

New Scientist

WEEKLY January 28 - February 3, 2017

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the right to remain silent?

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How babies learn
before they're born

GIFT OF THE GAB
The man who speaks
50 languages

HUMAN BSE Has the second wave begun?

THE MEANING OF LIFE

There's a purpose to existence,
if you know where to find it



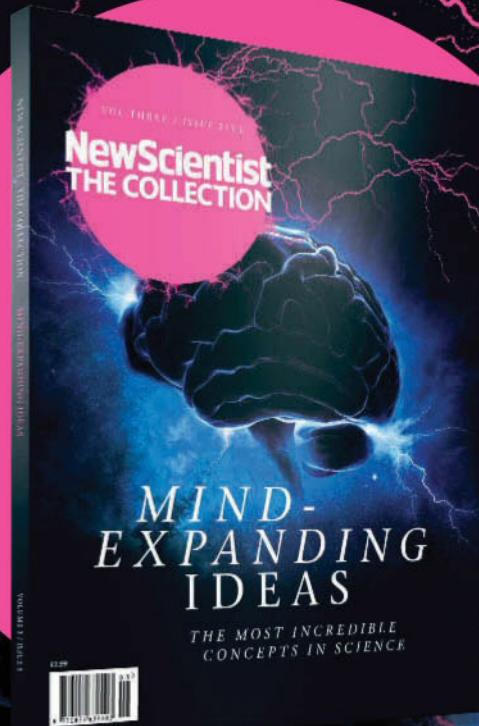
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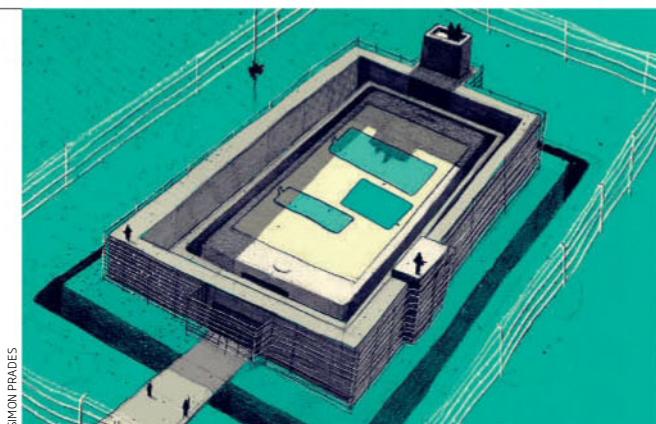
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PIERRE BONBON / ALAMY STOCK PHOTO

No beef with bureaucracy

Free trade is on the agenda, but food safety must come first

LOCALS were startled last week when thousands of Skittles were found on a road in Wisconsin. But they were even more startled when the fruity sweets turned out to have fallen off a truck carrying them as cattle feed.

It matters what we feed our livestock. A small change in UK cattle-feeding practices in the 1980s led to "mad cow disease", and then to horrendous illness and killed some people who ate affected meat. Now we know that many more people may have been infected than originally thought – and a new wave of vCJD may be on its way (see page 14).

That the number of cases is likely to remain fairly small is dumb luck. But it was not luck

that contained the epidemic in the first place, it was strict food safety rules – which protected beef-eaters worldwide. Between 1980 and 1996, the UK exported animal feed to more than 80 countries, much of it likely to have been infected with BSE. Regulations stopping this, and changing the handling of cattle, eventually stopped the disease spreading among animals.

Now, with Brexit likely to be triggered imminently, those controls – along with others carefully enacted over decades – are back up for debate. This is especially notable as the UK looks for new trade agreements with the US, with agriculture first in line for negotiation.

In this new world order, the temptation will be to wave aside rules that safeguard the food chain if they present barriers to striking deals. But such regulations are not just needless bureaucracy, despite political caricatures. The BSE epidemic demonstrates that they offer real protection: they cannot simply be cast off, no matter how vehemently industry claims they stifle sales and profitability.

Whenever regulatory regimes meet, gaps appear through which new risks emerge. We know there are other food-borne illnesses out there. Skittles-fed beef may (or may not) be innocuous in terms of human health. But we need to be sure what else we're eating. ■

Keep an eye on space

DURING last year's interminable US presidential campaign, some enterprising cynic made bumper stickers that read, "Giant Meteor 2016: Just end it already". That might now be a bit more likely.

The odds of an asteroid strike are low, but the effects would be catastrophic. So efforts to detect Earth-crossing objects have been ramped up – but we don't know what we'd do if we found one.

One idea is to nudge it on to a harmless trajectory. To help us do that, we'd need to know what such bodies are made of (see page 9). Two missions are planned to work on the problem: in 2022, the European Space Agency's AIM craft should arrive at the asteroid Didymos, while NASA's DART probe would crash into its companion, "Didymoon".

But both are now in doubt:

ESA's members haven't funded AIM, and DART is in limbo while the White House – which only recently released a document outlining the asteroid threat – decides what to do with NASA.

Given the ground-based risks we face (and axeing NASA's earth science programme is definitely on the Trump agenda), asteroids might not seem high-priority. But it would be prudent to keep an eye on threats from space as well as on Earth. If Trump won't back DART, ESA should go it alone. ■



Trump's anti-science era begins

THE writing is on the wall for Barack Obama's climate legacy. Hours after Donald Trump was sworn in as president, his administration removed the page on climate change from the White House website and published a new page, An America First Energy Plan.

This plan says Trump will roll back two key elements of Obama's environment policy: the Climate Action Plan and the Waters of the US rule, which expanded the freshwater areas protected by the Environmental Protection Agency (EPA) and the Army Corps of Engineers.

It outlines plans to exploit uncharted shale, oil and natural gas reserves on federal land and revive the US coal industry. It also says Trump will "refocus the EPA on its essential mission of protecting our air

and water", suggesting it will abandon regulating greenhouse gas emissions.

That may not prove simple. A US Supreme Court ruling established that carbon dioxide is a pollutant and the EPA must therefore address it under the Clean Air Act. "The Trump administration is legally obligated to do something and if they don't there will be litigation and lawsuits," says Henrik Selin at the Pardee School of Global Studies, Boston University.

Although Trump has called global warming "a hoax", his nominees for relevant cabinet positions have struck a more conciliatory note. For example, Scott Pruitt, his pick to lead the EPA, said: "Science tells us that the climate is changing and that human activity, in some manner, impacts that change."

Such statements make it difficult for their opponents to label them as

climate change deniers, while giving them room to manoeuvre on policy.

Other decisions in Trump's first days in office have also dismayed observers. He has reinstated a federal ban on US funding for international health organisations that counsel women on abortion.

And he selected Ajit Pai as chairman of the US Federal Communications Commission. Pai opposed net neutrality regulations that were passed in 2015 to ensure an open internet and prevent broadband providers from blocking or throttling access to content. Meanwhile, there were rumours that the EPA this week has frozen all of its grants and that the US Department of Agriculture has banned its scientists from talking openly about their work.

Quite the first 100 hours in office.

Texas abortion law

A LAW that was later ruled unconstitutional has been linked to a drop in clinic-performed abortions across Texas.

The 2013 Texas House Bill 2 required facilities that perform abortions to meet hospital-like building standards. Before the US Supreme Court overturned it in 2016, many clinics were forced to close. In 2012, 41 facilities offered abortions in Texas – by 2014, there were just 21. The distance a woman needed to travel to get an abortion increased by an average of 80 kilometres across the state.

Where this distance went up by 160 kilometres or more, Texas Department of State Health Services data reveals that the

"The law was purportedly intended to protect women's health, but forced many clinics to close"

number of clinic abortions halved. Overall, the number of abortions in Texas dropped by more than 12,000 in a two-year period.

"The law was purportedly intended to protect women's health," says Liza Fuentes at health organisation the Guttmacher Institute. But because some clinics were forced to stop offering abortions, some women could not get the services they were seeking, she says.

Potato warning

THE UK Food Standards Agency (FSA) has launched a campaign warning of the cancer risk associated with cooking potatoes and other starchy foods at high temperatures.

During cooking, sugars and amino acids react together to form thousands of chemicals. One of these is acrylamide, which can be found in foods like bread and potatoes when they have been cooked above 120 °C.

In the body, acrylamide is

60 SECONDS

converted to another compound that can trigger DNA mutations, and animal studies suggest this can cause cancer. But it has been difficult to establish the risk to humans. "Although evidence from animal studies has shown that acrylamide in food could be linked to cancer, this link isn't clear and consistent in humans," says Emma Shields at charity Cancer Research UK.

Nevertheless, the FSA is encouraging people to "go for gold" – aim for a golden yellow colour or lighter when frying, baking, toasting or roasting starchy foods.

Phone fire faults

SAMSUNG has identified the battery faults that caused its Galaxy Note 7 cellphones to catch fire, leading to a global recall of 2.5 million devices in 2016.

After testing more than 20,000 Galaxy Note 7 phones and 300,000 batteries, the company found two different issues with the phones' lithium-ion batteries that could cause them to short circuit and overheat. Independent investigations also found that the batteries were to blame.

In the initial batch of Note 7s, the battery's layers of negative and positive electrodes could sometimes get squished in one corner, causing them to bend and get close enough to each other to produce a short circuit.

After people reported incidents of their phones catching fire, Samsung changed battery supplier. But the new batteries had a different flaw. A thin layer that separates the positive and negative electrodes contained punctures, which could again lead to a short circuit.

