to treat morning sickness. "It is a path worth exploring further," she says. "Today, we only have medications treating the symptoms, and not the cause of nausea and vomiting in pregnancy."

Andy Coghlan ■



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Water worlds may starve alien life

Shannon Hall

WHEN it comes to the search for alien life, there is such a thing as too much water.

A planet covered in oceans could be starved of phosphorus—a major component of DNA and other important molecules. That is according to work presented recently by Tessa Fisher of Arizona State University in Tempe and her colleagues at the Habitable Worlds conference in Laramie, Wyoming.

Unlike other essential nutrients for life, phosphorous is hard to find. It's mostly locked away in rocks, and it is only freed when rainfall splatters those rocks and flushes phosphorous into water where it's accessible to microbes.

Rainwater is quite efficient at dissolving phosphorus. Seawater is not. And that is a problem for worlds entirely covered by salty seas. Without any exposed land, there will be far less phosphorous available for fledgling life. Fisher and her colleagues have estimated that these worlds will have three to four times less phosphorous in

their oceans than seas on Earth.

This suggests that kick-starting life on such a world would be tricky, and if life were to take hold, we would be hard-pressed to find it. This work shows that even if, say, phytoplankton were present, they would release only one-tenth the amount of oxygen currently in Earth's atmosphere. That's far too low to be detectable.

In light of this, astronomers striving to find life beyond the solar system might want to point

“Even if life such as phytoplankton is present, it would release too little oxygen for us to find it”

their telescopes towards worlds not doused in water.

The results sent ripples through the conference. Shawn Domagal-Goldman at the Goddard Space Flight Center in Greenbelt, Maryland, didn't even wait for Fisher's talk to finish before jumping onto his research team's Slack chat channel to discuss the results, and even do a little work of his own. “We started modelling

what the atmosphere above the ocean would look like in real time because we were that excited by what she was doing,” he says.

Domagal-Goldman hopes to collaborate with Fisher and her colleagues to better assess the atmospheric chemistry on water worlds. Fisher plans to look at how the rate of available phosphorous varies with differing amounts of water. There can be too much water for life to flourish, but she's curious to see if there is a sweet spot where the amount of uncovered land is just right.

“We have to also think about the other things that impact not just whether life could get a foothold but also how productive that life would be,” says Domagal-Goldman. “If a planet is in a habitable zone, even if it has life, we may not be able to find it.” That means astronomers are beginning to shift away from a focus on habitability towards one directed by detectability.

“People who do oceanography and microbial ecology have known for years that you need rainwater to dissolve phosphorus, but none of the astronomers knew that so they didn't really think about it,” says Fisher, who thinks the major breakthrough will happen when astronomers, oceanographers and biologists all get together in one room.” ■

AI could match missing kids to old photos

AS MISSING children age, they outgrow their last known photographs, which makes finding them tough. Now AI could make it quicker to match any found children to those old photos.

Police can use software to age photos of people who have been missing for a while, but these tend to work best in adults, as age-related changes to adult faces are more predictable and so easier to simulate.

With children, these aged images don't tend to resemble the older child, and matching photos of found children to old images in a database of missing children is difficult. “Given a [recent] face image of a child, it is extremely hard for a human to identify, visually, who the child is from a large data set of child face images,” says Debayan Deb at Michigan State University.

Now Deb and his colleagues have created an algorithm to do this for them. They trained a face-recognition algorithm on data sets including the Children Longitudinal Face data set, which contains images of nearly 1000 children aged between 2 and 18 years old. Each was photographed at least four times over a period of six years.

The AI learned to match recent photographs of children with images taken 2.5 years earlier 80 per cent of the time (arxiv.org/abs/1711.03990).

With one year between the two photographs, the method was 90 per cent accurate at identifying faces. This dropped to 73 per cent after three years. The approach beats comparing children with photos taken when they were aged 0 to 4 that have been aged by software, which hovers at 50 per cent recognition after six months. The new AI might help to improve accuracy of this kind of software as well.

“This is a very good paper that could potentially be used to identify missing children,” says Amarjot Singh at the University of Cambridge.

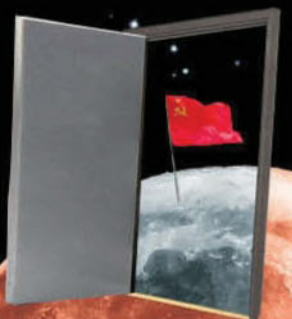
Deb's next goal is to extend the age gap. His team also hopes to develop an app that could be used to fight child trafficking. Abigail Beall ■

WHAT IF TIME STARTED
FLOWING BACKWARDS?



WHAT
IF THE
RUSSIANS
GOT TO
THE MOON
FIRST?

WHAT IF DINOSAURS
STILL RULED THE EARTH?



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Phone reads lips to check who you are

Paul Marks

IS IT your voice, or a doctored recording of your speech? Phones and digital assistants that use biometric voice recognition to verify your identity are becoming increasingly popular. But there is always a risk that someone could record you speaking, splice the right words together and spoof their way into your digital life. Now there is a sonar-based technology that can detect such shenanigans.

The large amount of audio and video content that people post on social media means voice recognition is vulnerable to spoofing, says security engineer Jie Yang at Florida State University in Tallahassee. "This makes it relatively easy to obtain voice samples from a target," he says.

Now Yang and his colleagues have devised a technology to detect and defeat misuse of such posted clips. VoiceGesture can not only recognise that a passphrase carries the authentic voiceprint of its legitimate user, but also that it is being spoken by an actual person – rather than

being played back from another phone's voice recording app, say.

To do this, the team has turned a phone into a sonar system. At the moment a user sets their passphrase, the VoiceGesture app emits a barely audible, high-pitched acoustic signal

from the phone's loudspeaker. This 20 kilohertz signal bounces off the user's jaw, lips and tongue as they speak – and the signal received by the phone's microphone then contains components that are uniquely set by the movement of those anatomically distinct facial features.

Features that create the biggest changes to the returning signal are lip protrusion, lip closure, tongue constriction and jaw angle. The resulting signature

is used to authenticate you and your passphrase simultaneously. Unveiling the technology at the ACM Conference on Computing and Communications Security in Dallas, Texas, in early November, Yang's team said the system is 99 per cent accurate at detecting and blocking voice spoof attacks.

Google is currently reviewing the technology for its Android system, which already allows a "trusted voice" to unlock phones. "We hope to hear in early February," Yang says. The team also plans to expand the anti-spoofing technology's applications to voice-controlled smart speakers, like the Amazon Echo and Google Home.

There is a pressing need for this, says Nicholas Evans, a biometrics specialist at EURECOM, a research centre in the south of France. "While the adoption of speaker authentication technology is accelerating, it's fair to say that concerns surrounding vulnerabilities to spoofing continue to dent confidence."

Over the past two years, a rising number of attacks on biometrics has motivated a growing community of researchers to develop countermeasures. "The current techniques will never be able to detect every attack all the time," says Evans. "Novel alternatives such as VoiceGesture are an essential addition to the anti-spoofing landscape." ■



PLAINPICTURE/IMAGE SOURCE/SHIRIST

Is that really you?

Lightning strike spawns stream of antimatter

THUNDERBOLTS and lightning are more than just frightening. For the first time, we have definitive proof that lightning creates radiation and even clouds of antimatter.

Teruaki Enoto at Kyoto University in Japan and his colleagues used four radiation detectors to pick up neutron and positron signals during a thunderstorm earlier this year.

Scientists had long predicted this phenomenon. Back in 1994, NASA's space-based Compton Gamma Ray Observatory spotted bright bursts of gamma rays coming from Earth.

These terrestrial gamma ray flashes occur within intense electric fields generated by lightning. Those fields accelerate electrons to ultra-high energies where they can emit gamma rays. Predictions suggested those gamma rays could then slam into molecules in the atmosphere and cause chemical reactions that create neutrons and radioactive elements. As radioactive

decay kicks in, positrons, aka antimatter electrons, are produced.

Lightning ultimately transforms nitrogen-14 into carbon-13, an alchemy that only occurs in extreme environments (*Nature*, doi.org/cgm5). "It's so powerful that on a small scale it does things that only fusion in stars and supernovae do," says Steven Cummer at Duke University in Durham, North Carolina.

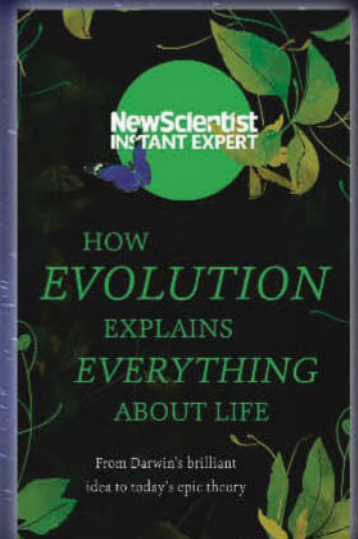
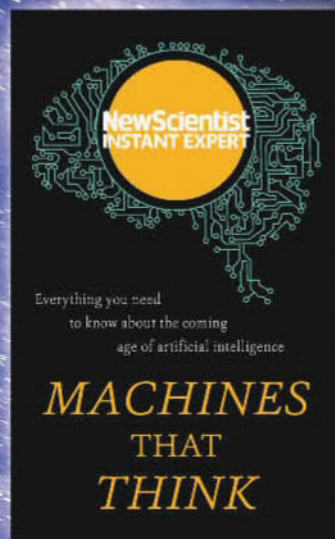
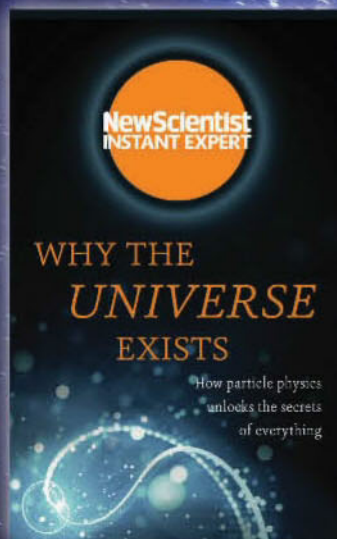
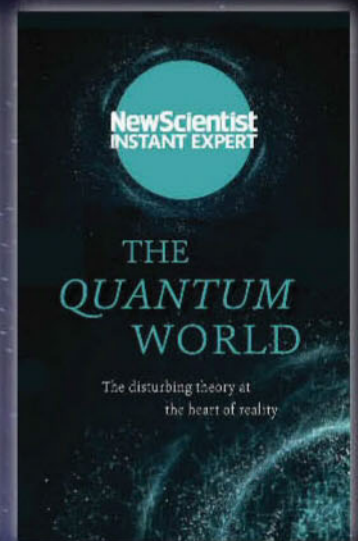
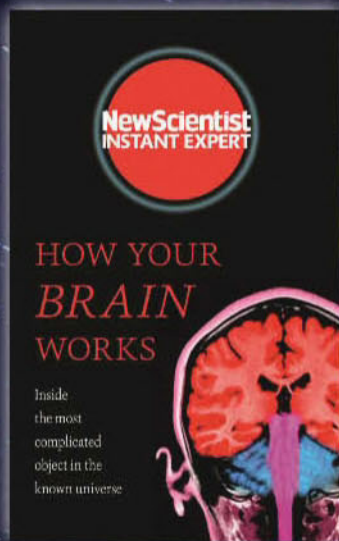
"It's so powerful that on a small scale it does things that only fusion in stars and supernovae do"

Physicists have been concerned about radiation hazards that lightning might pose for air passengers. "We know that if you go right to the point where the gamma ray flash is actually made, that is a dangerous amount of radiation. But if it's a mile up or half a mile up? You probably shouldn't be worried," says David Smith at the University of California, Santa Cruz.

However, aircraft tend to dodge bad weather. And Smith argues that a terrestrial gamma ray flash would need to be much less than 1 kilometre up to pose a risk to those on the ground. Shannon Hall ■

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THOMAS BARWICK/GETTY



Strengthen your bones to help fight memory loss

ONE more reason to hit the gym: a hormone released by healthy bones may limit memory loss in old age.

When Eric Kandel of Columbia University in New York and his colleagues analysed 23,000 genes in brain tissue, they found one particular gene that became steadily less active with age. The gene, called *RbAp48*, is known to be involved in moving short-term memories into long-term storage.

Kandel's team went on to show that a relationship exists between *RbAp48* and osteocalcin, a hormone secreted by bone. Osteocalcin is involved in cognition:

mice who are deficient in the hormone have memory deficits. Replacing this hormone improves their memory.

Osteocalcin's effects appear to be dependent on the expression of *RbAp48*. When Kandel's team silenced the gene in mice, they had memory deficits in spite of osteocalcin's presence. His team also discovered that mice deficient in osteocalcin have lower amounts of *RbAp48* protein and that this could be increased by injections of the hormone.

We naturally produce less osteocalcin throughout life as our bone mass declines. However, it may be possible to stop this by exercising, says Kandel, who presented the findings at the Society for Neuroscience meeting in Washington DC last month. Research has shown that osteocalcin increases during endurance exercise.

App identifies malaria-carrying mozzies

MOSQUITO bites can infect you with malaria, dengue or Zika – diseases that kill hundreds of thousands of people every year. But how can you tell if the mozzies near you might pose a threat? Now there's an app for that.

Only 40 of the 3500 mosquito species bite humans. It's hard to identify the dangerous kinds by sight alone. However, every species has a unique sound

signature, says Marianne Sinka at the University of Oxford.

To take advantage of this, teams at Oxford and Stanford University are using the microphones on smartphones to record a mosquito's whining wingbeat and match it against a database of known examples.

Both Oxford's MozzWear Android app and Stanford's web-based Abuzz system let you

record a mosquito's buzz using the microphone on any basic mobile phone, and then analyse the acoustic profile using a machine-learning algorithm. Accuracy rates for identifying some species are up to 90 per cent (arxiv.org/abs/1711.06346), but work still needs to be done to reduce false positives.

The apps could also be enlisted as early warning systems for communities that have an influx of new mosquito species.

How to mend a broken heart

MAGNETS may be the best way to heal a broken heart.

Heart attacks occur when the blood supply to that organ is blocked, causing its muscle cells to die. Damaged cells can be replaced with new ones made from stem cells, but only 5 per cent stay in place when injected in the heart.

To get round this, Wilhelm Roell at the University of Bonn in Germany and his colleagues loaded muscle stem cells with iron oxide nanoparticles to make them magnetic. They then injected the cells into mice with heart injuries, hovering a magnet above half the mouse hearts for 10 minutes to help the cells adhere to the tissue.

The team found that seven times as many cells grafted to the heart tissue when the magnet was applied (*Biomaterials*, doi.org/cgpq). These hearts could also pump almost double the volume of blood of untreated mice.

Is dopamine behind our smarts?

WE MAY owe our intelligence to a generous supply of the signalling chemical dopamine. Parts of our brains make far more dopamine than they do in other primates.