Samsung stopped producing Galaxy Note 7s in October, but will be launching the Galaxy S8 phone this year. The firm says it will introduce protocols including a new battery safety check to prevent problems in the future.

2016: Hottest year

LAST year was the hottest year on record globally, beating 2015's exceptionally high temperatures, the World Meteorological Organisation has said.

The global average temperature in 2016 was 1.1°C higher than pre-industrial levels and about 0.07°C higher than the previous record set in 2015. The WMO said that 2016 also saw record levels of greenhouse gases and melting ice.

"Long-term indicators of human-caused climate change reached new heights in 2016. Carbon dioxide and methane

concentrations surged to new records. Both contribute to climate change," said WMO secretary general Petteri Taalas.

The analysis is based on data from the UK's Met Office Hadley

"Carbon dioxide and methane levels surged to new records. Both add to climate change"

Centre, the University of East Anglia's Climatic Research Unit, the US National Oceanic and Atmospheric Administration and NASA's Goddard Institute for Space Studies.

No-strike list for Yemen's history

TENS of thousands of archaeological sites are being discovered in Yemen by researchers who are shortlisting candidates to go on a "no-strike list" for combatants in the latest attempt to protect treasures from the war.

Since 2015, the Yemen government, backed by a Saudi Arabian-led coalition, has been fighting Houthi rebels. The death toll reached at least 10,000 last week, and damage is widespread, including to the old cities of Sana'a and Zabid - both World Heritage Sites.

"It's almost a joke the rate at which we are discovering sites - it's hard to convey just how much we are recovering," says Michael Fradley at the University of Oxford's Endangered Archaeology in the

Middle East and North Africa (EAMENA), which is documenting ancient sites using Google Earth.

Spectacular discoveries include ancient walled cities, historic mountaintop villages, prehistoric burial sites and long rows of standing stones, or trilithons, linked with the incense trade.

EAMENA is producing a cultural heritage list that it says the US Committee of the Blue Shield will put to the Saudi-led coalition to use as a no-strike list.

Whether the combatants will pay heed is another matter. The list may increase the legal pressure on the coalition, because there is criminal liability for some cultural offences under a 1954 Hague Convention.



Will anyone heed the cultural list?

Mars cracks up

NASA's Mars Curiosity rover has examined slabs of rock that seem to be cracked, dry mud. Found in a region nicknamed "Old Soaker", the rocks are scored with thin, shallow ridges that break the surface into four and five-sided shapes, unlike anything else seen on Mars so far. The cracks might be from long-lived Martian lakes periodically drying up.

Early menopause link

Women are 31 per cent more likely to have an early menopause if they started menstruating before age 12. The largest study of its kind found that 8.8 per cent of women who got their first period aged 11 or younger experienced the menopause early, between the ages of 40 and 44. Just over 3.1 per cent began before the age of 40 (*Human Reproduction*, DOI: 10.1093/humrep/dew350).

Hack-proof

The world's first quantum communication satellite is performing "much better" than expected. China's Quantum Experiment at Space Scale (QUESS) satellite, launched in August 2016, will use quantum mechanics to enable ultra-secure communications.

10 metres of sea rise

Global sea levels could rise by up to 2.5 metres by 2100 and up to 9.7 metres by 2200. So says the US National Oceanic and Atmospheric Administration. The agency revised its worst-case scenarios now several recent studies suggest Antarctic ice is melting faster than expected.

Sexual feeling

In the mood? Injections of a hormone named kisspeptin increase the brain's response to arousing images (*Journal of Clinical Investigation*, doi.org/bxqh). The study involved 29 young men, but the team plans to look at the effects in women too. They hope the research may help devise treatments for psychosexual disorders.

Can pigs grow human organs?

Mouse pancreases have been grown in rats, livers could be next, finds **Clare Wilson**

TRANSPLANT waiting lists could become a thing of the past if we could find a way to grow human organs inside other animals. Now mouse pancreases have been grown inside rats – a first step towards a ready supply of organs for transplant.

When small parts of these organs were transplanted into mice with diabetes, it reversed their disease. This finding raises the prospect that someone needing a new liver, for instance, could have what is essentially their own organ grown to order inside a specially conceived piglet, within a year of providing a small skin sample. Pigs or sheep make the best candidates, because their organs are a similar size to ours.

Donor organs are in short supply. Only around 3 in 1000 people die in a way that makes them suitable as organ donors. In the UK, nearly a third of people who need an organ wait more than

two years in poor health, and one in 10 die while on the waiting list.

The shortage has prompted research into creating organs in the lab. Many of these methods involve stem cells, which can be encouraged to form most types of tissue using different mixtures of chemical cues and signalling molecules. However, growing large organs with complex three-dimensional structures and their own blood supply has proved far from easy.

Instead, Hiromitsu Nakauchi at the University of Tokyo, Japan, and his team used rat embryos as living incubators. They began by genetically modifying parent rats so their offspring would be unable to make their own pancreas. A few days after conception, they injected mouse stem cells into the tiny rat embryos, which developed as normal, except their pancreases mostly comprised mouse cells.

Once the rats reached adulthood, the team removed the pancreases and implanted clusters of these pancreatic cells into mice with diabetes. These clusters, or islets, restored the blood glucose levels of the mice to normal for over a year (*Nature*, DOI: 10.1038/nature21070).

This is the first time this kind of inter-species organ generation has successfully treated a medical condition.

"This is the first time this kind of inter-species organ generation has treated a medical condition"

condition. "It proved those pancreatic islets must be very functional," says Nakauchi.

That doesn't mean doing the same with whole organs in pigs and people is imminent, though. The team used clusters of cells, instead of transplanting whole pancreases, partly because the

procedure is relatively easy.

As humans and pigs are less genetically similar than rats and mice, the growing organ might be attacked by the piglet's immune system. The team found that the islet clusters contained some rat cells from other tissues, but that the mouse immune system seemed to kill these without harming the pancreas cells. However, this may be more dangerous if a whole, large organ is transplanted.

While the approach was used to cure mice with diabetes, people can already be treated with insulin. So the technique may prove more important for treating other diseases. New organs are more urgently needed for people with failing hearts, livers, lungs and kidneys, says Nakauchi.

So far, his team has managed to modify rats so they don't grow a liver, so it should be possible to grow mouse liver cells for transplant in a similar way to the islet cells. But getting rid of the heart is likely to be more difficult, he says.

There are also ethical issues. Because the technique would involve inserting human cells into pig embryos, the adult animals could have some human brain cells. Does that mean we should give those pigs greater moral consideration? Ethicists will need to tackle such issues as research into such human-pig chimeras continues, says Bernhard Hering at the University of Minnesota. "We are crossing a crucial line here. But exciting papers always come with new questions."

Researchers may be able to avoid creating pig-human brains by using human stem cells that have been genetically altered so they are incapable of forming brain tissue. ■



Organs made to order?

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Late arrival of Earth's water ruled out

THE arrival of water on our planet is shrouded in mystery. Our leading theory says icy meteorites brought it here after most of the planet and its core had formed, about 4.5 billion years ago. But now an analysis of isotopes from meteorites seems to imply that the wet stuff got here much sooner.

Mario Fisher-Gödde and Thorsten Kleine at the University of Münster, Germany, looked the Tagish Lake meteorites that fell in British Columbia, Canada, in January 2000. They compared the abundance of ruthenium isotopes in these meteorites with the abundance in Earth's mantle.

"Meteorites impacted Earth during its formation and they can leave signatures," says Katherine Birmingham at the University of Maryland. If this kind of icy meteorite brought water to Earth late in the planet's formation, then the isotopes inside them should match the isotopes in Earth's mantle.

"Ruthenium isotopes are stable. That means they can act as fingerprints," says Birmingham.

But the team found that the ruthenium isotopes in the meteorites did not match those found in Earth's mantle (*Nature*, DOI: 10.1038/

"We can now rule out water arriving on icy comets after the planet was mostly formed"

nature21045). "We can exclude a late water delivery," Fisher Gödde says.

"The ruthenium data suggest comets could not have played a large part in the late addition of material to Earth," says Lydia Hallis at the University of Glasgow, UK. Hallis previously used hydrogen isotope ratios in volcanic basalt rocks to conclude that Earth's water may in fact have been part of the very dust cloud from which the planet first condensed. Chelsea Whyte ■



Chelyabinsk was a close shave

Apocalyptic asteroids have chink in armour

WHEN you need to save Earth from an incoming asteroid, try shooting at its bright spots. A new analysis of fragments of the Chelyabinsk meteor, which exploded over Russia in 2013, suggests that firing something at an asteroid's lighter areas may be the best way to deflect it.

The Chelyabinsk object arrived without warning, injuring around 1500 people. If would-be planetary protectors do spot something similar en route, they could use a projectile to shift it off course. But figuring out how is tricky, and not something to be trying for the first time with an asteroid hurtling toward us.

The perfect shot transfers maximum momentum to the target without breaking it apart completely. To achieve that, we need to know its composition and internal structure, and then take aim accordingly. "Before firing the projectile, we would need to study carefully the surface of the body and select the best location," says Josep Trigo-Rodríguez at the Institute of Space Sciences in Barcelona, Spain.

Work led by Carles Moyano-Cambero, Trigo-Rodríguez's graduate student, looked at the three rocks making up the Chelyabinsk object: a pale and relatively pristine material with a grainy texture, a darker substance with opaque veins, and another dark material filled with droplet-shaped bits of metal. The team made tiny indentations in each with a diamond-tipped probe, to measure hardness and stiffness (arxiv.org/abs/1612.07131).

Those properties influence the choice of target and how much the asteroid's path could be shifted. "There are pieces that fly off a little bit like the droplets of fluid if you throw a rock into a pond," says Paul Miller of Lawrence Livermore National Laboratory in California. "[Aiming at] that material actually gives you bonus push, bonus momentum."

As a target, the pale material won out: it was softer, so can "splash up" as Miller describes more easily. That same rock is common in near-Earth asteroids, and can be detected from afar using spectral analysis.

One issue is that the three materials were mingled in the sample, which was only about a square centimetre in cross section. "It's not currently obvious how well we can extrapolate from small scales to asteroid scale," says Andy Rivkin at the Johns Hopkins Applied Physics Lab in Laurel, Maryland. For example, we don't know of asteroids where the different rocks form a patchwork of metre-sized or larger pieces that could be targeted. At best, we could look for an area with a high proportion of the paler rock.

Right now, our analyses are "literally skin-deep", says Vishnu Reddy at the University of Arizona in Tucson. "What we need to know in the end is what is inside an asteroid." To help us find out, a mission called DART is supposed to crash into a small asteroid in the 2020s, and another called AIM will study that impact. But the status of both is in doubt (see "Keep watch on space", page 5).

"Sooner or later we will convince our politicians that these pioneer missions to test impact deflection in asteroids are needed right now," Trigo-Rodríguez says. "The next asteroid to hit the Earth is probably not known yet. We should be ready."

Joshua Sokol ■

Bird evolves less flashy look as the world warms

SEX and beauty may not be the first things that come to mind when you think of climate change. But for the collared flycatcher, the three seem linked in some mysterious way. As temperatures have risen, male flycatchers' brilliant white forehead patches have flipped from being a valuable sexual signal into a liability.

Since 1980, ecologist Lars Gustafsson at Uppsala University in Sweden has been monitoring a

population of collared flycatchers on the Baltic island of Gotland. Every year, he and his colleagues have marked every new bird with numbered leg-bands, allowing the parentage, reproductive success and survival of many generations to be tracked.

Gustafsson's team had noticed that the males' forehead patches have been shrinking in recent years. Team member Simon Evans wondered whether this was just the response of individuals to

changing conditions, or whether the population as a whole was evolving.

So Evans combed through 34 years' worth of records. He found that early on, birds with larger forehead patches were more likely to contribute genes to future generations than their small-patched neighbours, as they could secure better territories and raise more offspring. But this edge reversed in the second half of the period. Further analysis showed that this change was associated with higher spring temperatures, a result of changing climate (*Nature Ecology and Evolution*, doi.org/bxp6).

Oddly, birds with large forehead patches fared worse in warm years, not because they had fewer offspring but because they were less likely to survive the ensuing winter. Evans, now at the University of Zurich, Switzerland, does not yet know why. But he speculates that males with large forehead patches must incur some cost for the display, perhaps in the form of more aggressive competition with other males. Warmer springs somehow increase this cost. "These traits are evolving due to climate change," says Evans.

This sudden change in the value of a mating signal might be a warning that the flycatcher's role in the ecosystem is also changing, says Cody Dey, a conservation biologist at the University of Windsor, Canada. Similar changes to sexual ornaments and signals may well be happening in other species, Dey thinks. Some ornaments may disappear while new ones evolve, and climate change may lead to winners and losers in the global beauty pageant, write Dey and his colleague James Dale from New Zealand's Massey University in a commentary on the study.

Evans was only able to spot the reversal in collared flycatchers because of Gustafsson's remarkable data set – proof of the value of long-term ecological research, Dey says. **Bob Holmes**



That style is less cool now

DIETMAR NILL/NATUREPL.COM

Exotic black hole shows its superfluid side

THE black holes in our universe may seem like bizarre beasts – but even stranger ones are possible. Simulations of black holes have now revealed the first superfluid specimen.

Superfluids are a form of matter that take mere melting a step further. When a solid turns to a liquid, what was once sturdy and inflexible begins to flow. Superfluids have zero

stickiness or viscosity: they can even flow uphill. They also have completely uniform temperature.

But superfluids are extremely difficult to create. Only liquid helium has been coaxed into going superfluid, and then only at temperatures close to absolute zero. The stuff is even harder to study or model: many of the important calculations are ones that nobody knows how to do yet.

Now, Robert Mann at the University of Waterloo in Canada and his colleagues have modelled a theoretical black hole, one that can

alter in a way that mathematically mirrors what liquid helium does when it turns superfluid (*Physical Review Letters*, doi.org/bxnb). This simulated object is exotic: it exists in a higher-dimensional space-time with properties very different from our own cosmos.

If gravity's interaction with matter meets certain conditions, the switch to superfluidity could potentially be

seen in a wider set of black holes – but probably not ones in the universe. "It's thinkable that these conditions could be satisfied in our universe, but they're probably not," says Mann.

Even so, simulating them could be illuminating. "This could tell us something about superfluids which we can't calculate by other methods, so that's part of the excitement," says Jennie Traschen at the University of Massachusetts Amherst.

"By using one enigma to model another, we're inching closer to an understanding of both."
Leah Crane

Workers warm up big cities on weekdays

IT'S going to be hot in the city – until the weekend. The crowds of commuters that pour in during the week can raise local air temperatures and alter wind, rain and clouds.

Heat generated by human bodies, cars, public transport and office buildings causes cities to gradually warm up from Monday through to Friday. The temperature then drops over the weekend.

A recent study led by Nick Earl at the University of Melbourne, Australia, shows that the average morning temperature in Melbourne is 0.3°C hotter on Thursdays and Fridays than on Sundays. "Some days will heat up more, if for example there isn't much wind," he says.

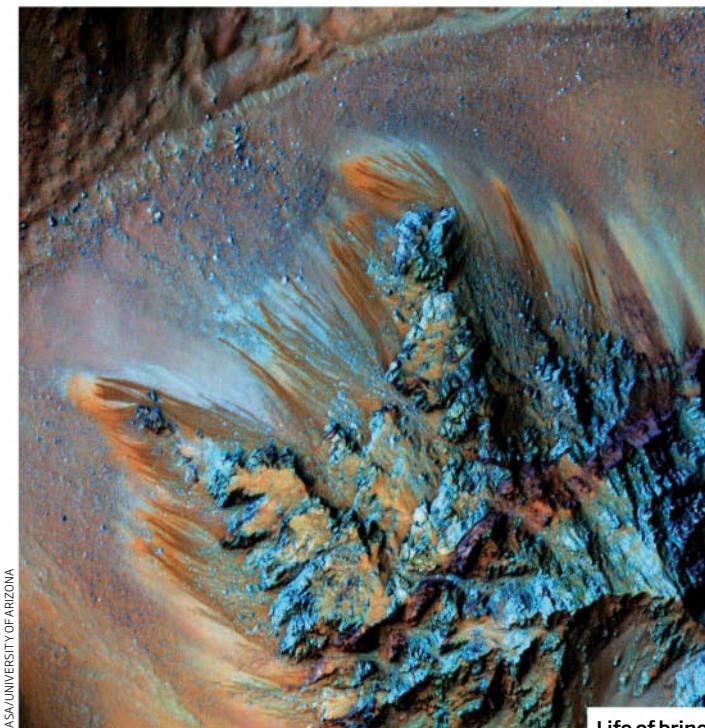
The difference is caused by heavy traffic and the 250,000 extra people in Melbourne on weekdays compared with weekends, says Earl. "Nothing in nature occurs on a weekly cycle, so it must be due to human activity."

Earl and his colleagues have shown that three other big Australian cities – Sydney, Brisbane and Adelaide – have similar weekly cycles. But less populated cities such as Hobart do not, probably because they have smaller workforces.

The findings were based on more than 50 years of records from Australia's Bureau of Meteorology. They will be presented at the annual conference of the country's Meteorological and Oceanographic Society in Canberra next month.

Previous research has found that central Tokyo and Moscow are hotter on weekdays than at weekends, and that wind speed, rainfall and cloud cover can also be greater in urban centres on weekdays.

Understanding the impact of humans on such cycles is useful for dealing with extreme weather events. This is important in Australia, where heatwaves kill more people than all other natural disasters combined, says Stephanie Jacobs at Monash University in Melbourne. Alice Klein ■



Life of brine

Slimy bacteria may thrive in Mars brine

Leah Crane

SLIME could help microbe stowaways survive a trip to Mars and thrive in the planet's salty waters once they arrive. Biofilms, colonies of cells embedded in a gooey protective coating, live longer than single cells when exposed to Mars-like brines – and even longer when they are dried out first, as they would be after travelling through space.

Biofilms are everywhere on Earth, from dental plaque and pond scum to the systems used to clean up oil spills. They also protect microbes from antibiotics, radiation, temperature changes and other extreme conditions that would otherwise kill them immediately.

But we are only just beginning to figure out how biofilms react to alien environments – which is crucial if we are to avoid

contaminating other worlds.

Although Mars is mostly dry, we know its ice caps contain water, and the planet may even have seasonal streams. To examine how biofilms might react to these Martian waters, Adam Stevens at the University of Edinburgh, UK, and his colleagues dunked them in seven Mars-like brines that

"Martian waters are the most likely spots to find life but also the best places for contaminants to thrive"

had a range of different dissolved salts and strengths.