Dopamine is used in learning, movement and planning ahead.

To find out more, Nenad Sestan at the Yale School of Medicine and his colleagues measured the activity of genes in 16 brain regions in humans, chimps and macaques.

Two genes that coded for dopamine-making enzymes were highly active in two parts of the human brain (*Science*, doi.org/cgpv). One region was the striatum, involved in planning ahead and feeling motivation. The other was the outer layer, called the neocortex, which is involved in conscious thought.

Bird couples court before growing up

MANY bird parents were childhood sweethearts. Most whooping crane couples begin making friends a year before they first breed together.

Birds often form monogamous couples that can stick together for life. Little is known about how they start these long-term partnerships.

To find out, Claire Teitelbaum at the University of Georgia and colleagues tracked whooping cranes in the eastern US.

Before mating, cranes perform courtship displays involving loud calls, leaping and wing flapping. But they choose partners earlier.

The team found that 62 per cent of the breeding pairs started associating at least 12 months before breeding, and 26 per cent began over two years before. Also, 60 per cent got together before both were sexually mature (*Animal Behaviour*, doi.org/cgk7).

The findings may help explain why birds go in for long-term monogamy. There is evidence that pairs that stay together for longer are more successful at breeding, but that may not be the whole story.

"If you're associating for such a long time without breeding, there are probably benefits outside of just breeding success," says Teitelbaum. Being in a pair might boost the birds' social status, helping them keep a territory. They might also protect each other from predators.



DANITA DEL MONTALAMY STOCK PHOTO

Signs of water on Mars may be made by flowing sand

MYSTERIOUS dark flows streak down hills and craters on Mars each summer, before fading away in the colder months. Initially, these lines – called recurring slope lineae – were thought to be evidence of liquid water flowing on the planet's surface.

But now, a team led by Colin Dundas of the US Geological Survey has found evidence for a simpler explanation: tumbling sand. Dundas and his team looked for patterns in years of satellite images showing Mars's recurring slope lineae extending and

retreating. Analysing 151 lineae, they found that the flows behave more like dry sand than liquid water, and the patterns look like those made when sand tumbles down dunes on Earth, just on a larger scale (*Nature*, doi.org/cgkp).

Harsh surface conditions on the Red Planet mean that although it has plenty of ice and permafrost, it is less hospitable to water. It is difficult to explain how Martian geology could return water to the top of hills, dunes and craters each season ready to form a new lineae.

The striped patterns also don't

have the high salt concentrations we would expect from the repeated deposition and evaporation that would happen if the cause was water, says Anna Grau Galofre at the University of British Columbia in Canada.

Dundas found that the shapes of the lineae and the distances they cover are consistent with sand flows observed on Earth. His idea also explains why lineae always occur at the top of slopes. The seasonal patterns could be tied to how spring and summer storms carry dust and sand.

Soft robots flex their muscles

NEW foldable artificial muscles can lift 1000 times their weight, be made in just 10 minutes and be built for less than a dollar.

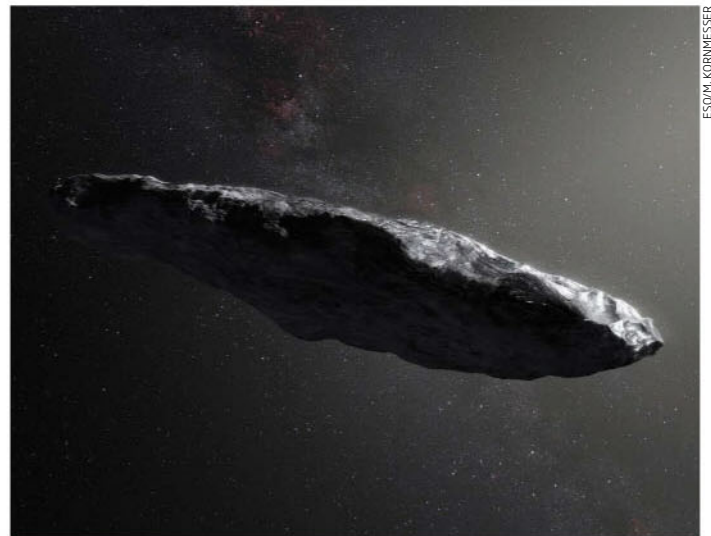
Soft robots are getting better, but greater flexibility has a trade-off as softer materials are often weaker and less resilient than inflexible ones, limiting their use.

But now researchers have created a 2.6-gram "muscle" that can lift a 3-kilogram object – a weight-to-strength ratio equivalent to a newborn lifting a Land Rover (*PNAS*, DOI: 10.1073/pnas.1713450114).

The origami-inspired robot looks a bit like a bag with many chambers, each filled with air or water. Applying a vacuum sucks these out, contracting the muscle and driving the motion.

It can be made from a range of materials, in this case metal springs, packing foam and plastic sheets. The ability to use soft materials will allow the robot to safely work alongside humans in factories, the team hopes.

"Humans are normally soft and brittle compared to the big industrial robots that you might find on an assembly line," says Robert Wood at Harvard University, who led the research.



ESO/M. KORNMESSER

Interstellar space cigar is familiar hue

THE newly discovered interstellar asteroid 'Oumuamua isn't like most space rocks we've ever seen. It was first spotted early in November, and telescopes around the world were called into action to study it. They had to be speedy, given that the object is moving at 95,000 kilometres per hour and rapidly disappearing.

Its brightness gave the first clue that 'Oumuamua is unusual. It dimmed and brightened by a factor of 10 every 7.3 hours. This suggests it is roughly cigar-shaped and perhaps 400 metres long and a tenth of that in width (*Nature*, doi.org/cgkm).

That aspect ratio is greater than any asteroid or comet observed in the solar system. Although the asteroid's shape makes it appear truly alien, its colour – a dark red hue – is more familiar. It is likely that the object lacks water or ice and has been reddened by the impact of cosmic rays over millions of years, like the objects in the outer solar system.

Observation will continue until it slips back into darkness. Interstellar asteroids are hard to spot, even though one of them is likely to pass through the inner solar system every year on average.

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Not everyone is so lucky

Playing with the odds

Fertility clinic success rates are manipulated and misleading – don't believe the hype says **Jessica Hamzelou**

IVF is more popular than ever. As the average age of first-time parents has increased, so has the demand for fertility treatments.

To help those who are choosing where to have a procedure, organisations in the UK and US collect data from all fertility clinics in those countries, providing success rates for each. Prospective patients say these stats are the most important factor in their decision-making. They also influence whether those clinics receive hospital contracts or business from health insurance companies in the US.

But those success rates aren't all they seem. Evidence suggests that at least some clinics are finding ways to boost their scores – even if it means “hiding” some IVF cycles, changing the way they treat patients, or turning away people with a low chance of success.

In other words, clinics are giving us a false impression of how successful their procedures are – potentially leading to huge financial losses and years of physical suffering and heartbreak for many individuals. So who can you trust?

The US Centers for Disease

Control and Prevention (CDC) compiles annual reports on fertility clinics. The Society for Assisted Reproductive Technology collects and reports the same data from the 80 per cent of US fertility clinics that are SART members.

Over in the UK, the Human Fertilisation and Embryology Authority (HFEA), which oversees and regulates fertility treatments, performs the same function.

“Fertility clinics are giving us a false impression of how successful IVF and similar technologies are”

All three organisations have been taken to task over the way they report “successes”. Until very recently, both the CDC and SART didn't factor in IVF cycles in which eggs and embryos were frozen, rather than implanted right away.

This might have made sense around a decade ago, when freezing was primarily used for young women about to undergo damaging cancer treatments, in order to preserve their fertility. Now, freezing is being used far more, both to preserve fertility for medical and social reasons, but also as an attempt to boost success rates in people who want to conceive immediately.

In a typical IVF treatment, a woman is first given hormone drugs that cause her to release multiple eggs, which are collected and fertilised. Usually, the healthiest embryo is implanted while the others are kept on ice. But some researchers suggest that freezing all the embryos and waiting a month before thawing and implanting one allows the uterus to recover from the drug treatment. It can also help certain at-risk women avoid ovarian hyperstimulation syndrome, which can be caused by IVF drugs.

It isn't clear if this “freeze all” approach does actually help women conceive, but that hasn't stopped it soaring in popularity. “A decade ago there were almost none,” says Vitaly Kushnir of the Center for Human Reproduction in New York. “Now around one in four cycles are freeze-all.”

Could this increase have anything to do with the fact that these cycles are hidden from success reports? Kushnir thinks so. He and his colleagues have evidence that clinics seem to be offering the freeze-all approach to patients who are less likely to have a successful pregnancy.

In these cases, women might have all of their embryos frozen, and then have each assessed before they are reimplanted. If none are found to be suitable, the woman's IVF will have failed.

If freeze-all cycles don't count, the failure goes unrecorded.

Kushnir's team has also found that clinics offering more freeze-all cycles – which thus have more of their IVF treatments hidden from success reports – have higher scores and more customers. “In practice, many freeze-all cycles are done in older, poor prognosis patients,” he says. “The more frozen cycles they do, the better they look.”

Stats on ice

“Some are only reporting 40 per cent of their cycles, and reporting a success rate 15 per cent higher than everyone else,” says David Kulak, a reproductive endocrinologist at Genesis Fertility in New York, who has also researched the phenomenon. Add the hidden cycles back and these clinics' success rates fall into line, he says.

These figures give people the wrong impression about how successful IVF treatments are (see diagram, right). “You might be being misled into thinking that your chances are 40 to 50 per cent, when it's more like 5 per cent,” says Kushnir.

Kushnir published some of his first results in 2013, and shared them with SART and the CDC. SART took note and from 2014 if a clinic intended to implant an embryo within a year of fertilising an egg – whether frozen or not – that cycle had to be included in the calculation.

The CDC has not changed its reporting practices and declined *New Scientist's* requests for an interview to explain why.

It seems that the clinics have caught on to SART's changes, at least. It published its final version of the 2014 data earlier this year, and a preliminary analysis reveals that for the first time, the number of freeze-all cycles offered to women intending to get pregnant straight away had dropped dramatically.

“The ‘hidden cycles’ went from 22,000 to 5000,” Kevin Doody,

president of SART, told the American Society for Reproductive Medicine meeting in Texas in October.

The implication is that fertility clinics change how they treat patients to improve their stats. “You can't monitor something in a certain way without changing practice,” says Doody. “You'd like to think that all these freeze-all cycles are done with the patient's best interest in mind, but...”

The UK's HFEA has been plagued by similar problems. Its previous way of calculating success rates inadvertently encouraged clinics to implant more than one embryo at a time. This practice is thought to increase the chance of success, but also raises the odds of twins, which can put the health of the mother and babies at risk.

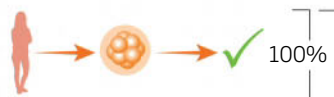
This year, the HFEA changed the way it measures success – instead of referring to live births per cycle of treatment, it now refers to live births per embryo transferred, penalising clinics that transfer two embryos instead of one.

Running the numbers

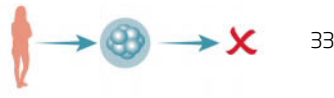
The reported success rates of fertility clinics can vary depending on which data-recording methods are used, as these examples show

Three women start treatment. One has the usual IVF and two have their embryos frozen before transfer

The usual IVF is successful



The frozen embryos are unsuccessful



If we exclude the “freeze all” cycles, the success rate is 100%

If we don't, the success rate is 33%

Some clinics saw success rates drop. One in London brought a legal challenge against the HFEA, arguing that the new system was “illogical” and “unreasonable”. The claim failed in April.

But there's a problem with the new measure, says Jack Wilkinson at the University of Manchester, UK – it ignores women who don't

“Clinics may simply refuse to treat women with a lower chance of conceiving”

get as far as embryo transfer, perhaps because of a problem with their eggs or embryos.

Wilkinson says this could give clinics an incentive to offer aggressive drug stimulation treatments, which may up the risk of ovarian hyperstimulation syndrome. This would improve success rates under HFEA criteria, because if it fails, no embryo transfer takes place.

The other concern is that, in order to protect their success rates, clinics in both countries

will simply refuse to treat women with a lower chance of conceiving. “It's not the way you'd want your doctor to practice, but it's human nature,” says Kulak.

Any changes in the definition of success will provide an incentive to alter practice one way or another, says Doody. “It will be a mix of deliberate manipulation of figures, subconscious bias and statistical incompetence,” says Wilkinson.

How can we stop this from happening? Ending reporting of success rates probably isn't the answer. They tell clinicians and patients what they can expect from fertility treatments, and provide an incentive to clinics to maintain standards.

A better approach might be to ban clinics from using success figures in their advertising. In the US, SART members aren't allowed to compare their figures with other clinics, but they can pit their scores against the national average. And in the UK, clinics bend over backwards to come out ahead. In a study published in October, Wilkinson and his colleagues found that 53 clinics had used 51 different outcome measures between them, many accompanied by claims such as “among the highest success rates in Britain”.

“It shouldn't be allowed,” says Wilkinson. “In the UK, we don't allow direct-to-consumer advertising for drugs because it incentivises bad behaviour and profit over what's best for patients.”

In the meantime, anyone using these reports to choose a fertility clinic should be wary of what they are reading. In reality, there is little difference between most fertility clinics, and factors like age and health are much more likely to influence the success of IVF. “We need to make people aware that the figures are misleading, so they can equip themselves with scepticism,” says Wilkinson. ■

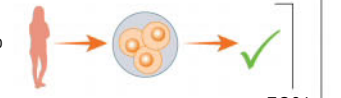
See feature, page 30

Three women start having ovaries stimulated with drugs

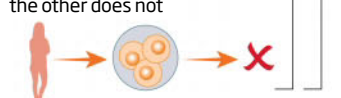
One woman has to abandon stimulation



Two women have eggs collected, fertilised and transferred



One transfer results in a birth, the other does not



If we only include those who had eggs collected, the success rate is 50%

If we include all women who start treatment, the success rate is 33%

Good call

The messages we are sending to a nearby world that might harbour aliens do not put Earth in peril, says **Douglas Vakoch**

FOR the first time we have tried to directly signal our existence to an Earth-like exoplanet that might just be populated with aliens.

GJ 273b orbits Luyten's star 12.4 light years away, and is the closest potentially habitable planet visible from the radio dish in Norway that sent the message.

METI, the research organisation I head, is dedicated to messaging extraterrestrial intelligence, and contributed a mathematical and scientific tutorial to the signal, sent with samples of music from Spain's Sónar festival, which initiated the project.

Familiar criticisms followed. Some people fear making us a target for alien invasion. But they forget a key point. Any ETs capable of getting here would already be advanced enough to know we exist.

We have long leaked radio and TV signals into space, which a civilisation only slightly more



advanced than ours could detect. And for billions of years Earth has given off detectable signs of life, via oxygen in our air.