In the weakest brines, all of the biofilms thrived, lasting well past the 5-hour observation time. As the brines became harsher, though, a divide started to appear: biofilms that were dried out prior to dunking did better than those that remained hydrated.

Any biofilms that made it from Earth to Mars would probably be desiccated from the trip. It turns out that this arduous ride could prepare them to thrive on Mars.

After a momentary shock in the most intense brines – which were about 70 times saltier than the weakest – dessicated biofilms started to grow. This may have been a consequence of communication throughout the biofilm: a cell on the outside edge of the film, exposed to Mars's brutally salty brines, could send a warning signal to the insulated cells deeper down. Those cells could either form more goo or reproduce more quickly to build their barrier.

After 5 hours in the harshest brines, all the microbes in the dried-out biofilms were dead. But the hydrated biofilms fared far worse: their cells died within an hour and some were done for in less than half an hour ([bioRxiv](https://doi.org/bxnc), doi.org/bxnc).

On Mars, areas with water (even salty, briny water) are designated as "special regions" by the international Committee on Space Research. They are the most likely spots to find Martian life, but also the best places for Earth-based contaminants to thrive.

Biofilms could help Martian microbes survive, so they might be something to look for in Mars's briny recurring slope lineae or in the salty seas of icy moons further out in our solar system. But the danger is that they could also help microbes from Earth thrive, overtaking any previous life and polluting the science.

"This research gives us some information about what we could possibly look for if we do go and investigate these brines – which, on the flip side, we're saying maybe we shouldn't," says Stevens.

"To me, this is a kind of a call to pick up the baton of this area that we really need to understand as we launch into an era of space travel," says Jennifer Macalady at Penn State University in University Park. ■

Buildings predict their own faults

Chris Baraniuk

IMAGINE a building that tells you that the heating is about to fail – a week before it happens. Some companies are using machine learning to do just that. It's called predictive maintenance.

Software firm CGnal, based in Milan, Italy, recently analysed a year's worth of data from the heating and ventilation units in an Italian hospital. Sensors are now commonly built into heating, ventilation and air-conditioning units, and the team had records of information such as temperature, humidity and electricity use relating to appliances in operating theatres and first aid rooms as well as corridors.

They trained a machine learning algorithm on data from the first half of 2015, looking for differences in the readings of similar appliances. They then tested it on data from the second half of the year – could it predict faults before they happened? The system predicted 76 out of 124 real faults, including 41 out of 44 where an appliance's temperature rose above tolerable levels, with a

false positive rate of 5 per cent (arxiv.org/abs/1701.03633).

"We started with the hospital because the heating, ventilation and air conditioning system is critical," says Carlo Annis of building management firm

eFM, which worked with CGnal on the experiment.

The idea is that these predictive algorithms could help fix faults before facilities crash – and also avoid unnecessary work.

"It's a nice technique that can be applied to existing telemetry [remote sensing] data sets," says David Shipworth at University College London. But, he says, the differences in function may become less distinct as the units age. "The barrier between normal

and faulty operation will become more and more blurred."

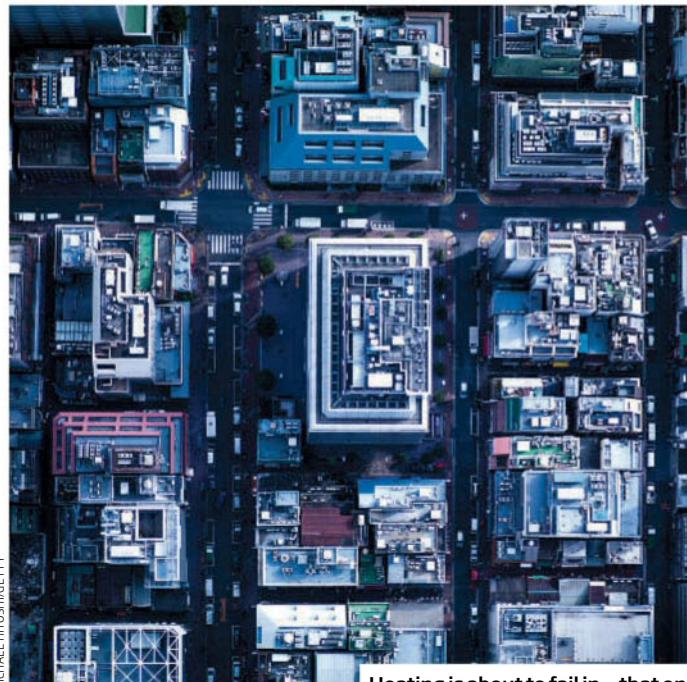
Others are crunching this kind of data for different purposes. Finnish start-up Leanheat puts a wireless temperature, humidity and pressure sensor into apartments to remotely control heating and monitor appliance health. Its system is now installed in nearly 400 apartment blocks, says chief executive Jukka Aho.

"Once we had these sensors in place, very quickly there was evidence that buildings were not controlled optimally," he says.

Instead of adjusting heating simply based on the outside temperature, Leanheat's models take into account how the weather has changed. Has the temperature fallen to zero from 10 degrees – or risen from 10 below?

It's not just for heating. US-based start-up Augury is installing acoustic sensors in machines to listen for audible changes in function and spot potentially imminent failures. CEO Saar Yoskovitz says Augury has "diagnosed" machines in hospitals, power plants, data centres and a university campus.

As the cost of sensors continues to fall, Shipworth says there will be more systems like these on the market. "We'll see a whole bunch of different machine learning approaches thrown at this over the next few years," he says. ■



MICHAEL HITOSHI/GETTY

Heating is about to fail... that one

Psychopaths aren't so clever after all

MANIPULATIVE, dishonest and lacking empathy – the traits that describe a psychopath aren't particularly pleasant. But the idea that they are also fiendishly clever isn't accurate.

Because many psychopaths are charming and manipulative, people have assumed they often also have above-average intelligence, says Brian Boutwell at St Louis University in Missouri. Psychologists term this

the "Hannibal Lecter myth", referring to the fictional serial killer from *The Silence of the Lambs*.

But Boutwell wasn't convinced. "Psychopaths are impulsive, have run-ins with the law and often get themselves hurt," he says. "That led me to think they're not overly intelligent."

To investigate, Boutwell and his colleagues analysed 187 studies on intelligence and psychopathy. These papers included research on psychopaths in prison as well as those enjoying high-flying careers. They also included a range of measures of intelligence.

Overall, the team found no

evidence that psychopaths were more intelligent than people who don't have psychopathic traits. In fact, psychopaths, on average, scored significantly lower on intelligence tests ([bioRxiv, doi.org/10/bxj4](https://doi.org/10/bxj4)). "I think the results will surprise a lot of people," says Boutwell.

Matt DeLisi at Iowa State University hopes that the findings will help put the Hannibal Lecter myth to rest. "The character promulgated the notion that

'Psychopaths are impulsive and get themselves hurt. That led me to think they're not overly smart'

psychopaths were highly intelligent, and there were real offenders that embodied this, like Ted Bundy," says DeLisi. "But I have interviewed thousands of offenders, some of whom are very psychopathic, and I have found that the opposite is true."

In his experience, DeLisi says psychopaths tend to do poorly at school. "They are very sensation-seeking," he says. "They don't like to sit and read books – they end up engaging in substance abuse." He has found psychopaths to be rather inarticulate, and to swear a lot. "They talk over you in a brusque, aggressive style," he says. Jessica Hamzelou ■

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More mad cow disease to come

Debora MacKenzie

IT'S happened. Until now, vCJD – the disease caused by infection with BSE – has struck only people of a certain genetic makeup. Now, for the first time, a case has been confirmed in someone with different genes – which may mean we have been misdiagnosing a new wave of cases.

In 2014, a 36-year-old man in the UK started developing aggressive personality changes, memory loss and problems walking. The symptoms and brain scans were typical of ordinary CJD, a rare disease that usually affects elderly people, not linked to BSE. But checks after he died in February 2016 showed that, in fact, he had vCJD, the kind caused by "mad cow disease". This was particularly surprising given his DNA.

BSE is caused by a misshapen protein, called a prion. It spreads when prions in the blood interact

with the normal version of the protein, and pass on the deformation. These prions build up in the brain, eventually causing neural disorders and death.

But the normal protein comes in two forms. Either it has the amino acid methionine (M) at position 129 in the amino acid chain that makes up the protein, or it has valine (V). Because we inherit a gene for this protein from each of our parents, there

"We have been concerned about the rise in the rate of CJD diagnoses since the mid-90s for some time"

are three possibilities – people whose bodies only make the M form, people who only have the V form, or MV people who make some of both.

All 223 people previously diagnosed with vCJD worldwide, including 177 in the UK, made only

the M type protein. But the 36-year-old man had a mix of both – the first MV case, apart from an unconfirmed case in 2008 (*New England Journal of Medicine*, doi.org/bxk3).

One reason we've not seen an MV case until now could be that MV people make less M protein. The BSE prion only deforms the M type, so it takes longer for the prion to build up in the body and cause symptoms in these people.

Since 2000, cases of vCJD have been declining in the UK. But it is highly likely there will now be another wave of cases in MV people, says Graham Jackson, at University College London. In the UK, 38 per cent of people make only the M type of protein, while 51 per cent of people are MV.

Moreover, more people may be infected with prions than previously predicted. Researchers in 2013 looked at how many removed appendixes contained the BSE prion, and estimated from this that one in 2000 people in the UK carry it. But the recent case had no detectable prions in his appendix. If that is true of more MV people, then the figure could be an underestimate.

The second wave might already have started. The number of ordinary human CJD cases diagnosed has doubled since the mid-1990s. "We have been concerned about this for some time," says John Collinge, of the National Prion Clinic in London, where the man was treated. This could be due to better diagnosis of CJD, but some cases may also be misdiagnosed vCJD in MV people.

Exposure to the BSE prion was at a high level in the UK until 1989, when some of the meat most likely to contain it was taken out of the food chain. So far, no one born after 1989 has been diagnosed with vCJD.

These prions seem to develop into disease in only a few cases. Even if just 1 in 2000 people carry the prion, we should have already seen 6000 cases of vCJD in people making only the M protein. ■

Brainwave login fails if you're tipsy... hick

GETTING drunk can make it harder to enter your password – even if your brainwaves are your login.

Brainwave authentication using electroencephalogram (EEG) readings is one of many biometric measures touted as an alternative to passwords. How would it work? A computer could display a series of words on a screen and measure the user's response via an EEG headset. But while research suggests that EEG readings can authenticate someone's identity with around 94 per cent accuracy, there could be confounding factors – including whether you've had a few too many drinks.

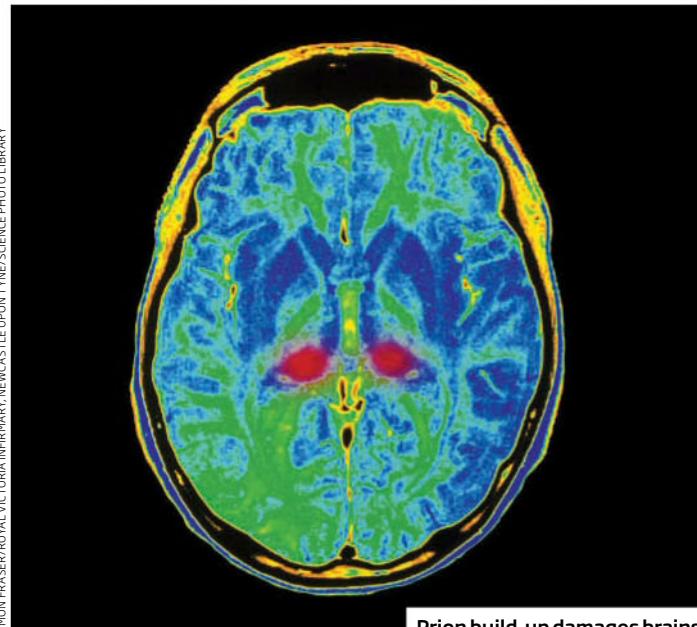
Tommy Chin at cybersecurity firm Grimm and Peter Muller at the Rochester Institute of Technology, New York, tested this by analysing people's brainwaves before and after drinking shots of Fireball whisky.

They presented their findings at security conference ShmooCon in Washington DC this month. Initial results from a small number of tests indicated that accuracy could fall to 33 per cent in inebriated users.

"Brainwaves can be easily manipulated by external influences such as drugs [like] opioids, caffeine, and alcohol," Chin says. "This manipulation makes it a significant challenge to verify the authenticity of the user."

The problem is not confined to drink and drugs. John Chuang at the University of California, Berkeley, has previously found that the accuracy of EEG authentication degrades immediately after exercise (though it quickly recovers). He suggests that other factors such as hunger, stress or fatigue could also reduce reliability.

One solution might be to collect multiple brainwave "templates" by mapping a user's EEG signature when drunk, tired and so on. Chin and Muller also found tweaking the EEG data analysis via machine learning improved results for participants who were inebriated. Nicole Kobia ■



Prion build-up damages brains

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Robot 'skin dip' senses body heat

Edd Gent

A HEAT-SENSING film could let robots detect when humans are around, like pit vipers hunting out warm-blooded prey.

The flexible, transparent coating is made of pectin, a low-cost plant material used to set jam. Unlike conventional electronics, it relies on currents of ions rather than electrons to detect temperature variations – just like natural membranes used by the snakes.

The film can sense temperature changes as small as 10 millikelvin, which is twice as sensitive as human skin. It can detect a warm body the size of a rabbit from a metre away, something the team tested by microwaving a teddy bear and setting it at different distances from the film. Changes in temperature cause the film's resistance to vary, which is picked up by electrodes along the edges and transmitted to a computer.

Applying it over a robot's entire body could provide all-round thermal sensing, says Raffaele Di Giacomo at the Swiss Federal Institute of Technology in Zurich,

who led the research. That could help machines navigate crowded areas without hitting people, or help search and rescue robots locate humans in rubble or smoke-filled rooms. It could also help them to avoid damage and be more helpful to people. A robot assistant might need to know if a cup of tea is too hot to hand over, for example.

For Di Giacomo, helping robots learn about their environment is key. "The most important thing about combining AI and humanoid robots is that this AI needs to be shaped by its senses like we are," he says. "You need

"The film could be dip-coated, like the process used to coat robots in the TV series *Westworld*"

to provide full sensory feedback so the AI can build up a picture of the world."

The temperature-sensitive film could also be used in prostheses to help give the wearer sensory feedback.

Unlike previous flexible heat



Getting ready to feel the heat?

sensors, the membrane is sensitive across a broad temperature range and is very simple to make. The researchers cast pectin in a mould and then dipped it in calcium chloride, as the calcium ions make the pectin sensitive to heat changes.

Signals from the electrodes along the film's edges can pinpoint heat sources, and the team is now developing algorithms to map temperature across complex surfaces like body parts (arxiv.org/abs/1512.01161).

Di Giacomo says the film could

also be sprayed or dip-coated – like the "skin dip" used to coat robots in the TV series *Westworld* – to give almost any object temperature-sensing capabilities.

"The sensitivity of the sensor is remarkable," says Zhenan Bao at Stanford University in California, who has developed her own version of electronic skin.

The skin dip approach looks feasible, she says, but incorporating the film into a multipurpose synthetic skin with flexible and rigid components may be challenging. ■

Seals detect breathing of hidden fish prey

IT'S a slasher film scenario playing out in nature. Harbour seals use their whiskers to follow underwater currents rippling away from the gills of fish so they can track down and kill their next victims.

Until now it wasn't clear how seals locate and catch bottom-dwelling flatfish that hide beneath the sand. "We have solved a long-standing riddle," says Wolf Hanke, the biologist at the University of Rostock, Germany,

who led the study. "These flatfish are very cryptic. They burrow in the ground and they're covered with sand or silt, but the seals still grab them."

The only way for the fish to avoid being eaten would be to hold their breath until the seal swims on – although it's unclear if flatfish do this when they spot the threat. "When partially immersed in sand on the ocean bottom, many flatfish leave their eyes sticking out, and with 360 degrees of vision they would very likely see a seal swimming towards them," says Alex Schreiber, who studies flatfish at St Lawrence University in Canton, New York.

Flatfish constitute up to 70 per cent

of the diet of harbour seals, so being able to detect the fish is key to the predator's success. After attaching a camera to a seal and watching it pinpoint flatfish despite having no visual clues to their position, Hanke and his colleagues set out to figure out how the seals do it.

They monitored three male seals in the Baltic Sea in a netted enclosure, one fitted with eight nozzles that could release water at an angle and rate designed to mimic the breathing patterns of flatfish. Each nozzle could be individually activated.

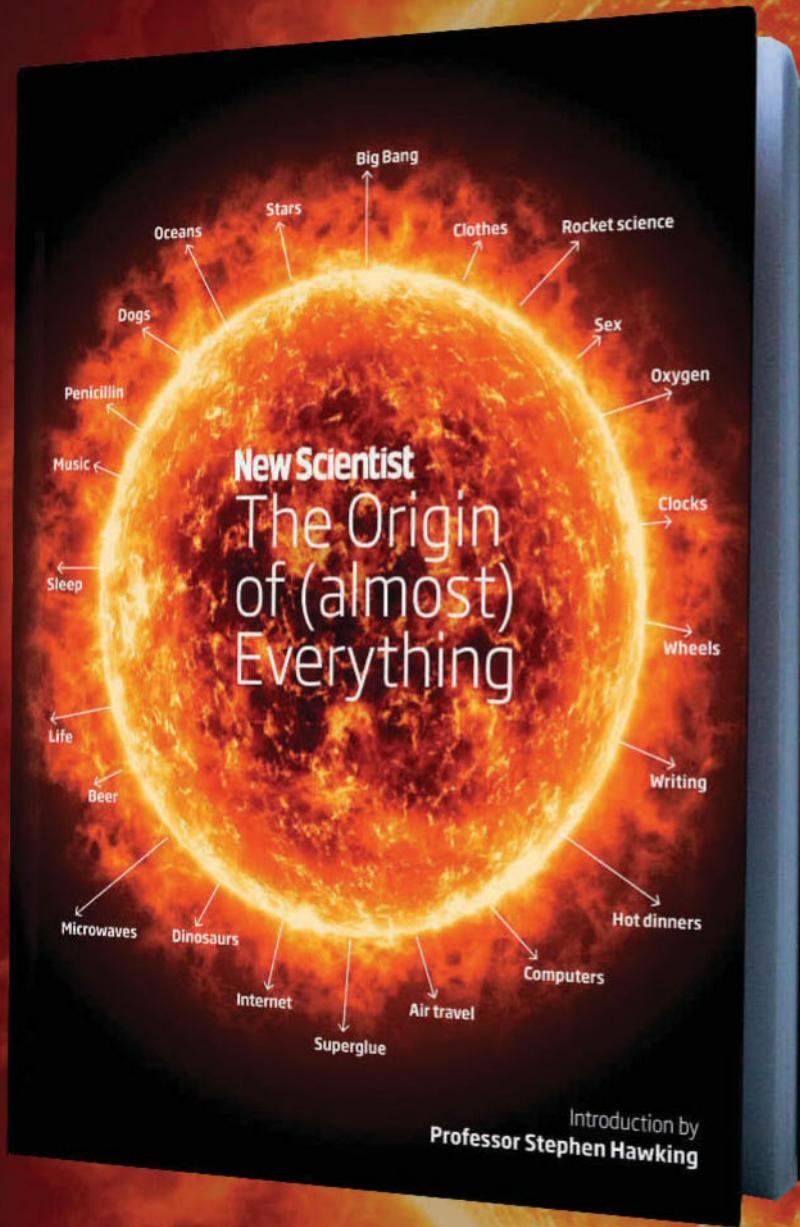
The seals were blindfolded for half the trials. When they could see, all the seals found the activated nozzle at