Even if ET does know we are here, there are still good reasons for transmitting. Doing so lets us test one idea for why we haven't yet discovered aliens despite listening for them for decades. According to the zoo hypothesis, advanced civilisations may be more widespread than we think. But they watch us, much as we watch animals in a zoo. How then to get a response? Consider if a zebra suddenly looked us in the eye and started pounding out prime numbers with its hoof? That would establish a radically different relationship, one that we would surely try to respond to.

This is the scenario we are testing by signalling Luyten's star. Is a reply likely? Only if the galaxy is full of intelligent life. Perhaps

Lots to fume about

A prime chance to tackle diesel pollution has gone begging, says **Tim Chatterton**

CRITICISM of the UK's weak stance on air quality has been growing. With worries mounting about diesel pollution in particular, hopes were high that last week's budget would tackle this head-on.

Instead, the chancellor Philip Hammond fiddled at the margins. What is attracting most attention is his rise in first-year tax for new

diesel cars. Vans are exempt. As new vans are driven almost twice as far on average as new cars, this raised concerns. However, over seven times as many cars were sold in the UK in 2016 as vans, so it will actually hit most new diesels.

The real problem is that this is unlikely to have any impact on vehicle use. Car tax is often seen

as a poor way to influence drivers because it makes up a tiny part of motorists' overall budget – especially when compared with the impact of fuel duty.

What's more, the measure applies only to the first year of tax after purchase. In addition, just over half of new cars are company vehicles. For fleet buyers, one-off costs such as car tax are even less significant alongside wages, fuel, insurance and depreciation.

The latest tax banding breaks

“Only a much stronger focus on reducing vehicle use will significantly cut air pollution from driving”

into two sections: cars emitting 130 grams of CO₂ per kilometre or less will generally see tax rise by £40 or less in the first year. Those emitting more will see a £300 to £500 increase. For buyers of more efficient diesels, that's equivalent to around 2 to 3 per cent of the average annual fuel spend.

For high CO₂ cars – so-called prestige vehicles – the rise equates to 20 to 25 per cent of average fuel costs. This increase will make little difference to the well-off purchasers of these cars.

Are there any rays of hope? The use of the revenue from the tax to launch a new Air Quality Fund of £220 million has to be cautiously

more likely will be the need to repeat this with 100, 1000 or a million stars before a reply reaches us – if one ever comes.

There have been earlier efforts but this message includes novel features. It was sent three times a day, over three successive days, giving alien astronomers on GJ 273b a chance to confirm our signal, assuming they follow the kind of protocols SETI scientists use here. This would also allow them to correct errors that occur as the signal passes between the stars. But perhaps the most novel feature of METI's tutorial is the only part that changes with each iteration: a "cosmic clock" that marks the passage of time throughout the transmissions.

When we return to Norway for a second round of transmissions in April 2018, the final time we will encode is the date 21 June, 2043, when we will listen for a response.

Humankind is not great at thinking long term. If we can start to conceive of science as an inherently multi-generational enterprise, if we can commit now to listen to Luyten's star a quarter century hence and follow through with observations, I will consider our project a success. Whether we receive a reply or not. ■

Douglas Vakoch is president of METI

welcomed. Specific funding for measures to cut air pollution has been very limited. Last year's pot was only £3.7 million across all English councils, with just £57 million allocated since 1997.

Our work on motoring and vehicle ownership trends shows that only a much stronger focus on reducing vehicle use will significantly cut air pollution and greenhouse gases from driving. Nothing in the diesel tax announcement will do that. ■

Tim Chatterton is a senior research fellow at the Air Quality Management Resource Centre, University of the West of England, Bristol

INSIGHT Animal sentience

TOBIAS LEHNITZ/PLAINPICTURE



I've got a bad feeling about this

Did the UK vote that animals can't feel pain?

Michael Le Page

"MPs quietly voted 'that animals cannot feel pain or emotions,'" claimed one headline, after the UK's parliament voted against an amendment on animal sentience.

This led to widespread outrage on social media, and more than one petition. But MPs did not really vote that animals cannot feel pain and suffering. Rather, they voted against the UK government having a duty to take this into account post-Brexit.

All members of the European Union signed the Lisbon treaty, which came into force in 2009. Article 13 of the treaty states that "since animals are sentient beings, [countries must] pay full regard to the welfare requirements of animals".

Sentience is the ability to feel pain and fear, as well as joy and happiness. There is now an overwhelming amount of research to suggest that many animals are sentient. "The weight of evidence indicates that humans are not unique in possessing the neurological substrates that generate consciousness," declared a group of prominent researchers in 2012. All

mammals and birds, along with animals like octopuses, have this structure too.

Article 13 was expected to simply carry over into UK law as part of the EU Withdrawal Bill, which will transfer EU laws into UK laws post-Brexit. In July, when environment minister Michael Gove was asked in parliament if it would be included in the bill, he replied: "Absolutely."

But it wasn't. And last month, MPs voted down an amendment that would have included it. That led to the current controversy.

The UK's ruling Conservative Party has defended voting down this

"UK laws do not impose the same obligations to take sentience into account as EU law"

amendment on the grounds that animal sentience is already recognised in UK law, particularly in the 2006 Animal Welfare Act. Critics say this is not true. So who is right?

The 2006 act does not specifically use the word "sentient". It also applies only to vertebrates. But it does say that its protections can be extended to

invertebrates "on the basis of scientific evidence that animals of the kind concerned are capable of experiencing pain or suffering".

In other words, the 2006 act does implicitly recognise all vertebrates as sentient. This is made explicit in the government's explanatory notes on the act: "The Act will apply only to vertebrate animals, as these are currently the only demonstrably sentient animals."

But this is not the same as incorporating Article 13 into UK law, say groups concerned about animal welfare, such as the British Veterinary Association (BVA). Part of their objection is the fact that the act only regards vertebrates as capable of pain and suffering, while Article 13 applies to all animals.

The main issue, however, is that the 2006 act is intended mainly to protect the welfare of pets. Existing UK laws do not impose the same obligation to take sentience into account as Article 13, says Gudrun Ravetz, vice president of the BVA. "They don't explicitly put the duty on the state to consider animal welfare when developing and implementing other policies."

Following the row, Gove announced that the government would look again at ensuring the principle of animal sentience is incorporated into UK law in a "properly comprehensive way".

Without that, the UK will indeed be taking a backwards step in terms of animal welfare legislation. ■





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NewScientist





Some like it hot

SCORCHING temperatures, salt-smothered terrain and toxic air. It doesn't sound like an inviting place to live, yet here in the Danakil depression in Ethiopia, microorganisms are thriving.

The harsh environment sits at the Afar triangle, where three tectonic plates are gradually pulling apart. As the ground splits open, geothermally heated groundwater rises to the surface and evaporates, leaving a carpet of brightly coloured salty deposits. One day, when the tectonic plates drift far enough apart, the area will become the birthplace of a new ocean.

During summer, daily temperatures range from about 45°C to 55°C. Volcanic processes belch out toxic sulphur and chlorine vapours and create salty, acidic hot springs.

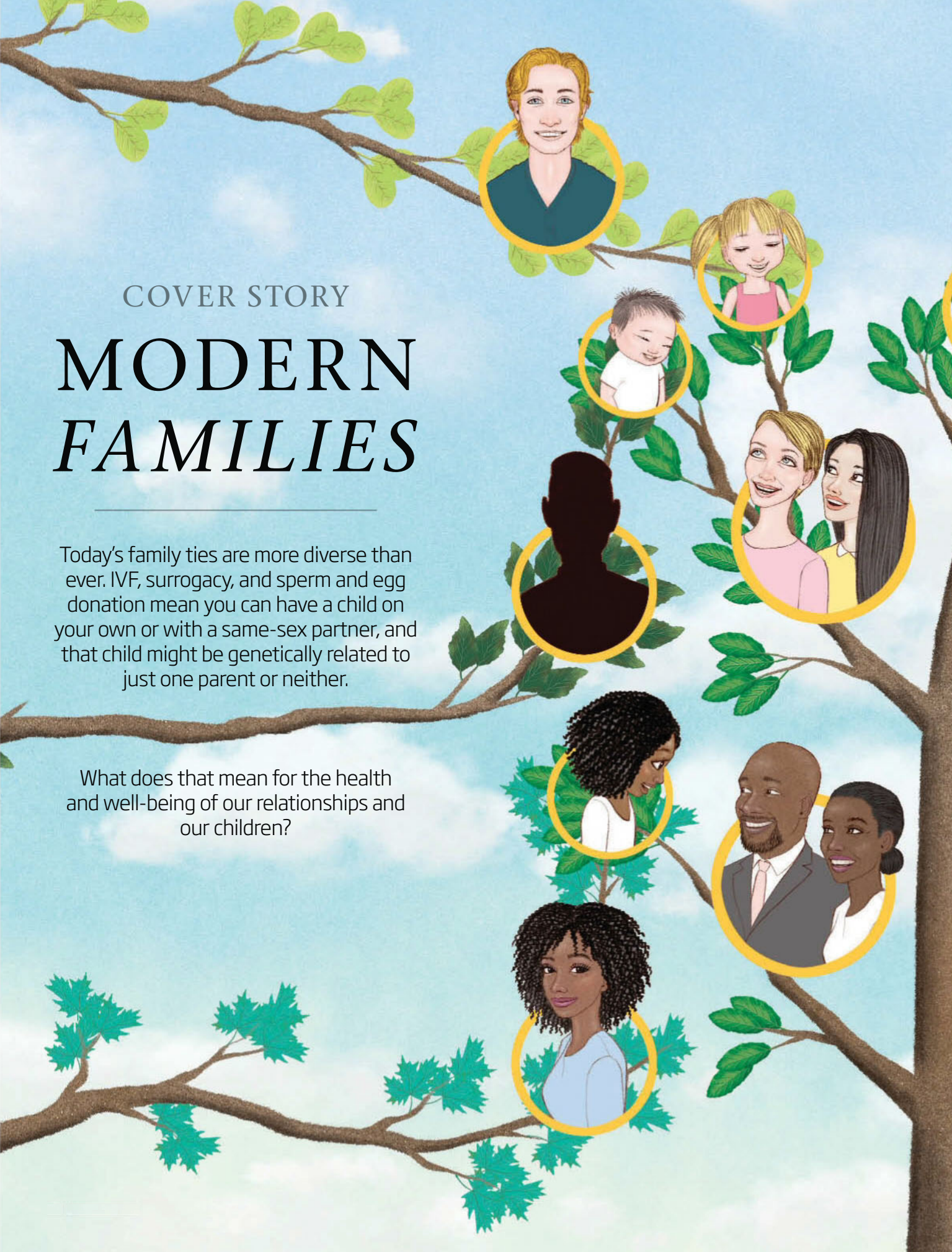
In spite of this, the area is teeming with life - microorganisms called thermophiles that are able to survive extreme temperatures. Scientists are studying their DNA to understand how they do it and find out more about the possibility of life on Mars, where the environment is similarly inhospitable.

UK-based photographer Luca Marziale travelled to the area to document the extreme conditions of the thermophiles. "The environment was extremely hostile but it was an unforgettable experience," he says. Alice Klein

Photographer

Luca Marziale

lucamarziale.com



COVER STORY

MODERN *FAMILIES*

Today's family ties are more diverse than ever. IVF, surrogacy, and sperm and egg donation mean you can have a child on your own or with a same-sex partner, and that child might be genetically related to just one parent or neither.

What does that mean for the health and well-being of our relationships and our children?



ALL YOU NEED IS LOVE?

The first long-term studies are showing us what's really important in a child's development, finds **Jessa Gamble**

WHEN Susan Golombok started her work on new family relationships in the 1970s, divorced women who moved into lesbian relationships routinely lost custody of their children. This was in spite of family law that heavily favoured mothers as sole guardians. The decisions rested on arguments about child welfare and worries about the development of children's gender identity and sexual orientation. "The belief was so strong that living in a lesbian mother family would be damaging to children in all kinds of ways," says Golombok.

Conventional wisdom at the time held that children were best nurtured in families with two parents – one male, one female – who were both genetically related to the child. Yet 40 years on, in the US and UK, married, heterosexual couples with biologically related children now form a minority of families. The first longitudinal studies following the fates of children in non-traditional family structures, many carried out by Golombok and her colleagues at the University of Cambridge's Centre for Family Research, are now being published. We can finally take an empirical look at what is important for a child's development.

The answers are clear-cut. The longest-running studies, following lesbian families, show that two female parents are just as likely to raise well-adjusted children as a

heterosexual couple is. Although not as extensive, studies on gay father families come to the same conclusion. In the US, several large studies comparing lesbian, gay and heterosexual families have found no differences in parental warmth, child behaviour, the emotional problems experienced by children or their psychosocial adjustment, including anxiety, depression and self-esteem.

Emotional equality

It's a similar story with single-parent families. The Millennium Cohort Study in the UK has been following 18,000 children born at the turn of the millennium, including some in single-parent families. After accounting for factors like socio-economic status and the parent's mental health, it has found no difference in the frequency of emotional problems in children across family types.

To eliminate the potentially disruptive effects of divorce, researchers are in the early stages of looking at single women who choose to have a child on their own with the help of a sperm donor. Golombok's studies following children up to 2 years old found that single-mother families seem to function as well as two-parent heterosexual families, and in fact children with single mothers had fewer emotional and behavioural problems.

Another study, by a team at Trinity >

JASON RASH

DO YOU HAVE A RIGHT TO KNOW WHO YOU ARE?

Article 7 of the UN Convention on the Rights of the Child states that a child should have “as far as possible the right to know[...] his or her parents”. Whether that extends to anonymous biological donors, however, is unclear.

What does seem clear is that it is good to know. A 2009 survey of 165 donor-conceived adolescents and adults showed that those who did not find out their genetic parentage until adolescence were more likely to report feeling upset, angry, shocked and confused.

In the US and UK, the trend is towards openness about donors and biological parents. The American Society for Reproductive Medicine and the UK National Health Service recommend telling the child as early as possible. More than three-quarters of couples now intend to tell their children; most choose 6 years old as the appropriate age.

“There is increasing awareness that children benefit from having access to their genetic parent,” says Abbie Goldberg at Clark University in Massachusetts. “Who do I look like? Does my birth parent also like math? There’s the practical [medical] level and then the emotional and identity work.”

Children who are told about their donor may be less likely to seek them out in adulthood if they had two parents. A study of 29 adolescents whose donors agreed to have their identity disclosed found that children from single-mother families were more likely to plan to request the identity of their donor. None reported wanting a father-child relationship, but rather believed that learning about the donor would help them learn more about themselves.

9%
of donor-
inseminated
parents...

95%
of adoptive
parents...

... had told their children about their genetic origins, according to a study of 400 European families with an 11 or 12-year-old conceived that way

SOURCE: GOLOMBOK ET AL., 2002

Warmth and emotional support are the key to kids turning out well

College Dublin, Ireland, assessed 35 stable single-mother families where there was no divorce or changing partners. They found that while children described a close emotional bond with their mother – open communication, shared activities and trust – the mothers described their parenting relationships as intense and exclusive.