least 90 per cent of the time. Even blindfolded, they still identified the correct nozzle with at least a 75 per cent success rate (*Journal of Experimental Biology*, doi.org/bxkw).

"To see a seal following an underwater wake is amazing," says Colleen Reichmuth, a marine biologist at the University of California, Santa Cruz. "It's as if the animal is pulled by an invisible thread."

The researchers also covered the seals' faces and whiskers with a mask. In those trials, the animals failed to find any of the active water nozzles, and instead mostly spent their time drifting on the surface. Chelsea Whyte ■

Where did we come from? How did it all begin?

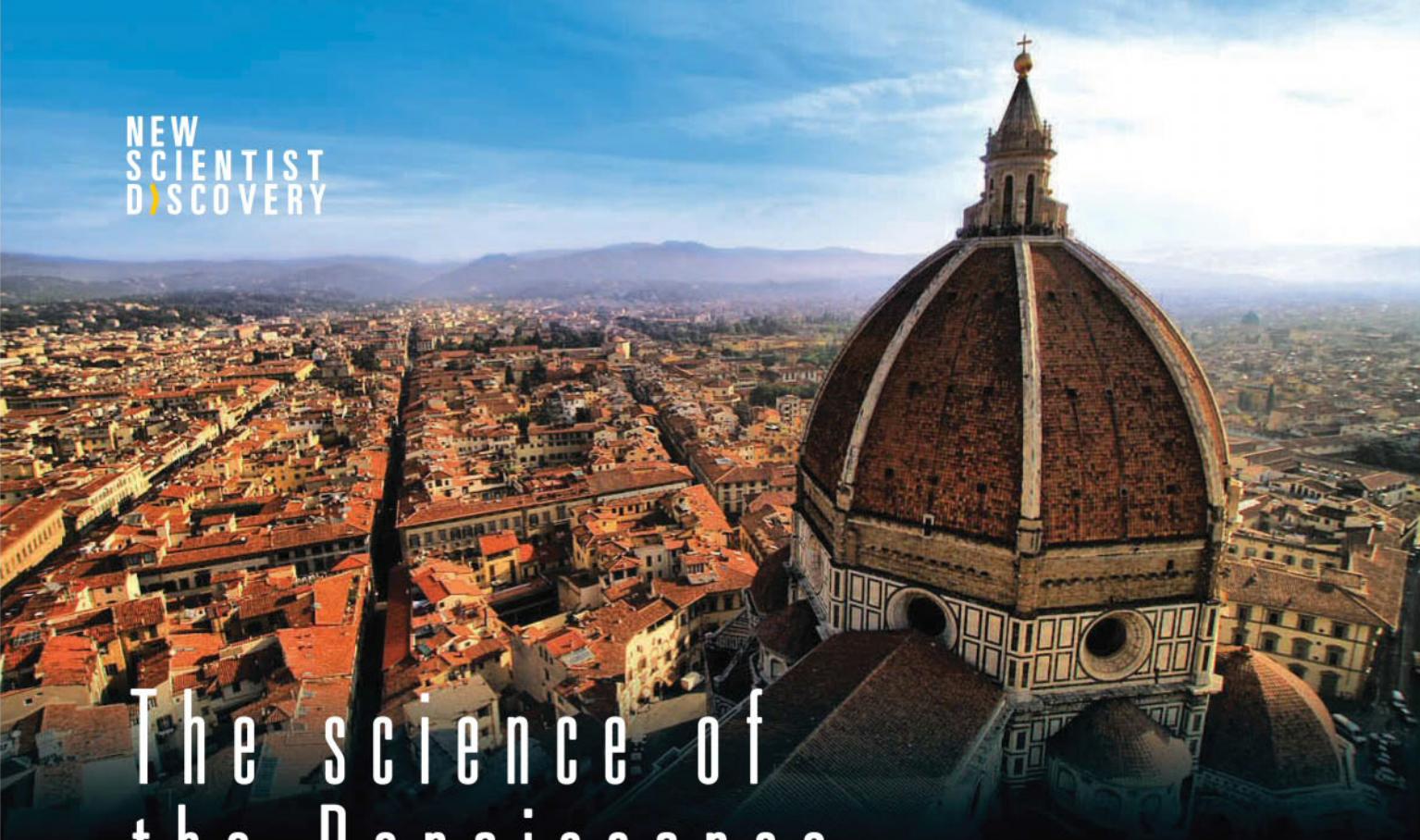


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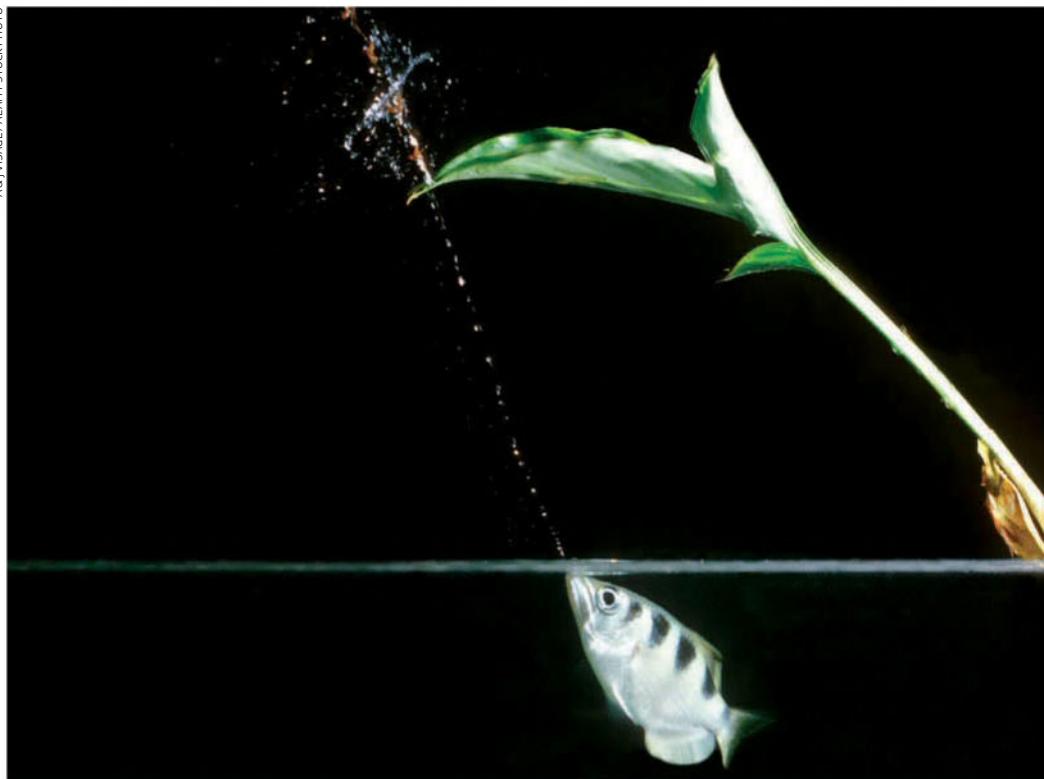
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Archerfish shoot their deadly jets to hunt underwater, too

SPIT and kill. Archerfish are famous for shooting mouthfuls of water at insects to dislodge them from vegetation above the water. Now they have been shown to use the jets to hunt underwater, disturbing sediment where prey is lurking and snapping up the spoils.

This suggests archerfish use their jets as tools, adapting them to serve both in aerial and underwater hunting, says Stefan Schuster at the University of Bayreuth in Germany. Schuster's team decided to investigate after observing the behaviour of wild fish on arrival in the lab. "We often see them 'shooting' at things

on the ground of their tanks, such as leaves or small fragments of wood," he says.

The team filmed five fish in a lab after presenting them with prey hidden in bowls of various types of sediment. They found that the fish used the same mouth manoeuvres underwater as they do at the surface to produce jets. The archerfish were able to alter the length and type of water blast to suit the type of sediment. Their shots were shortest if the sediment was coarse-grained and increased in length as the sand became finer (*Journal of Experimental Biology*, doi.org/bxks).

Which came first – aerial or underwater shooting – remains to be established. "Perhaps some tendency to produce underwater jets might have been there first, because this is widespread among fish," says Schuster.

Laser's 'sonic boom' caught on camera

SHOOTING a light-speed event requires an even faster camera. A set-up capable of 100 billion frames a second has captured the first footage of a photonic Mach cone – a sonic boom with light.

Einstein's theory of relativity forbids anything from travelling faster than the speed of light. So Jinyang Liang at Washington University in St Louis, Missouri, and his colleagues mimicked light

breaking its own speed limit.

They shot a laser pulse through a tunnel filled with dry-ice fog and flanked by two silicone rubber panels. Light travels more slowly through the silicone than in the fog, resulting in a conical shock wave trailing behind the head of the pulse.

The video system Liang's team used solves a problem in ultrafast medical imaging, which usually

requires multiple takes – meaning that the event being recorded must be precisely repeatable. This system eliminates that need and lets us to analyse light scattering that would distort images of tissues (*Science Advances*, doi.org/bxnj). It could be integrated into standard cameras, microscopes and even telescopes.

"It's got a very high 'wow, this is amazing' factor," says Bruce Tromberg at the University of California, Irvine.

Eggshells make cracking data chip

IF YOU want to make a computer, you've got to break a few eggs. A new data storage device made from crushed-up eggshells could pave the way for faster, greener computers.

The new device has resistive random access memory (ReRAM), which could be faster, provide a higher storage density and use less power than existing methods.

A team at the Guizhou Institute of Technology in China ground eggshells to produce a fine, nanoscale powder, which formed the electrolyte part of the chip.

Resistive memory relies on materials that remember change in electrical resistance when a current is applied to them. The device wrote a 1 or a 0 into its memory 100 times before breaking down (*Current Applied Physics*, doi.org/bxkz). Other materials can handle billions of cycles, but it's still impressive, says Kees de Groot at Southampton University, UK.

Out-of-body illusion eases fear of death

THE illusion that you're disconnected from your body can lessen your fear of dying.

Mel Slater at the University of Barcelona, Spain, and his team used a virtual reality headset to make 32 volunteers feel as if a virtual body that mimicked their every move was their own.

The headset then showed them floating away from the body, observing it above – an experience that many people who have come close to death say they've had.

The volunteers then answered a questionnaire, which found that the feeling of disconnection significantly lowers fear of dying (*PLoS One*, doi.org/1o/bxkv).

"It gives a sense that it's possible to survive beyond death," says Slater.

Foxes apply puma scent for safety

OUTFOXED? Gray foxes in the mountains of California have been filmed deliberately rubbing themselves in the scent marks left by pumas – possibly as odour camouflage against other large predators such as coyotes.

Over four years, Max Allen at the University of Wisconsin at Madison filmed 26 puma visiting sites known as community scrapes, where males leave scent “signposts” to communicate with others.

He was surprised when cameras revealed that foxes regularly visited these sites and repeatedly rubbed their cheeks on ground that had been freshly marked by the mountain lions. “The foxes rub very specifically on the areas where the pumas mark,” says Allen.

Coyotes often kill gray foxes, which are half their size, to reduce competition. “Coyotes are very reliant upon smell when hunting and are much bigger than the foxes,” says Allen, who thinks the foxes use this scent camouflage to give themselves a chance to escape (*Journal of Ethology*, doi.org/bxj9).

“Gray foxes climb trees to avoid predators,” says Allen. “In many cases, they probably only need a few seconds’ hesitation from a coyote for them to get up a tree. Smelling like a puma might give them that time.”



KARINE AIGNER/NATIONAL GEOGRAPHIC CREATIVE

Mystery fairy circles in Namibia's grassland explained at last?

THE Namib desert in southern Africa has strikingly regular bare circles in its grassland whose origin is fiercely debated – but it now seems that both leading explanations may be right.

One camp claims the empty patches, known as fairy circles, are created by termites under the soil clearing vegetation around their nests. An alternative idea is that the circles are caused by plants competing for water.

Corina Tarnita at Princeton University and colleagues thought both ideas had merit.

“Each one was bringing convincing arguments,” she says. So the researchers modelled what would happen if both had a role.

Their computer models predicted the large-scale pattern of bare circles we know about, but also a smaller pattern in the vegetation between the circles.

When they went to Namibia, they discovered these smaller circles, about 20 centimetres in diameter and 20 centimetres apart, which had never been reported before. “The fairy circles have drawn so much attention,

people haven’t paid attention to how the vegetation looks between the circles,” says Tarnita.

Neither mechanism can explain both patterns on its own. And because the new observations match the models’ prediction, it appears that the two mechanisms act simultaneously to make both types of circle (*Nature*, doi.org/bxkb).

But not everyone is convinced and there are claims that some circles aren’t associated with termites at all. It seems the turf war isn’t over yet.

Galactic collision birthed young stars

AN INTERGALACTIC scuffle seems to have resulted in the birth of new stars. Astronomers have spotted a large ring of young stars around our galactic neighbour, the Large Magellanic Cloud, that probably formed when the Small Magellanic Cloud smashed past its sibling.

Located just 160,000 and 200,000 light years away, respectively, the Large and Small Magellanic Clouds are the most luminous of the more than 50 galaxies that orbit the Milky Way. As the clouds revolve around us, they have also orbited each other.

Right now, they are 75,000 light years apart. But they were far closer when they passed each other 200 million years ago. The Small Magellanic Cloud may even have smashed right through its sibling.

Now Christian Moni Bidin at the Catholic University of the North in Antofagasta, Chile, and colleagues have spotted what they believe are the glowing remains of this skirmish: six young stars on the fringe of the larger cloud, each part of a vast ring some 80,000 light years in diameter (arxiv.org/abs/1612.03072). “It was surprising,” says Moni Bidin. “There was no indication of recent star formation in this region.”



HARVARD BIODESIGN LAB

This suit was made for walking

WALK a mile in a robot’s shoes and it won’t feel so far. A robotic “exosuit” cuts the energy used to walk by 23 per cent and could be used by soldiers or people who struggle to get around because of health issues.

The flexible exoskeleton consists of two stretchy fabric wraps around the calves connected to a waist belt by vertical straps and the ankle by a cable. A motor tethered to the suit delivers force to the ankle so the wearer uses less of their own energy to move their foot. The straps transmit the power to the hip joint (*Science Robotics*, doi.org/bxkz).

It takes a while to get used to the assistance, says lead researcher Conor Walsh at the Harvard Biodesign Lab. “When you really notice it is if you turn it off very quickly,” he says. “Your legs feel a little bit sluggish because your muscles were doing less work than you were used to.”

A soft exosuit adds less force than a rigid exoskeleton but is lighter and easier to put on. The soft structure makes the most of someone’s existing musculoskeletal structure, says Jeff Koller at the University of Michigan in Ann Arbor, “and that’s been designed over millions of years of evolution”.

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Plaques aren't the whole story

The Alzheimer's problem

Touted breakthroughs keep coming to nothing. Are we close to a cure, or have we got the disease all wrong, asks **Andy Coghlan**

NEW drug will finally cure Alzheimer's! Sound familiar? Seemingly every other week, the results of one preliminary trial or another promise that a game-changing drug for Alzheimer's disease is just around the corner.

Check back a few months later, though, and all mention of the drug has vanished, save perhaps for a terse story about a failed trial. Almost all clinical trials of new drugs to combat Alzheimer's fail. No drug has bucked the trend in 20 years, but you wouldn't know it from the constant promises of a breakthrough.

Last November, after the failure of a particularly high-profile trial, for some the jig was up. "There are no treatments that can slow or reverse this devastating condition," says Bryce Vissel at the University of Technology in Sydney, Australia. "There is no question that we have to look at Alzheimer's in a different way." So are we heading in the right direction, or do we need to rip up all the textbooks and start over?

Alzheimer's is the most common cause of dementia, and by some metrics its prevalence is rising. Alzheimer's Disease

International estimates that in 2015, 46.8 million people worldwide had dementia, a number that is set to double every 20 years, mostly because of an increasing number of older people in developing countries like India and China, leading to a global healthcare crisis.

The lack of meaningful treatments is not for lack of trying. The pharmaceutical industry has poured billions into research – Eli Lilly alone has spent £3 billion over three decades trying to develop a successful drug, and the US National

Institutes of Health has spent more than half a billion dollars a year in pursuit of treatments.

Despite the money and effort, the last Alzheimer's drug licensed in the UK can only treat the condition's symptoms – it doesn't halt the underlying deterioration. At best, it can buy someone a bit more time.

"There is no question that we have to look at Alzheimer's in a different way"

So where has all that money gone? Into experimental drugs that garner much press coverage as they clear various early clinical stages (see diagram, below right). However, none of the 123 drugs developed between 1998 and 2014 have cleared all the hurdles.

Most have focused on disrupting the sticky plaques that Alois Alzheimer found more than a century ago in the brains of people who had died with the dementia to which he gave his name. As these plaques clog up the brain and destroy brain cells, it is thought they take with them the vital memories and mental functions that the cells underpin. Get rid of the plaque, the thinking goes, and you get rid of the disease.

The plaques are a build-up of a protein called beta-amyloid, so it is that substance that most of the drugs have targeted. Eli Lilly's drug solanezumab was an especially promising example. It attacked the precursors that form new beta-amyloid, and was billed as the best hope yet. The company sent out several press releases about exciting preliminary results before the end of the trial.