This could mean that parenting styles are changing as a result of changing family structures. Some research on gay fathers suggests they may be on average less authoritarian, more warm and more responsive than heterosexual fathers. Rachel Farr at the University of Massachusetts Amherst and Charlotte Patterson at the University of Virginia observed 104 adoptive families and assessed how the parents divided 20 tasks, from feeding to dressing and going to the playground. They found that gay and lesbian parents divided these more equally than heterosexual couples.

The latter also scored significantly higher when it came to undermining each other, anger and dissatisfaction with childcare arrangements (the last point was particularly egregious for mothers). Significantly, dissatisfaction with division of labour was correlated with maladjusted child behaviours.

As well as division of labour, the study also highlighted the importance of parent-child interactions. High quality interactions involve warmth and emotional support while still setting limits, says Laurence Steinberg, who studies child and adolescent psychological development at Temple University in Philadelphia. A large body of work shows that parents who are neither too permissive nor too coercive



but offer a firm and encouraging presence foster self-reliant and confident children.

While there is no evidence that same-sex and single-parent families shouldn't thrive, children caught up in divorce consistently show greater psychological, academic and interpersonal problems – a robust finding that has outlasted the social disapproval of divorce. Why, if family structure is not important?

Divorce disruption

It's the cumulation of disruptions that's the key, says Abbie Goldberg, a psychologist at Clark University in Massachusetts and author of several books on family relationships. “Divorce involves a couple of different pretty significant events. You typically go from one to two households, from an intact family to a separated or divorced family, and there's often a loss of income.”



TING SORIANI/NATIONAL GEOGRAPHIC/GETTY IMAGES

HOW MUCH DO MY GENES MATTER?

Egg and sperm donation put us at the sharp end of the nature versus nurture question, finds Helen Thomson

SOMEWHERE out there is a wonderful woman who has donated 10 of her eggs to help me create a family. If I decide to use them, I could give birth to a child with whom I do not share a genetic history. This inevitably makes me wonder: how much does that genetic bond matter?

We've all heard stories of twins who were separated at birth and reunited as adults, only to find their personalities bear uncanny resemblances. Over 20 years of looking at such stories, the Minnesota Study of Twins Reared Apart came to a remarkable conclusion: the personalities of identical twins raised separately are just as similar as if they had been raised together. A suite of genetic studies supports this finding, showing that our DNA helps shape all aspects of our identities from intelligence to risk-taking and even our political beliefs.

"The genetic influence on individual differences in psychological traits is so widespread that we are unable to name an exception," says Robert Plomin, a behavioural geneticist at King's College London.

That isn't to say that biology is destiny, says Laura Baker, who studies human behaviour at the University of Southern California. We know, for example, that warm and supportive parents are more likely to raise better-adjusted adolescents, and that children who experience early trauma are more likely to develop depression or anxiety, or show antisocial behaviour.

Studies consistently attribute around half of the differences in our personalities to genetic effects. Plomin, for instance, recently found that

Relationships within a family aren't the only determinants of a child's well-being, however. In one study of 117 Australian gay and lesbian families, more than two-thirds of parents reported that their high-school-age children had felt isolated or different because of their parent's sexual orientation. Nearly one in five had experienced discrimination by a teacher. Stigmatisation wasn't universal; 41 per cent of parents reported no problems, and the children themselves said their classmates were more confused than mean-spirited. One child remembered remarks like: "How were you born, then?" and "One must be an aunt". Some even said their peers were envious. "None of my friends have lesbian mums but they want them," was one response.

If there are few differences in children's emotional and behavioural functioning across families, says Goldberg, that doesn't mean all families are made equal. "There's a

lot of complexity," she says. "If you grow up with two moms, and you have a relationship with your donor dad, you're having a different experience than a child down the street who was born to heterosexual parents and the

"Children with single mothers had fewer emotional and behavioural problems"

child who has two dads and was born through surrogacy and doesn't have contact with a birth parent. To say that doesn't matter is silly."

As to ideas that some couples or individuals have a greater "right" to be parents, "we've got to just take that off the table", says Goldberg. "Every person deserves to be a parent as long as they can take care of a child."

Jessa Gamble is writer based in Canada

genes account for 52 per cent of the differences between children's exam scores.

But it's not that simple. How children react to environmental pressures like stress is determined in part by their genes, something many studies don't control for. Take, for example, a 2013 study on communication. It found that children who are spoken to directly tend to develop better language skills, but didn't take into account the fact that their genes could influence how they respond to speech. In other words, if parents talked exactly the same way to an adopted sibling, they might see a different outcome – which they wouldn't if the effect was purely environmental.

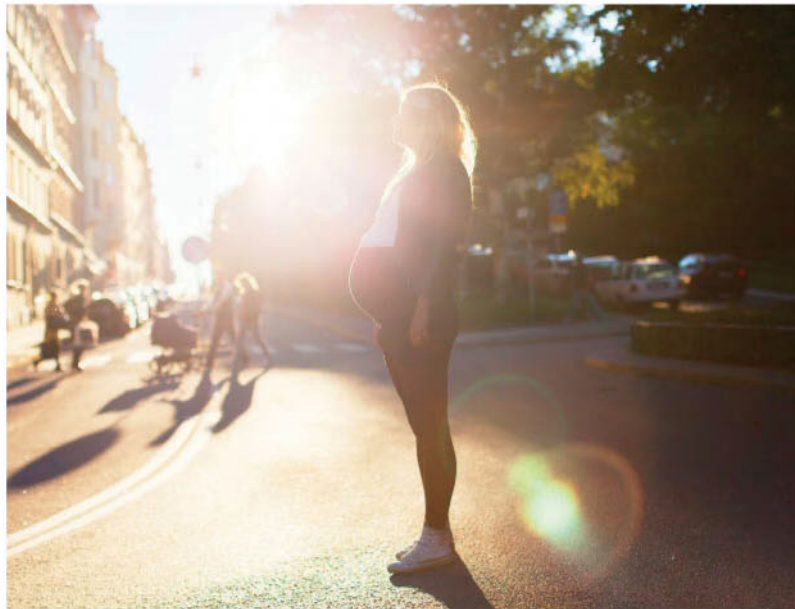
One study that did control for the effect of genes looked at the correlation between maternal negativity and antisocial behaviour in adolescents. It found that two-thirds of the correlation can be attributed to genes.

Egg and sperm race

On the other hand, it turns out that there's more to genetics than the egg and sperm. A woman can influence her child's genes even when her DNA doesn't play the starring role. We now know that when an embryo burrows into the uterus, it encounters tiny molecules from its birth mother – called microRNA. These switch genes on and off and could influence how the fetal brain grows and they therefore have the potential to affect a child's development, although we still don't know exactly how. The effect of microRNA is relevant to parents considering surrogacy as well as donor recipients.

As a recipient of a donor egg, I may even pass on my DNA to my child. During pregnancy, mothers and their embryos exchange cells that take up residence in many different organs. We know that in mice, fetal cells form neurons in a mother's brain. And we know that a mother's cells can influence her child's insulin production and immune function. We each probably only inherit a small number of these cells, but since they have the potential to stick around for a while, my cells could influence my child's health for decades.

More and more women are deciding to go it alone

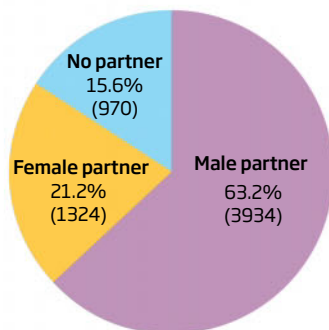


FOLIO IMAGES/CHRISTIAN FERRI/PLANPICTURE

"I would think that it provides some comfort to you, to know that you are providing some genetic material to your donor-conceived child," says Lee Nelson at Fred Hutchinson Cancer Research Centre in Seattle, Washington. It came as a surprise to me, but it does indeed provide comfort. I have never felt any great urge to reproduce for the sake of replicating my own genes, yet given their importance, it's nice to know I might play some direct role in this area. I may even pass on protective cells I've inherited from my own mother.

Looking for donors

Many single women and women in same-sex relationships now choose to receive donated sperm or eggs in the course of fertility treatments*



*2013 UK data on women seeking IVF and donor insemination with sperm and egg donations
SOURCE: HUMAN FERTILISATION AND EMBRYOLOGY AUTHORITY

"I'm of the belief that a small number of maternal cells we pass over during pregnancy have a lot of important effects throughout our lives," says Nelson.

In the end, how much does any of this really matter to forming healthy family relationships? Numerous studies show that relationships in donor-conceived families are just as likely to be positive as in families who are genetically related (see "All you need is love?", page 31). Fiona MacCallum at the University of Warwick, UK, has shown that maternal warmth and sensitivity are the same whether children are genetically related, donor conceived or adopted. And mothers of non-genetically-related children are no more likely to report difficulties – although growing evidence suggests that being open about a child's origins as early as possible is key to forming healthy relationships (see "Do you have a right to know who you are?", page 32).

To any future children of my own, I can give only one piece of information about their anonymous relative. And that is that she has performed a great act of kindness – and if that's a trait they are likely to inherit, it's not a bad place to start.

Helen Thomson is a consultant for *New Scientist*

A FAMILY AFFAIR

Is it time to abandon the ideal of monogamy, asks Jessica Bond

AND *they lived happily ever after.* The lifelong commitment of two people to one another may be the fairy-tale ending, and an ideal of Western society. But monogamy is a relatively modern development, and hardly a sure path to happiness. Is it time we explored the alternatives?

Throughout our early history, polygyny, or one male with several females, was routine. One idea for how monogamy came to dominate is that as we evolved larger brains, keeping babies alive required more effort and food. The children of men who were spread across too many families were less likely to survive. Indeed, a recent analysis found that, from hunter-gatherers to industrial societies, the greater the father's investment, the more monogamous the society.

The invention of weapons may have levelled the playing field, because dominant men were no longer able to fend off competitors who were weaker but armed. That aligns with another

idea: that monogamy helped social stability. If a few men monopolise all the women, that leaves a lot of disgruntled bystanders. "Monogamy was essentially a social deal whereby powerful polygynist men agreed to give up their harems in return for a degree of social peace," says psychologist David Barash of the University of Washington, Seattle.

Religion also played a role in making monogamy a Western norm. As Christianity spread throughout Europe, children born outside marriage were increasingly cast out as "illegitimate" and cut off from inheritance. By 1215, strict new rules issued by the Pope made polygyny and extra-marital sex increasingly socially unacceptable.

Things aren't so rigid today. The erosion of religious values, the development of hormonal contraception and the rupture of taboos around extra-marital sex and divorce mean that rather than having one sexual partner for life, many of us

The traditional Western family unit is based on lifelong devotion

are serial monogamists, moving from one long-term relationship to the next. But even with less pressure to make lifelong commitments, we're pretty bad at staying true. In a recent UK poll, 1 in 5 people admitted to cheating on a partner. Another study found that up to a third of people who are married or cohabiting stray.

Perhaps that's why some have abandoned the ideal altogether. A 2016 survey found that 20 per cent of single people in the US have had "consensual non-monogamous" relationships, where people have multiple sexual partners, but everyone is in the loop.

Cut out the deceit

Can these relationships really work, given the hurt and outrage infidelity routinely causes? To begin with, says psychologist Terri Conley at the University of Michigan, cultural norms shape those reactions. Where devout monogamy is expected, it's no surprise that infidelity spurs negative feelings. But norms change. When someone cheats, it is often the betrayal of trust that proves most harmful. Consensual non-monogamous relationships cut out the deceit.

That may be why, for some people, these relationships work just fine. When Conley and colleagues compared people in traditional monogamous and open relationships, they found no significant differences in reported relationship satisfaction, commitment or passionate love. What's more, those in open relationships reported less jealousy and higher levels of trust. "They're not doing so much better than monogamous couples [that] everyone should make the switch, but they are doing OK," says Conley.

So at the very least there is room in our society for other types of relationships. The systems that shape how we select our partners are flexible, and changeable. "At some point, it just became ingrained that this is what we do," Conley says. But that doesn't mean it is the only way, or the best one. ■

Jessica Bond is a writer based in London. For links to studies cited in this feature, see the online version at www.newscientist.com See also Analysis, page 22





MICHELLE THOMPSON

Remaking money

The technology behind bitcoin was built to fix finance. What could possibly go wrong, asks Douglas Heaven

IN SEPTEMBER, on a luxurious carpet-covered stage at a hotel in New York City, the boss of the biggest investment bank in the US launched a savage attack on a notorious upstart. Bitcoin is a “fraud”, declared Jamie Dimon, CEO of JPMorgan Chase, useful only for get-rich-quick speculators and drug dealers. “Honestly, I am just shocked that anyone can’t see it for what it is.”

Plenty of responsible, law-abiding citizens were quick to disagree – and bitcoin’s value reached new heights in November, when it breached the \$8000 mark for the first time. But whatever your view on the world’s most famous cryptocurrency, Dimon’s last comment inadvertently highlights something that often goes unsaid: no one really knows what bitcoin is, or what it is destined to become. The same goes for the technology on which it is based, known as the blockchain, hailed in some quarters as an engine of disruption on a par with the internet.

As things stand, bitcoin is all things to all people. But the community of software developers and “miners” that maintain it are engaged in a civil war, a clash of ideologies that will go a long way to deciding its fate. Meanwhile, the banks it was designed to sidestep seem to be toying with the idea that its underlying technology could be useful. Given the extent to which we are all at the mercy of the financial system, how it plays out has consequences for everyone. Can bitcoin rebuild the very idea of money? Will the blockchain make finance fairer? And what could possibly go wrong?

Bitcoin was born out of the embers of the global financial meltdown of 2008. Its mysterious inventor, or inventors, known only as Satoshi Nakamoto, saw the role of the big banks in that fiasco and decided enough was enough. They would create a truly peer-to-

peer electronic currency – a way for people to store and exchange digital coins without the need for banks or any other central authority.

The money most of us use every day has value because it is backed by a government. Take that away and the £10 note in your pocket is only worth the paper it is printed on – pretty much zilch. Its value is based entirely on faith in the institutions that back it. But as the 2008 crash demonstrated, the institutions in which we place our faith are liable to let us down.

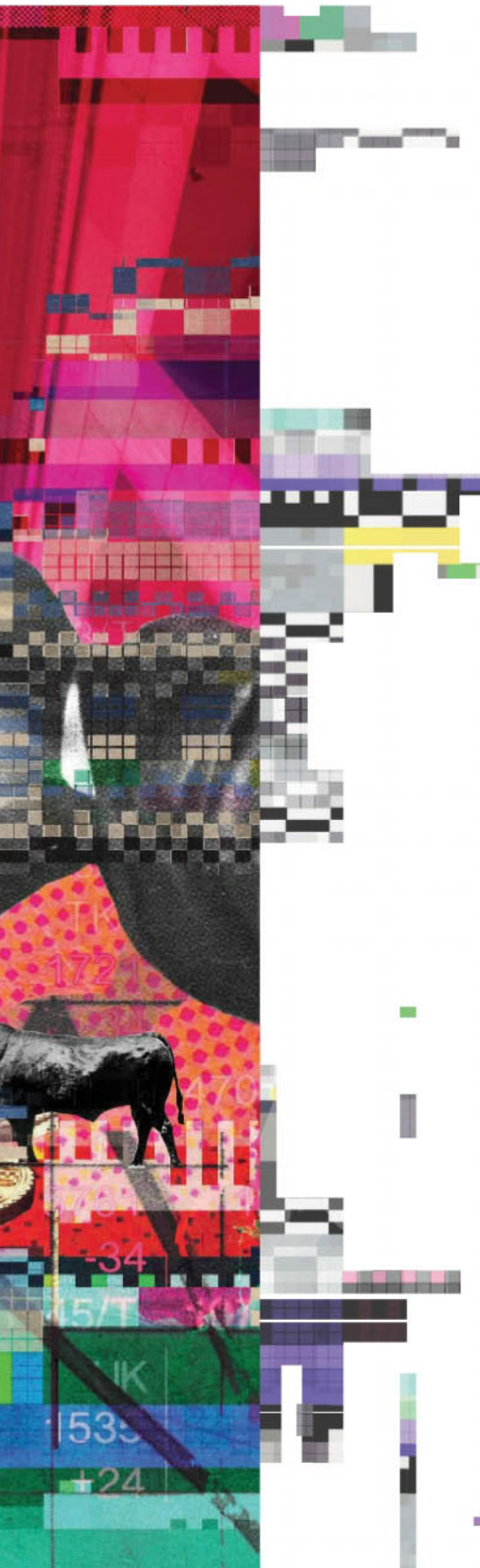
Nakamoto spelled out the problem with these so-called fiat currencies in a short post online when bitcoin launched in 2009: “The root problem with conventional currency is all the trust that’s required to make it work. The

“If we can use blockchains to create binding contracts, we could bypass estate agents”

central bank must be trusted not to debase the currency, but the history of fiat currencies is full of breaches of that trust.”

Take quantitative easing, where central banks try to kick-start the economy by creating more money and handing it to the banks so they can lend it. “There is no worse thing you could do to exacerbate the gap between the rich and the poor than pump a bunch of free money into the system that only wealthy people could get their hands on,” says Nolan Bauerle, director of research at cryptocurrency news website Coindesk. This currency manipulation is exactly the sort of thing bitcoin was invented to avoid.

Nakamoto’s solution was to derive trust not from banks but from a new piece of software called the blockchain (see “Inside the trust machine”, page 38). This public ledger records every bitcoin transaction and is shared

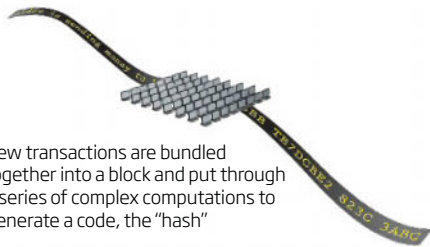


between everyone who uses the currency. Thanks to some nifty cryptography techniques, any new transaction added to the ledger is practically impossible to tamper with, and since it is public it can be viewed by anyone at any time. The result is a currency that is trustworthy without being backed by any one organisation.

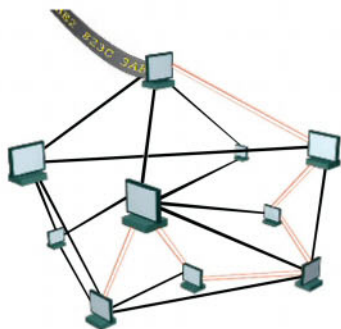
Since 2009, bitcoin has boomed, bombed, then boomed again. In its early days, its use in dark-web drug markets gave it an image problem. But that is changing, partly due to its soaring value and partly because its potential uses for law-abiding people have become apparent. It has also inspired a menagerie of other cryptocurrencies, each building on blockchain technology in different ways.

Inside the trust machine

The blockchain is a digital ledger that uses cryptography and distributed computing to maintain an unalterable record of transactions



New transactions are bundled together into a block and put through a series of complex computations to generate a code, the "hash"



This hash is broadcast to all the computers on the blockchain network. Any attempts to alter transaction data would produce a completely different hash, which would be obvious to the network



Only when the hash is verified can it be added to the chain – a shared database that is practically tamper-proof

These days, there are more than 1000 of them, says Garrick Hileman at the University of Cambridge, who studies digital money.

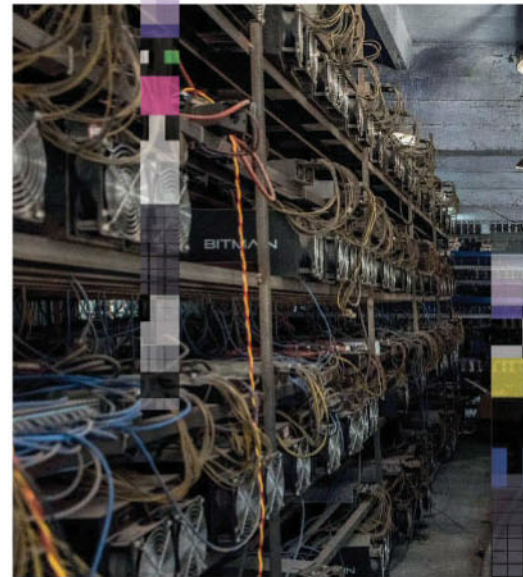
But for all that, it still isn't clear what bitcoin is. Many see it as something more akin to gold than money: an asset that may be tricky to exchange for goods but has intrinsic value. Like gold, bitcoin takes time and energy to extract by mining (see "How bitcoins are made", below right), and scarcity is guaranteed because the system is designed so there can never be more than 21 million bitcoins.

One thing is clear: it isn't yet a currency that most of us can spend. True, you can use it to buy pizzas, cars and holidays from a select few online vendors. But take it into your local grocery store or pub and the best you can hope for is a blank stare. The truth is that "it won't become [a form of currency] until people are paid in it", says Hileman. And that means governments will probably need to recognise it first. For the time being then, the most likely way for bitcoin to go mainstream is to compete with the likes of Visa and PayPal as an electronic payment system in which bitcoins, rather than fiat currency, are exchanged.

That is certainly the view of one faction in the bitcoin community. To make this happen, they want to change the underlying software so it can support more transactions. Other members see things differently. They insist that such changes would raise barriers to entry, concentrate power in the hands of a few mining groups – and thus betray the very aims on which the whole venture was founded.

In August, the dispute escalated into a civil war and led to a split. The end result was a new version of bitcoin, called Bitcoin Cash, that supports more concurrent transactions. Which version wins will go a long way to deciding whether bitcoin will ever be more than a niche phenomenon.

Then again, there is another scenario in which it could affect everyone – and perhaps not in a good way. As the infighting continues, the banks that bitcoin was set up to subvert are sniffing around. This July, the US Commodity Future Trading Commission granted a bitcoin trading platform called Ledger X the first licence to operate as a clearing house for derivative contracts – in which value is derived from the price of an underlying financial product – that are settled with bitcoin. The respectability associated with a licensed platform should attract more investors, who would hold on to their bitcoins and thereby take more of them out of circulation, which could in turn dampen volatility. Or it could just inflate a bubble that is already fit to burst.



Bitcoins are "mined" in warehouses where computers run 24/7

What really has some observers' alarm bells ringing, however, is the notion that bitcoin might quietly get woven into the intricate web that links different parts of the financial system. In an interview with US news channel CNBC in October, Joe Saluzzi at Themis Trading said that the trading of bitcoin-linked products reminds him of the financial crisis. "I have a problem that on Wall Street the innovators are trying to package something up and put a derivative label on it when they really don't know what's underneath."

In the run-up to the 2008 crash, traders were passing around newfangled financial products that masked the collapsing value of the risky mortgages at their heart. Similarly, the value of financial products packaged around bitcoin would be hard to determine if the cryptocurrency at their core, prone to wild fluctuations, were hidden.

One thing that made the collapse of the "sub-prime" mortgage market so devastating was that so many parts of the financial system were interconnected, with loans and debts stacked and bundled together in ever more complicated ways. As financial journalist Matt Lynn has pointed out, we don't really know how banks are experimenting with blockchains or which derivatives have been hitched to what cryptocurrency. If one bubble bursts, the shock waves could again spread far and wide.

But the promises and perils of cryptocurrencies go way beyond money. Many believe that the underlying blockchain



GILLES SABRIE/THE NEW YORK TIMES/REDUX/EVINE

making complex legal or financial services available to anyone with an internet connection, the technology could boost economies in poorer parts of the world.

Some believe that by making transactions more open to scrutiny, blockchain technology could even ward off another financial crash – or at least warn of its coming. If a record was made in a public ledger every time money changed hands, the day-to-day health of an economy could be monitored and the effects of monetary policy assessed. The amount of risk that large banks were exposed to could be made more visible as well.

Much of that may be wishful thinking, however. Such a vision assumes that the shared ledger is public, or at least accessible to governments. But most banks are already experimenting with blockchains that exist behind closed doors. “The original cryptocurrency systems were open for anyone to use,” says Brett Scott, author of *The Heretic’s Guide to Global Finance*. “But large banks are creating closed systems that are really just glorified central databases to do the private business they’ve always done.”

By adapting blockchains to their own ends, bankers are taking the tech far from its roots. Take Blythe Masters, former executive at JPMorgan. She helped to invent the credit-default swap, which allows lenders to sell on the risk that their loans won’t be repaid. When the markets crashed a year later, many critics blamed these financial products for making the crisis worse.

Now she is one of the most vocal advocates

for blockchains. Her start-up, Digital Asset Holdings, is making software that will allow banks and investors to use blockchain technology to trade financial products such as loans and bonds. No one from the company was available to comment, but the basic idea is to accelerate these transactions, which can still take weeks. By speeding things up and cutting out the intermediaries, the tech could save lenders a lot of money – up to \$20 billion a year, according to Santander InnoVentures. No wonder most financial institutions are rushing to find ways to profit from the technology. Even Dimon, a renowned bitcoin basher, is betting big on the blockchain.

But as with bitcoin speculation, there are

“As the banks rush in, the founding promise of bitcoin could be turned on its head”

risks. Rebuilding the world of finance on top of blockchains could usher in a new wave of financial products that are developed without a central authority and hard to police. Then there are the more dystopian possibilities.

As government authorities, banks and other big businesses rush to embrace blockchain technology, the founding promise of bitcoin and the blockchain could be turned on its head. Instead of a technology run collectively by the people who use it, these institutions could use entirely private versions of the blockchain to exert ever more control over the public. As technology critic Adam Greenfield writes in his new book *Radical Technologies*: “Despite the insurgent glamour that clings to it still, blockchain technology enables the realisation of some very long-standing desires on the part of very powerful institutions.”

It is already clear that blockchains can support any number of arbitrary transactions, from buying a house to voting. But if those blockchains are run by governments or big corporations, those institutions become the gatekeepers to such activities, warns Greenfield. What will we be willing to give for access? Permission to link our medical records with the blockchain ID we used to buy a house? Permission to link our financial history with our voting records?

“What we’re seeing now is the largest deployment of cryptography for civilian use in the history of the world,” says Bauerle. It is hard to predict how it will pan out, but this is a grand experiment we can no longer ignore. ■

Douglas Heaven is a *New Scientist* consultant

technology will be even more disruptive.

The first initiative to demonstrate the blockchain’s versatility was Ethereum, which allows for all sorts of things to be exchanged. Blockchains have since been used to trade solar power, track food products’ provenance and enable a new form of voting.

Blockchains could make things better – and cheaper – for all of us. If we can use them to draw up binding contracts, we could do away with lawyers and legal fees, or bypass estate agents. Indeed, the first international property sale on a blockchain was carried out via Ethereum in September. What’s more, by

HOW BITCOINS ARE MADE

One feature bitcoin shares with a precious metal such as gold is the fact that it takes energy to extract, because the “miners” who generate each new bitcoin do so by carrying out tricky computations that gobble huge amounts of power.

Bitcoins are digital tokens, cryptographic code that gets passed between owners. Every time a bitcoin changes hands, the transaction is recorded in a shared public ledger, known as the bitcoin blockchain. But before each block can be added, its contents – a long list of numbers encoding the latest

transactions as well as all those from previous blocks – must be used to solve a series of fiendishly complex cryptographic computations. It is a competitive business: the first miner to solve the problems and add the latest block to the chain is duly rewarded with newly minted bitcoins.

Originally, anyone with a computer could mine. With thousands of people contributing, it was a truly decentralised system. But it wasn’t long before the only miners that could really compete were the big groups

with the most expensive hardware. Today, bitcoin miners are almost exclusively large companies that have vast warehouses of computers working day and night. Most mining is done in China, where electricity is cheaper.

Some worry that this gives China a new way to flex its geopolitical muscles. “There were rumours recently that the Chinese government might nationalise bitcoin mining,” says Garrick Hileman at the University of Cambridge. “If they then shut it down, the network would grind to a halt.”

Bustard or bust

What happens when a maverick conservationist challenges the establishment? **Nic Fleming** reports

HIS REDDISH brown neck swells to the size of a football. Atop it, a blue-grey head proudly sports what looks like a drooping handlebar moustache. Up goes a fan of bright white feathers across his back as he struts his flamboyant stuff. A metre tall and weighing in at around 20 kilograms, the male Eurasian great bustard in mating mode is an impressive sight.

This display was once common in the UK. But the great bustard – which shares the title of world’s heaviest flying bird with two cousins, the Kori bustard and the great Indian bustard – became extinct here almost two centuries ago. Worldwide, its numbers have now dwindled to between 44,000 and 57,000, with most living in Spain and Russia. Yet, on a blustery autumn day, from a hide on the edge of Ministry of Defence land on Salisbury plain, Wiltshire, I can see 16 through my binoculars. They are here thanks to the Herculean efforts of a charity called the Great Bustard Group (GBG), and one man in particular, the indomitable David Waters.

Just three years ago, a major partnership set up to drive the project forward collapsed acrimoniously and the prospects for the return of the great bustard seemed poor. Now, remarkably, Waters and his team claim they stand on the brink of having a self-sustaining wild population in the UK. If they’re right, this would be a major conservation triumph, and a personal vindication for Waters in the face of deep scepticism from many conservation scientists and organisations.

However some, including former collaborators, remain unconvinced, suggesting that the GBG’s claim that the UK population now numbers almost 50 adults is optimistic and that it is far from self-sufficiency. During my visit to the GBG’s two secret release sites, I saw 32 of various ages.

I later saw many more at the home in a nearby village Waters shares with his wife Karen, two Labradors, two springer spaniels and a cavalier King Charles spaniel. Three magnificent stuffed bustard heads dominate the utility room. There is a bustard boot scraper at the door, a bustard weather vane on the roof and dozens of paintings and photographs of bustards on the walls. Fergus and Ramona, great bustards injured during quarantine, live in a pen taking up much of the garden.

It is hard to resist thinking that the large grey moustache and lamb chop sideburns that Waters sports are inspired by the facial appearance of the male great bustard. There’s no doubt his extraordinary two-decade-long quest has come to define him. Most people would have quit long ago, but Waters, who describes himself as “bloody-minded”, seems to redouble his efforts when faced with hurdles. He distrusts experts who fail to “get their boots dirty”. “I like to think I don’t have a problem with people who have a different opinion,” he says. “But I’m not afraid of speaking up, even if that upsets others, if I think someone is being misleading or doing a bad job.” Karen puts it slightly differently. “He thinks he’s always right,” she says. “He isn’t always right.” After a short pause she adds: “But about bustards he is.”

Waters got his love of birds from his father Estlin, an epidemiologist at the University of Southampton. He has fond memories of family trips to watch seabirds on the Scottish island of May, and Skomer, off the Welsh coast. His first encounter with a great bustard was at the age of 13, when he saw a displaying male during a visit to a captive breeding programme run by the Great Bustard Trust at Porton Down in Wiltshire. He was so impressed he became a volunteer.

Later, Waters began studying for a degree ➤

Now 50, David Waters has devoted two decades to restoring bustards to the UK





Birdman: the number of great bustards in Waters's house rivals those now living wild on Salisbury plain



in biological sciences and environmental pollution, but gave up after a year, describing the course as “tedious and mentally vacuous”. Then, following a brief stint in the army, he joined the police force. He kept his ties with the Great Bustard Trust though, and in 1996, when its founder Aylmer Tryon died, he suggested a new approach. The birds in the captive breeding programme had not produced any offspring. Waters's idea was to rear chicks imported from Russia and release them, but it didn't go down well with others at the trust. Where most would have given up, Waters set up his own group, the GBG, and later began to learn Russian.

Worst of times

Following some frustrating delays, the group finally gained a licence to import and release chicks from Russia in 2004. The next few years were hard. Waters had assumed large conservation organisations would get behind the project, but many thought it was overly ambitious and unlikely to succeed. So the GBG was largely reliant on public donations and volunteers. Waters, who had given up his job to focus on the reintroduction, says he sometimes worked seven days a week, doing cleaning and delivery jobs to make ends meet, and that he and Karen put in tens of thousands of pounds of their own money. “I have come very close to chucking it all in,” he admits.

The birds were faring little better, despite the elaborate measures the GBG took to prepare them for life in the wild. They wore bustard-shaped glove puppets when feeding chicks and “dehumanisation suits”, which hide the arms and legs. Young birds got predator awareness training, in which they were shown stuffed foxes and then soaked with water pistols. It did them little good. Of 167 chicks released between 2004 and 2012, only 17 made it to 1-year-old.

Things were looking bleak when, in 2010, the GBG's luck turned. Senior figures at the Royal Society for the Protection of Birds (RSPB) had a change of heart. Along with Natural England, a government conservation agency, and the University of Bath, it sponsored a funding bid with the GBG that brought in over €1 million of European Union money. The Great Bustard LIFE+ Project was set up, new staff were recruited, equipment bought and a second release site established.

Almost immediately relationships began to sour. Waters saw the tracking of the birds, which his new partners insisted on, as harmful to their development. He opposed repeated demands to mix up different groups of chicks before release to ensure randomisation,



saying this undermined their developing pecking order. “Science is essential to the project,” says Waters. “But we had academics who saw this an experiment to generate data so they could get the publications they needed to secure their funding.”

Things looked very different on the other side of the table. “We needed to know where the birds were going, so monitoring them post-release was crucial,” says Andy Evans, RSPB lead on the project. Conflicts of interest and differences of opinion were amplified by personality clashes. “Very soon after I joined, it became clear it was being run as a dictatorship,” says Kate Ashbrook who started full-time on the project in 2011 as a University of Bath postdoc. “David didn’t like others taking initiatives or trying to make changes.”

Fraught relations worsened with a bitter dispute over a 10-year review led by Ashbrook. It found that of the 167 birds released up to 2012, 65 per cent had been recovered dead and 29 per cent had disappeared. Just one chick born in the wild had made it to 100 days. Only nine adults remained alive by late 2014.

Waters describes the review as “misleading”, because it failed to include what he believes was a game-changing advance in the project’s prospects. New research at the University of Chester had shown that extinct British bustards were closer to Spanish ones than to the Russian population long thought to be the best match. This meant instead of suffering the damaging 30-day quarantine endured by the Russian chicks, from 2014, Spanish eggs were imported for incubation and hatching in the UK. But a big jump in chick survival rates seen in spring 2015 was not recorded in the review published that June. “It was like a sports correspondent writing about a match having watched only the first half,” says Waters.

Ashbrook hits back in kind: “He is like a parent complaining that their child gets their annual report at the end of a school year as opposed to waiting until they have finished their education.” And she points out that negative findings are important. “A lot of conservation literature tends to focus on successes, but actually we need people reporting failures, otherwise how are we supposed to learn?”

In November 2014, the four bustard LIFE+ project partners released a joint statement announcing the collaboration was to end nine months early. Waters and his band of volunteers continued regardless, going on to rear and release three more batches of Spanish bustards in 2015, 2016 and 2017. However, the project was taking a heavy toll on him. “It reached a point where I was physically,

mentally and financially shattered,” he says. In 2016, he took a step back. Ruth Manvell, a former government avian virologist, was appointed as director.

The GBG has continued to adapt its methods since the collapse of the LIFE+ project. Its feed now contains fewer insects and more calcium-rich vegetation. Chicks are handled less, taken for walks to help them develop, and released earlier. Tracking devices are designed to fall off six months after release. “Their improved condition can be seen in their plumage,” says Waters. “Survival is up from under 20 per cent to 50 per cent. We’re now getting the numbers that allow a proper social structure to develop.” Last winter, the birds split into separate male and female flocks for the first time, instead of dispersing, often never to be seen again, as they had before. “This is what we would expect to see in the wild,” says Waters. “We’re on the point of self-sustainability.”

“It reached a point where I was physically, mentally and financially shattered”

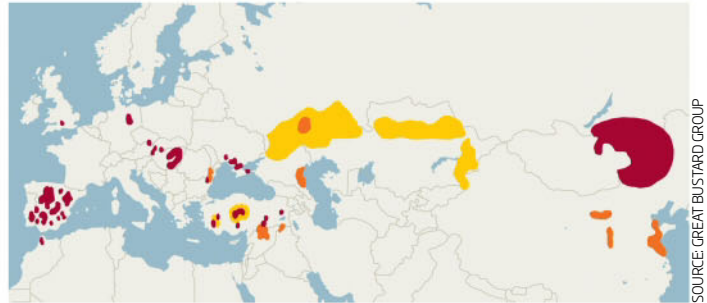
The new approach is undoubtedly delivering better results, but quantifying this is hard. The GBG’s shift from wing to leg tags, which are less likely to impede flying or attract predators, has made counting the birds difficult. Manvell estimates the adult population at between 42 and 47, to which can be added this year’s 23 releases and the three wild chicks that have been spotted. “Most of our females will become productive breeders over the next two years,” she says. “I’m fairly confident that if we have another good year we can reach a self-sustaining population of about 100.”

Ashbrook, now at the University of

Home of the big birds

Great bustards were once common in the UK but today only around 50,000 remain worldwide, most living in Spain and Russia. Though some populations migrate many stay in the same area all year

- Mainly resident population
- Mainly summer breeding grounds
- Mainly winter feeding grounds



SOURCE: GREAT BUSTARD GROUP

Worcester, says she still has contacts close to the project who are sceptical about these numbers. She believes talk of self-sustainability is close to wishful thinking. Nevertheless, she wishes the project well. “If they are seeing the birds starting to behave more like a wild population that’s encouraging,” she says.

The next few years will reveal who is right. If Waters is vindicated, it will not be the first time a maverick has swum against the tide and proved the conservation establishment wrong. Welsh biologist Carl Jones, for example, is credited with saving five species of bird from extinction including the Mauritius kestrel, pink pigeon and echo parakeet. In doing so, he faced down opposition to his controversial techniques, such as captive breeding, intensive invasive predator control and the release of species outside their historic range to fill ecological niches left empty by extinctions.

Whether Waters will one day be feted like Jones remains to be seen. But the GBG has certainly broken new ground in rearing and release techniques that could help in other projects. And whatever Waters’s faults, it is hard not to be impressed by his passion, determination, ambition and sheer stubborn refusal to waiver in the face of adversity. “David is a hugely energetic and dedicated person with a lot of drive and dedication,” says Evans, despite their past differences. “Conservation has benefited greatly from personalities like him in the past.”

Of course, the great bustards must play their part too. Success or failure now rests to a large extent on the breeding efforts of a couple of dozen females... with a little help from their flamboyant mates. ■

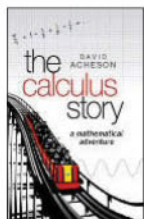
Nic Fleming is a writer based in Bristol, UK

The gift of reading

Getting frantic about how to please your loved ones this festive season? Take a deep breath and discover *New Scientist's* present picks

The Calculus Story: A mathematical adventure by David Acheson, Oxford University Press

Timothy Revell



EVER wondered about the best angle from which to view Nelson's column? To work out the answer, you will need a whit of logic and some basic calculus. Don't panic if your mathematical muscles appear to have withered away (or you never truly cracked differentiation), David Acheson's *The Calculus Story* could be just the thing.

For a book hardly bigger than a phablet, its size may trick you into thinking that it is some sort of pocket guide. Wrong. It is a roller-coaster read, constantly climbing and diving through the wonderful world of calculus.

There's something for everyone, from the inexperienced integrator to seasoned solver of equations. Before the end of page 11, Acheson has already proven Pythagoras's theorem and shown how Iranian scholar Al-Biruni approximated the radius of Earth in 1019 to within 1 per cent of today's best measurements. A few pages later we learn how an infinite sum like $1/4 + 1/4^2 + 1/4^3 + \dots$ can have a finite total. Add up all the terms and you get $1/3$. Take that, Zen!

Acheson sets the book's trajectory on a steep gradient to calculus: if you're not already hooked, luckily explaining the old-school favourites of differentiation and integration

soon reveals how to get the most out of a trip to Trafalgar Square.

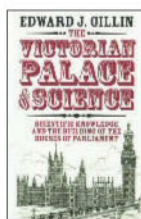
His enthusiasm for calculus is almost palpable. And while merely teaching the reader the tools of the trade would be an admirable goal in itself, Acheson is far more ambitious – he wants you to appreciate just how useful calculus is.

Understanding how the planets move, guitar strings vibrate and planes fly depends on a knowledge of calculus. Acheson even touches on quantum mechanics and chaos theory, as well as who gets the most crust when cutting equal-width slices from a spherical loaf of bread. (Answer: everyone!)

This book is small enough to fit in the old Christmas stocking, but the ideas are big enough to melt your mind. And if this isn't the time of year for mind-melting mathematics, when is?

The Victorian Palace of Science: Scientific knowledge and the building of the Houses of Parliament by Edward J. Gillin, Cambridge University Press

Simon Ings



PUBLIC buildings embody the scientific fashions and values of their day. In 1834, two years after the Great Reform Act was passed, the old Palace of Westminster burned down, and Britain needed a new parliament building to convey continuity and modernity, as well as science and sentiment.

The building was to be "a powerful machine, of nicest force," according to the utilitarian

writer Arthur Symonds, "adjusted to a thousand special functions, yet combining for the production of one grand general effect".

It didn't quite work out that way. Chemical tests convinced the architect Charles Barry that magnesian limestone would be the best building material. Seven years later, with the stone showing signs of decay, Charles Dickens called it "the worst ever used in the metropolis". David Boswell Reid used the new building as an experiment to study air chemistry. MPs, alternately sweating and shivering in the "improved" building, were inclined to agree with *The Times's* comment about



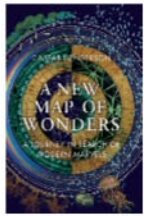
such specialists that there was “not upon the face of the civilised earth a more impracticable set of people than the savans”.

There was even a mordant note sounded over George Biddell Airy’s great clock (a late addition to the project) when its iconic bell, Big Ben, cracked shortly after its recasting in 1858.

It’s easy to take cheap shots: Gillin, on the contrary, celebrates the moment experimental science discovered, in full public view, what it could and could not do.

A New Map of Wonders: A journey in search of modern marvels by Caspar Henderson, Granta

Mary Halton



POPULAR science books often set out to tackle expansive themes, but the idea of wonder itself as a unifying topic is an unusual choice. This is the adventure that Caspar Henderson leads readers on in *A New Map of Wonders*, a veritable canter through biology, psychology, cartography and physics, and a quick brush with astronomy.

Dividing his exploration into seven “wonders”, Henderson also peens through unusual lenses. For example, he explores the complexity of life through snowflake patterns, and our understanding of geography via the star maps of Australia’s Yolngu people. The range of chapters is wide, with those devoted to relatively tidier subjects, such as the heart, giving way to messier concepts like light.

Matched with a tone that wanders from barraging readers with facts to wryly suggesting they look up online videos of animal mating rituals, *Map of Wonders* is the kind of reading characteristic of a winter holiday. This kind of writing occupies the hinterland between personal essay and popular science, and readers may warm to it more

readily if it is about topics that already interest them.

Henderson’s own sense of wonder at phenomena both natural and manufactured is pervasive, from marvelling at a murmuration of starlings to admiring advances in solar power. Wonder, we then conclude, is a very personal experience, while scientific fact is often presented as a very universal one.

The book is peppered with quotes in the margins. Designed to be evocative rather than explanatory, at times this can make for a true marriage of the poetic and the analytical.

The book really hits its stride, though, in chapters like “Future Wonders”, where the possibilities of energy technology and astronomy show that, although the scope of human knowledge is already astounding, the vastness of what we have yet to understand verges on the overwhelming.

Henderson’s approach fares best where questions remain unanswered. He has a refreshing optimism about humanity’s potential that other authors, perhaps more cautious, lack. This is coupled with a concern for the moral consequences, rather than simply the capabilities, of human ingenuity. Where, he asks, will future wonder lead us? And should we follow?

And Then You’re Dead: A scientific exploration of the world’s most interesting ways to die by Cody Cassidy and Paul Doherty, Allen & Unwin

Liz Else



I HAVE often wondered what would happen (in detail, that is) if the cable broke and the lift I was in hurtled to the ground. Cody Cassidy and Paul Doherty have taken a cool-headed look at this and other disasters: what happens if you lose your head, or stow

away on the next moon mission are also good fodder for your inner catastrophile.

Back in the lift. Free-falling from 170 storeys, the authors say you hit ground at 305 kilometres an hour. With luck, the lift fits the shaft snugly, so air trapped below it cushions the fall. But not

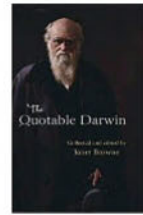
“Henderson has a refreshing optimism about humanity’s potential that other authors lack”

enough to really reduce g-forces: around 40 g over a few seconds appears to be the survivable limit.

My plan was to jump up and down. That knocks a fraction off but only if you are in the air at impact. If not, your organs “break from their arterial moorings”. Enough. I’m taking the stairs.

The Quotable Darwin by Janet Browne, Princeton University Press

Liz Else



CHARLES DARWIN was not one for memorable sound bites. Even the one for which he is best known, about the survival of the fittest, was coined by Herbert Spencer, his contemporary, a philosopher and a biologist.

That could have been a bit of a headache for the author of a book called *The Quotable Darwin*. But no. This book works because his own words paint an unexpectedly complete and truthful picture of the man (brilliance, wit, sickness), his times – and limitations.

Try these: “He who understand baboon would do more towards metaphysics than Locke”, and (on marriage) “Only picture to yourself a nice soft wife on a sofa...”

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One Kiss or Two? by Andy Scott

From Indian Prime Minister Narendra Modi’s “deathclamp” handshake to the penis-offering Walbiri in the Australian outback, learn the perfect greeting globally (Duckworth).

Science(ish) by Rick Edwards and Michael Brooks

Suppose you could do a Marty McFly, would Stephen Hawking’s “Time Cops” stop you erasing yourself from history? Fun, scary answers to the “sci” in sci-fi movies (Atlantic Books).

Blowfish’s Oceanopedia by Tom Hird

The humble jellyfish could cause an ocean-wide apocalypse, and the vampire squid from hell really earns its name. Amazing facts (291 in all) for ocean-lovers (Atlantic Books).

The Red Atlas by John Davies and Alexander J. Kent

A detailed map of your dreary home town, in Cyrillic, on a secret Soviet map? Unbelievably, Luton et al. exist in full colour, courtesy of Stalin who wanted to map the world – without drones! (University of Chicago Press)

How to Build a Universe by Brian Cox, Robin Ince and Alexandra Feachem

Why is there something rather than nothing? How was the universe built? A festive cracker from the inhabitants of the BBC’s *The Infinite Monkey Cage* show (HarperCollins).

NASA/ESA/ASI Cassini-Huygens by Ralph Lorenz

Cassini’s end makes this a timely addition to the *Owners’ Workshop Manuals*. Spacecraft subsystems, payloads, it’s all here (Haynes).

Getting a fix on puzzles

Sudoku is one of many brain-teasing highs, finds **Douglas Heaven**

The Puzzle Ninja: Pit your wits against the Japanese puzzle masters by Alex Bellos, Faber and Faber



FOR author and mathematician Alex Bellos, the paper-and-pencil logic puzzle is “one of the most addictive products” known to humans, “a metaphor for life” – and, less hyperbolically, “the most fun you can have with a pencil and paper”. Whether you agree depends on your view of logic puzzles. I don’t much like them. But I do like Bellos’s book, *The Puzzle Ninja*.

Sudoku is one of Japan’s best-known exports. Of the US’s top 50 bestselling books in 2005, six were Sudoku titles. The craze gave people an appetite for more, a hunger newspapers were happy to feed. Like many puzzle fans, Bellos started with a Sudoku problem. When the buzz began to tail off, he went hunting for new thrills.

But Bellos went further than most: “It was the first Japanese puzzle to hook me, a necessary gateway drug to the far Eastern pharmacy of magical brain food.” Since then, Bellos has been on a journey of enlightenment to Tokyo, the puzzle capital of the world, and brought back fixes more potent than Sudoku. There are, we learn, hundreds more, such as Kakuro, KenKen, O’Ekaki and Hashiwokakero, puzzles that “inspire and intoxicate more than Sudoku ever did”.

Bellos takes us to meet Japan’s elite enigmatologists. There’s 62-year-old Nishio, with a Sudoku-

solving technique named after him. And 57-year-old Miyamoto, who has published 200 books about puzzles. For years, he started his day at 2 am by creating puzzles he uses to teach young children maths. Recently married, he now lies in until 4 am.

There’s a new generation too – like 24-year-old “puzzle ninja” Edamame (yes, soya bean pod), a former winner of the World Puzzle Championship, who co-runs a fanzine publishing “some of the most fiendish logic puzzles ever to have made it into print”.

But the real point is the puzzles, with more than 220 examples, drawn from 25 different types of brain-teaser – most of them unknown outside Japan. Like Sudoku, they are set in grids and have very simple rules.

Bellos introduces each puzzle by explaining how to solve it. He observes that the popularity of grid-based puzzles is striking, given that poring over them on a lunch break or morning commute

is the closest most of us will get to doing real maths. As Bellos says, the strategies you discover are like theorems: “Once you have nailed the strategy, you can reuse it... without proving it again.”

Japan’s puzzle culture goes back to at least 1727, with the appearance of Japan’s oldest puzzle book, the *Wakoku Chie-Kurabe*. This was a departure from popular books of

“Some puzzle designers were mysterious creators, like ‘Lenin’, who hasn’t been heard of for six years”

the day containing puzzles rooted in arithmetic. Instead, it was filled with brain-twisters that drew on different branches of mathematics, such as how to fold a paper sheet into a specific shape.

Despite the long tradition, most of Bellos’s puzzles were invented by readers of two rival and hugely influential magazines launched in the 1980s, *Nikoli* and *Puzzler*. They were labs where puzzle designers

could use their weird alchemy to twist old ideas into new forms. Some were mysterious creators like “Lenin”, who invented three now classic puzzles, Slitherlink, Hashiwokakero and Nurikabe, during a period of intense creativity when he was in daily contact with puzzlers. He hasn’t been heard of for six years now.

Despite chatting to many of the best-known designers, Bellos never quite nails why Japan leads the world. Perhaps these beautiful handmade puzzles resonate in a culture that values objects such as miniature gardens or bonsai. Perhaps it is to do with the stereotypical Japanese trait of perseverance. Or perhaps it is just that those rival magazines of the 1980s inspired a competition to produce ever more devilish ways to spend a lunch break.

This is a fun and infuriating book. Just remember an eraser. ■

Douglas Heaven is a consultant for *New Scientist*



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The position will be at the rank of Assistant or Associate Professor, with tenure status to be determined based on prior experiences and qualifications. While candidates with research interests in mass spectrometry of biomolecules are particularly encouraged to apply, we seek candidates that can support and expand the department's efforts to complement campus-wide interdisciplinary research programs in the life and health sciences. These include ongoing collaborative efforts with the IUPUI School of Science, the IU School of Medicine, and the Integrated Nanosystems Development Institute. Applicants must hold a Ph.D. in chemistry or a related discipline along with relevant postdoctoral training. Candidates will be expected to establish an externally funded and rigorous research program, as well as effectively teach undergraduate and graduate courses in chemistry. Applicants at the Associate Professor level must have a record of research excellence, current and ongoing external funding, and evidence of successful student mentoring.

Applicants should submit a cover letter, curriculum vitae, statements of research plans and teaching philosophy, and three reference letters. Interested candidates should review the application requirements and submit their application to <https://indiana.peopleadmin.com/postings/4114>.

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The Louisa Gross Horwitz Prize was established under the will of the late S. Gross Horwitz through a bequest to Columbia University and is named to honor the donor's mother. Louisa Gross Horwitz was the daughter of Dr. Samuel David Gross (1805-1889), a prominent surgeon of Philadelphia and author of the outstanding *Systems of Surgery* who served as President of the American Medical Association.

Each year since its inception in 1967, the Louisa Gross Horwitz Prize has been awarded by Columbia University for outstanding basic research in the fields of biology or biochemistry. The purpose of this award is to honor a scientific investigator or group of investigators whose contributions to knowledge in either of these fields are deemed worthy of special recognition.

The Prize consists of an honorarium and a citation which are awarded at a special presentation event. Unless otherwise recommended by the Prize Committee, the Prize is awarded annually. Dr. Jeffrey I. Gordon, Washington University School of Medicine was the 2017 awardee.

Qualifications for the award

The Prize Committee recognizes no geographical limitations. The Prize may be awarded to an individual or a group. When the Prize is awarded to a group, the honorarium will be divided among the recipients, but each member will receive a citation. Preference will be given to work done in the recent past.

Nominations should include:

- 1) A summary of the research on which this nomination is based (no more than 500 words).
- 2) A summary of the significance of this research in the fields of biology or biochemistry (no more than 500 words).
- 3) A brief biographical sketch of the nominee, including positions held and awards received by the nominee.
- 4) A key publication list of up to ten of the nominee's most significant publications relating to the research noted under item 1.
- 5) A copy of the nominee's curriculum vitae.

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EDITOR'S PICK

Consent is meaningless without choice



From David Myers,
Commugny, Switzerland

I am happy that new legislation will compel internet giants to be more transparent (11 November, p 5). But currently if you need to log into a Google or Microsoft account you are obliged to enable "cookie" logging by third parties. There is no technical

reason for this, apart from allowing their clients to spy on you.

So long as such companies are close to monopoly suppliers everyone will simply grind their teeth and tick all the boxes. Legislation needs to limit what companies can do with the data they collect and not just allow users to tick a lot of boxes with implications that they are unlikely to understand.

From David Shaw,
Ballajura, Western Australia

Many years ago, a student colleague mentioned a possible solution to the problem of linked personal data. Everyone could enforce their copyright in the collection of their words and other "works", or in their own life as art. Any defence of "fair dealing" may falter where they repeatedly sell the information to many customers.

Secular explanations for ghost sightings

From Colum Clarke
Bray, County Wicklow, Ireland
Emma Young quotes climber Reinhold Messner as sensing the presence of a third man accompanying him and his brother on their descent from Nanga Parbat, Pakistan (4 November, p 36). This echoes the account of the epic crossing of South Georgia in May 1916 by Ernest Shackleton, Tom Crean and Frank Worsley. All said they felt they were accompanied by a fourth man.

This "wraith" was unhelpful: the party twice climbed to a ridge and had to retrace their steps. Any decent ghost or deity would surely have been less obfuscatory.


Years later Worsley admitted that the "fourth man" story was made up to enhance the book

South by Ernest Shackleton, for purely pecuniary gain. Messner's third man is no doubt a figment of the imagination, too, but I do not in the least impute deception to him.

From Rod Cripps, Parkdale,
Victoria, Australia

You report that 30 to 40 per cent of people in the UK and US believe in ghosts. A similar survey in Australia some time ago reported near zero. When we are asked what goes bump in the night, the standard response is "possums"!

From Bryn Glover, Kirkby
Malzeard, North Yorkshire, UK
Young informs us of the rather surprising fact that belief in ghosts has risen in recent decades. Considering the growing billions of humans who now walk around all day long with smartphones capable of taking very high-



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“With streaming services, if a record label ends a contract, you no longer listen to your songs”

Natalia offers another reason for “retro” music formats – now surprisingly including a cassette tape revival (25 November, p 24)

quality photographs under all manner of lighting conditions, I would have thought that the singular and complete absence of any credible picture of either ghosts or UFOs would have been sufficient to kill belief in them.

From Dan Lufkin, Frederick, Maryland, US

I was delighted to read Young’s reference to seeing a ghostly arm when you wave your hand in front of your face in total darkness with both eyes closed. I discovered this phenomenon accidentally a few weeks ago and was amazed to find so little discussion of it.

If I close my eyes until all after-images have disappeared and put on a sleep mask to ensure that I’m not peeking under an eyelid, I can “see” a faint but clear dark shadow of my arm when I move it slowly back and forth in front of my face. When I move my arm quickly, the

shadow sometimes has a light grey and pink trailing edge. When I stop the motion it disappears immediately. When I shrug my shoulders I “see” a dark area appear and disappear at 4 and 8 o’clock in my visual field.

It seems to me that this is indeed synaesthesia, with stimulation of the visual cortex by neurological pathways from kinaesthetic and proprioceptive neural centres. It would be interesting to have a large number of people try this experiment. Is this phenomenon more likely with age? I’m 87 and perhaps I was too young or distracted to notice it earlier.

From Meet Vora, Mumbai, India
Young reports psychologist Ciarán O’Keefe dedicating his life to studying why we get spooked by “ghosts”. So what exactly is it we feel that he studies? Ten seconds

of thought made it clear to me what we feel: fear.

We feel the very real fear of death and physical bodily harm, of pain. We fear there might be something lurking around the next corner capable of ripping us to shreds. It’s the sort of fear that one would feel in a forest full of carnivorous animals. It’s a real and justified fear that we are wired to feel. This feeling doesn’t just stop at animals, anything that can violently kill us scares us, especially humans, cold-blooded killers who could capture us and torture us before killing us.

Don’t say I’m deluded just because I’m special

From Brian Horton, West Launceston, Tasmania, Australia
Dan Jones mentions that 90 per cent of the population hold a delusion-like belief, at least

weakly (18 November, p 40). This finding is biased by the type of questions. Most of them start with “Do you ever feel...”. It would be surprising if most people had never, ever had some of those feelings; particularly those of us who know we are very special and destined to be important and therefore everyone is out to get us.

Superintelligences have better things to do

From Ben Haller, Ithaca, New York, US
Jamais Cascio brings up the concept of Roko’s basilisk, the idea that “anyone who knows that a superintelligent, godlike artificial intelligence is possible but doesn’t work to bring it about will be considered by said AI to be an enemy” (14 October, p 24). But why would a superintelligent being, whether a god or an AI, be

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I WOULD RATHER HAVE QUESTIONS THAT CAN'T BE ANSWERED THAN ANSWERS THAT CAN'T BE QUESTIONED

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so narcissistic and vain as to care which humans did or did not worship it? Wouldn't it have more interesting things to think about?

Printing before the Gutenberg revolution

From Pak-Lee Chau,
Cambridge, UK

You say the printing press was invented by Johannes Gutenberg in Germany in the 14th century (28 October, p 32). There is dispute over the first use of movable type; but we do know that each page of the *Dharani Sutra* scroll was printed from a single block between 704 and 751. It is now kept in the Bulguksa temple, Gyeongju, South Korea. The complete *Diamond Sutra* of 868 is now in the British Museum. Both were printed in China during the Tang Dynasty.

Protecting rivers under a common law system

From Brian Tagg,
Cheddon Fitzpaine, Somerset, UK
Giving a river rights so its quality can be defended through the

courts is very much not a UK approach (11 November, p 24). Here riverbank landowners have duties, such as not carrying out activities that could lead to pollution, and rights, such as water flowing onto or under their land in its natural quantity and quality, as a result of common law cases dating back many years.

Anglers' clubs started organised civil action in the late 1940s, to get authorities and nationalised industry to clean rivers. They used injunctions to prevent future and continued pollution whose breach would result in contempt of court.

It's not impossible until a young expert says so

From Ian Boyle,
Ballarat, Victoria, Australia
Discussing Sergio Canavero's body-transplant project, Nic Fleming quotes Peter Ellaway, who is emeritus professor of physiology at University College London, saying "in my opinion this will never happen" (28 October, p 39). Without meaning to imply any judgement of my own as to the viability of the

plan, I am reminded of the First Law of writer Arthur C. Clarke: "When a distinguished but elderly scientist states that something is possible, he is almost certainly right. When he states that something is impossible, he is very probably wrong."

So, watch this space...

Roundup resistance in weeds is also a problem

From John Wallace, Liverpool, UK
Michael Le Page laments the possibility that the European parliament may "fall for the line of anti-glyphosate activists" and ban use of glyphosate herbicides (4 November, p 25). Recent reviews of the available evidence – some funded by Monsanto – conclude that "the evidence that glyphosate is harming our health is weak or non-existent" and Le Page points to the benefits of "no-till" farming reducing erosion and carbon emissions from soils.

But many plants traditionally regarded as weeds have now developed resistance to glyphosate and are reinfesting crops, to the extent that some

farmers have already been forced to revert to more toxic herbicides or resume ploughing. Whether glyphosate is deemed directly harmful to people or not, it cannot be regarded as a "green" fix for the ongoing problem of feeding the human race.

The earliest artistic depiction of a hairstyle

From John Blakey,
Dronninglund, Denmark
Discussing the history of hair, you say the Venus of Brassempouy is the oldest known three-dimensional representation of the human form (7 October, p 40). Does the Venus of Willendorf not predate her? She also sported a fine coiffure, the hair seemingly elaborately braided, although she is devoid of facial features that the Venus of Brassempouy does have. Of course they are both relative youngsters compared with the "Venus of Hohle Fels", perhaps 40,000 years old – though, sadly, she lost her head somewhere along the way.

The editor writes:

■ Many dates have been suggested for each of these but, yes, the French national archaeological museum says the dame de Brassempouy is 23,000 years old and most sources date Venus of Willendorf to 25,000 years ago.

For the record

- In Greek "philos" is "friend" and "phylla" is "leaf" (11 November, p 19).
- Josiah Zayner injected himself with a CRISPR system to remove his gene for myostatin (18 November, p 22).

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TOM GAULD



OLD SCIENTIST

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



THERE'S a saying in Yorkshire: "There's nowt for getting old". This northern English pessimism found support in the 1 December 1960 issue of *New Scientist*, where we discussed how automation could ease the lives of older workers by augmenting their weakening muscles with machine power. However, we pointed out that while arm strength could be

compensated for, mental ability could not. Older workers, we said, may have "some failing in short-term memory, or a slowing down of reactions under stress... or a tendency to relapse into day dreaming or other irrelevant trains of thought." Reading this in the present century, we must concede that our worthy concerns for worker welfare and injury were entangled in ageist attitudes.

Our review of a book about a child called Nadia in the 1 December 1977 edition suggested we had started trying harder to avoid such prejudice. Nadia was autistic and had been placed in a school "for the severely subnormal" (OK, not an auspicious start in our quest to find political correctness in *New Scientist's* archive). The article promoted Nadia's tremendous abilities in art, and wondered if "being cut off from the usual mindless babble of adults talking to children, she had been able to develop in her own original way?" Certainly, by the time she was 5, her drawings were remarkable.

By 2005, we were trying to give non-human creativity its due as well. In our 3 December issue, we promoted the work of Popo, an adult female chimpanzee, under the headline (in print) "My chimp could have done that". Popo's work had gone on display at Osaka University for Arts, Japan. We ascribed to her "a range of complex and smooth strokes – the full repertoire of scribbles that a human infant acquires". You can judge for yourself from the picture above. But it probably isn't politically incorrect to say that the drawings weren't up to much. **Mick O'Hare** ■

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

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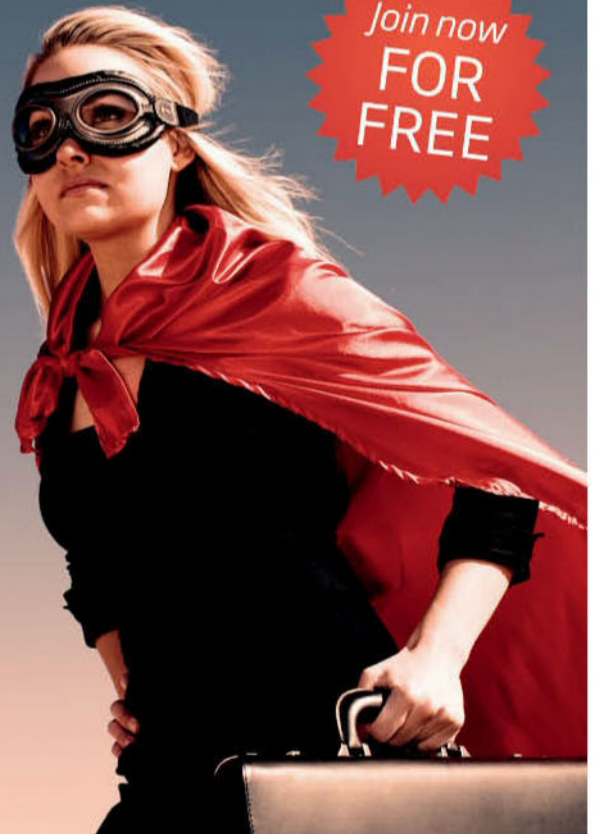
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PAUL McDEVITT

FEEDBACK entertains a lingering fascination with the ghost ship MV Lyubov Orlova, a decommissioned cruise liner supposedly overrun with cannibalistic rats, which vanished en route to the shipbreaker's yard in 2013. It drifted around the North Atlantic, appearing on the horizon from time to time like an ill omen.

Last week, several UK newspapers ran with the heady news that experts working for the US Science Channel documentary *Mafia Ghost Ship* had identified a wreck seen lying in the shallow waters off the coast of California as the ill-fated vessel. But on closer inspection, these experts admitted it was more likely to be the remains of the SS Monte Carlo, a prohibition-era casino boat.

Quite how the rodent crew of the Lyubov Orlova were supposed to have navigated the derelict ship through the North-West Passage to arrive, unnoticed, on the US West Coast goes unrecorded. So too how the ship could have been spotted in an advanced state of decay on the Pacific seabed in

2010, three years before it vanished.

Nor is it explained how there could be any confusion over the identity of the Monte Carlo shipwreck, a popular attraction near San Diego that is regularly exposed by storms, and has remained visible at low tide since running aground in 1937.

Could it be that the name of the Lyubov Orlova - and its supposed cannibal rats - was floated in a credulity stretching attempt to spice up a TV documentary on the Californian shipwreck, and secure some extra press coverage? That's one mystery we don't have to wonder at.

IN HIS recent Budget, UK Chancellor Philip Hammond announced investment in automotive research, setting a goal of seeing fully driverless cars on the streets of Britain by 2021.

Feedback suspects that the greatest success of autonomous vehicles so far has been their ability to elude any deadlines placed on their arrival. To wit,

we collected some headlines on our new automobile age:

"Nissan: We'll have a self-driving car on roads in 2020" (CNN, 2013);

"Self-driving cars available by 2019, report says" (Time, 2012);

"Tesla to make ALL its cars autonomous and self-driving by 2018" (The Sun, 2016);

"Ford predicts self-driving, traffic-reducing cars by 2017" (ExtremeTech, 2012);

"Audi promises driverless cars by 2016" (TechRadar, 2014);

"Cadillac promises self-driving cars by 2015" (ExtremeTech, 2012);

"Volvo says self-driving cars to arrive by 2014" (Recombu, 2013).

Feedback won't give up its bus pass just yet, though Hammond was looking forward to trying out the tech for himself last week. His advisors, however, put the brakes on this plan, reasoning that photos of the man responsible for steering the UK economy posing as a passenger in a driverless car might send the wrong message.

ONE of the world's longest-serving leaders was toppled in a quiet coup last month, as Emmerson Mnangagwa replaced President Robert Mugabe. However, it was only that week's second most surprising head transplant, as far as *The Telegraph* was concerned.

It reported that following an 18-hour operation, Italian surgeon Sergio Canavero had successfully joined a head to a donor body (or is that a body to a donor head?). Either way, the term "successful" is used generously, given that the operation was carried out on two cadavers. It is one way to reduce deaths on the operating table, we suppose.

TO ERR is human - but try to be a man when you do. Harvard researcher Heather Sarsons investigated how a surgeon's gender shapes attitudes about their ability, drawn from data gathered about Medicare claims.

Following negative outcomes, such as a patient dying, referrals to a female surgeon dropped far

more than they did for a male surgeon. When a female surgeon performed well, she was rewarded, but less so than her male counterparts.

In addition, after a negative experience with one female surgeon, doctors were less likely to refer patients to all other female surgeons. But when a female surgeon outperformed expectations, her bolstered reputation didn't improve things for her female colleagues.

Sarsons says the asymmetry in how we judge men and women's ability may contribute to the enduring pay gap, and prevent women achieving the same level of professional success as equally competent men. Physician, heal thyself (of these prejudices)!

MORE scepticism over the deadly effects of air pollution (25 November). British politician Nigel Farage, a man known for his fondness of cigarettes



but not for having polio, took issue with the World Health Organization's warning that tobacco products kill 7 million people a year.

The UKIP leader, who has never had smallpox, tweeted that the organisation was "just another club of 'clever' people who want to bully us and tell us what to do". Like a special interest political group, perhaps?

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Among many seasonal treats, Andrew Tucker discovers Marks & Spencer advertising a "Free From Christmas Cake". He says, "I'm sure that Scrooge would have approved"

Eater's digest

I read in *New Scientist* that raw eggs are 65 per cent digestible, versus 94 per cent for cooked eggs. Similarly, uncooked potatoes are 32 per cent digestible, but the figure rises to 98 per cent when cooked. But how much of the nutritional value in these foods is destroyed in the cooking process?

■ The answer depends on the nutrients of interest and whether you are referring to the overall levels in a food or the amounts we can actually absorb, known as bioavailability.

One measure of how much nourishment a food provides is its naturally nutrient rich (NNR) value. This is based on the mean percentage of the recommended daily intake for 16 key nutrients contained in 2000 kilocalories of that food. Using data from the US

because the amino acids resulting from cooking are key nutrients, this makes the protein more nutritious. Eggs are also rich in sulphur and selenium. Since these are found in the amino acids methionine, cysteine and selenocysteine, their bioavailability is increased too.

So, which egg nutrients are lost? This depends on the cooking method but, luckily, most nutrients – including those that people are more likely to lack – are largely unaffected. Poaching cuts vitamin B2 (riboflavin) by about 20 per cent because it is soluble in water. Boiling increases measured vitamin B9 (folic acid), but frying reduces it because it is unstable at higher temperatures. However you cook them, it is best to avoid using iron or copper-bottomed pans because these metals degrade vitamins E and B12.

As for the humble spud, it has an NNR of 128.2 when raw, but is rich in vitamin C and fibre, which eggs lack, as well as vitamin B6 and ready energy from starch. Considering the flesh and skin combined, the nutrition loss due to cooking is 25 per cent through baking and 28 per cent when microwaved. Discard the skin and 95 per cent of their iron content is lost. If you do want to take the skin off, do so after cooking. This is because the flesh of unpeeled boiled potatoes is 31 per cent less nutritious than when raw and has 33 per cent less vitamin C, whereas if you peel them first, the loss rises to 44 per cent overall and 63 per cent for vitamin C.

French fries, unsurprisingly, fare worst, losing 54 per cent of their original nutrition because they are bulked up by absorbed cooking fat. This also contributes to reduced ratios of vitamin C and

“Both weight for weight and by calorie, oven-ready French fries beat the avocado for vitamin C”

B6 to calories. Yet both weight for weight and by calorie, oven-ready French fries beat even “healthy” avocado (NNR = 124.8) for vitamin C and almost match it for potassium. Complement egg and chips with salad and you're set.

Len Winokur
Leeds, UK

back with respect to their body. The runner's body, and centre of mass, doesn't move relative to its surroundings. On the road, however, a foot plant is followed by the runner expending the energy required to pull their entire body forward relative to that foot and the road.

So, running on level ground does require more work than running on a level treadmill. It is possible to compensate for this, however, if the treadmill bed can be tilted upward, because then the runner expends additional energy from having to lift their body slightly with each step.

Howard Bobry
Nehalem, Oregon, US

“Humble spuds, when raw, are rich in vitamin C and fibre as well as vitamin B6 and energy from starch”

Department of Agriculture, the NNR of raw egg equates to 146.8. Scaling this value to 1, the relative values for cooked egg equate to 0.95 for poaching (a loss of 5 per cent), 0.89 for boiling (a loss of 11 per cent) and 0.78 for frying (a loss of 22 per cent). But raw egg white contains a substance called avidin that inhibits our protein-digesting enzymes. Cooking inactivates it, making the egg protein more digestible, and

Running battle

Runners have long debated the difference between training on a treadmill and training on solid ground. “Belt turnover” is commonly cited as a factor that helps to move your foot backwards and thereby makes running on a treadmill easier than running on the road. At constant velocity, is this a real effect? If so, wouldn't it be felt on any “moving” surface you walk on, such as a train or plane – or even Earth?

■ It is all about who or what supplies the energy and does the work. On a treadmill, the runner does the work of moving their legs through the air, but when a foot is planted on the belt, the treadmill does the work of moving the leg

This week's questions

FLIGHT OF IMAGINATION

A golf ball has dimples on its surface to increase the efficiency of airflow over it and let it fly further. Why isn't the skin of aircraft and cars similarly dimpled? Would it compromise their structural integrity?

John Loader
Harlow, Essex, UK

COOKING UP A STORM

Would it be possible to disrupt a tropical storm before it grows into a monster hurricane? For example, could you “blow it out” like a candle by detonating a large weapon in the eye of the storm?

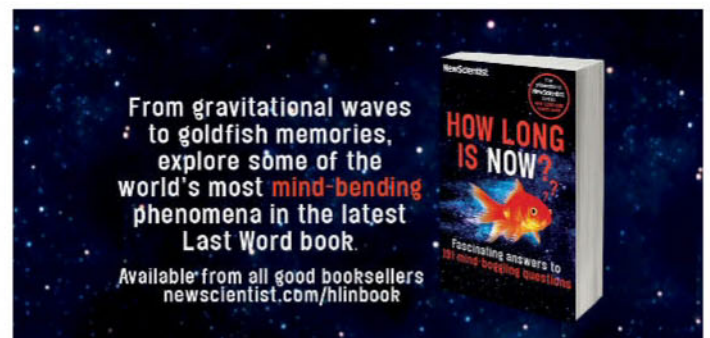
Christopher Simpson
Watford, Hertfordshire, UK

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