Then it failed. The results of the early trial, they concluded, were simply not significant enough to warrant putting a drug on the market. For many, the failure of this trial was the straw that broke the camel's back. "Is this the end of the amyloid hypothesis?" asked a panel of experts convened after the failure. "We must urgently get

back to the biology of this disease," says Vissel. That doesn't mean throwing out the enormous body of work on beta-amyloid with the bathwater, he says: "Any holistic view of the data will have to account for it."

However, there has been growing recognition that beta-amyloid may not be the whole story. Lost amid the almost single-minded focus on the "church of the holy amyloid" are cases in which people have died of what is supposedly Alzheimer's, but postmortem examinations revealed no plaque in their brains. Equally baffling postmortems revealed enormous plaque build-up in the brains of people with extraordinary memories.

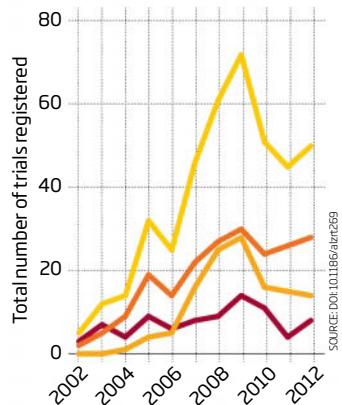
The strongest evidence for a relationship between removing these deposits and improvements in brain function comes from mice that have been bred to mimic symptoms of Alzheimer's. Part of the reason human trials have been unsuccessful is that plaque eradication doesn't translate into similar cognitive improvements in people.

Could the plaques be a symptom rather than a cause? According to one hypothesis,

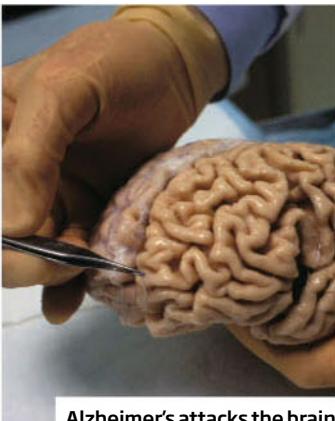
Church of the holy amyloid

Researchers continue to trial Alzheimer's drugs that target beta-amyloid, despite their history of failure

● Phase 1 ● Phase 2
● Phase 3 ● Phase 4



KAREN KASMAUSKI/GETTY



Alzheimer's attacks the brain

plaques may actually be a defence against bacterial invasion. In fact, they may play a number of roles in a disease that could have many contributing factors (see "Beyond the usual suspects", right).

But plaques may also play a part in healthy brains. There is growing evidence that the brain may need some amyloid protein – in one trial, removing it entirely resulted in side effects such as brain swelling. "Amyloid is in the brain for a reason," says Vissel. "We still know so little about its normal role."

Against this backdrop, Eli Lilly executives remain optimistic about beta-amyloid. "We are on the cusp," John Sims, senior medical director at Eli Lilly, told *New Scientist* last December at the annual Clinical Trials on Alzheimer's Disease meeting in San Diego, California, where the firm announced the failure of solanezumab. "With each little trial, we're taking one step closer to understanding the pathology better."

What can explain the unchanged enthusiasm after all the failures? Some wonder if it's because of the amount of money that has already been sunk into this. "There is an element of that," says David Reynolds, chief scientific officer at Alzheimer's Research UK. "If you've invested a lot, you must get to the finishing line," he says.

But Sims insists that even though the effects seen were

modest, they were consistent across all trials – and across all the cognitive tests applied to the patients. "That means they must collectively be showing mild efficacy of the drug." Now, the company and others are looking to boost that efficacy with other agents that tackle different aspects of plaque. Sims is orchestrating a trial of a drug that switches off production of plaque in the brain.

Rudolph Tanzi of Massachusetts General Hospital in Boston, who isolated the gene that makes amyloid, doesn't count the hypothesis out yet. "To get so close to statistical significance with a drug that doesn't even dissolve the amyloid that's already in the brain is highly encouraging," he says. Tanzi is excited about the prospect of mixing a solanezumab-type drug with another drug being trialled, aducanumab, which attacks existing plaques.

No cause for alarm

If all these drugs individually have moderate effects, it will redeem the beta-amyloid hypothesis, and Tanzi thinks, point the way to a multi-drug approach to treatment.

One drug might remove existing plaque, while another keeps new plaques from forming. "I can see aducanumab being used as a kind of liposuction for the brain for a month or so," he says, and then a different regimen – which, like solanezumab, disrupts amyloid formation – prevents further accumulation thereafter. This approach would be similar to how cholesterol blockers are given preventively to people with high cholesterol.

Several such drugs are in late-stage clinical trials that will conclude over the next three years, beginning this summer. Their results should establish once and for all whether hitting amyloid benefits humans.

BEYOND THE USUAL SUSPECTS

Beta-amyloid is widely thought to be the main player in the mental decline that characterises Alzheimer's disease. But its significance is coming into question (see main story), and researchers are investigating alternatives.

TAU TANGLES

Tangles of tau protein form in brain cells, kill them and spread from cell to cell. Amyloid and tau may work together to destroy areas of the brain vital for memory, learning and cognition. A trial of the first drug to remove tau failed, but researchers saw hints of improved cognition.

INFLAMMATION

Inflammatory diseases such as diabetes, heart disease and metabolic syndrome are often preludes to Alzheimer's. Anti-inflammatory drugs have shown early signs they could reverse the disease's psychiatric symptoms.

HERPES VIRUS

In experiments with cultured brain cells, herpes simplex virus 1 seems to speed the accretion of beta-amyloid and tau. If so, Alzheimer's could be treated by antiviral drugs.

CALCIUMOPATHY

Could faulty calcium signalling play a part? It's been a long-held hypothesis, but fresh evidence implicates calcium in neural dysfunction.

If drugs don't make a difference, there are other methods waiting in the wings, including using light therapy to boost a kind of brain wave that disrupts plaques.

While we wait for the verdict, we can take solace in the finding that we can do things to prevent dementia. There is growing evidence that certain behaviour reduces the chances of developing it, especially frequent exercise, sensible eating and avoidance of smoking and excessive alcohol. What's good for your heart, it turns out, is good for your brain. ■

States of detention

Chelsea Manning's jail term and treatment were unremittingly punitive. Commuting her sentence is right, says **Rebecca Dallison**

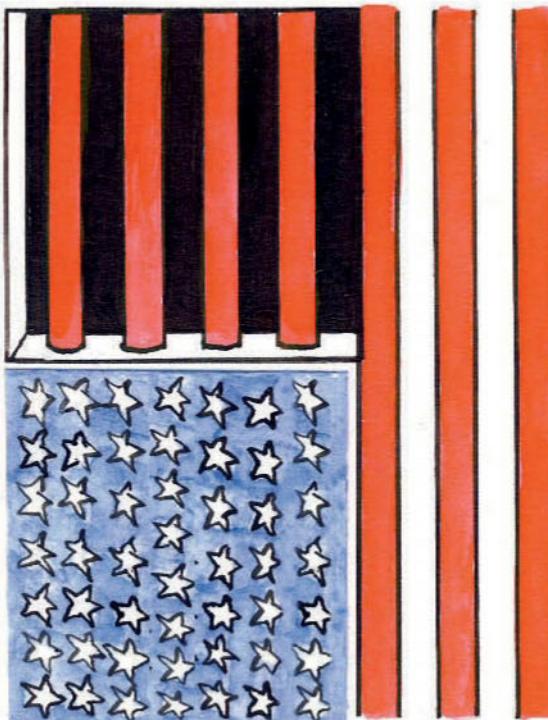
IT'S been a long time coming, but Barack Obama's decision to commute Chelsea Manning's unduly severe prison sentence in his final days as US president was hugely welcome.

When Manning, as a US Army intelligence analyst in Kuwait, copied thousands of files onto a CD and smuggled them out of her military base, she set in train a series of events that helped define a new era in internet activism.

Within weeks, documents she said showed "the true nature of 21st-century asymmetric warfare" were put online by WikiLeaks.

Many files that the US military wanted to remain secret showed in disturbing, unspun detail what was happening on the battlefield as well as behind the scenes as the military attempted to keep a grip on events in Iraq and elsewhere.

On the one hand, the "Iraq War Logs" lifted the lid on the mayhem



there during some of the fiercest periods of sectarian violence and resistance to US occupation. One day alone, 17 October 2006, saw 146 killings. On the other hand, the files showed that US military tactics could be as brutal as the militias terrorising the country.

One incident in 2007, caught on video and seen by millions due to Manning's intervention, involved two US helicopters strafing people on the ground with gunfire in what appeared to be a reckless fashion. Children were wounded and two Reuters journalists killed.

Such incidents were potential war crimes, often sanitised in the retelling by US military officials.

The main US response was to punish the messenger rather than listen to the message. Once identified as the leak's source, the US military treatment of Manning was unremittingly punitive.

She was kept in pre-trial solitary

A price on health

Amid NHS pressures, should costly drugs for rare diseases be sidelined, wonders **Zara Aziz**

THE vast majority of people in the UK support National Health Service treatments for rare diseases. But would that still hold true if treatments for cancer or hip and knee surgery were to be rationed on a regular basis?

As the NHS winter crisis deepens, it would appear that with increasing longevity and

complexity of medical conditions the economic burden on health and social care has no limit. So such questions arise.

It remains a challenge, even more so in the current climate, to balance finances with health benefits for the population. Can we as a society afford to devote significant sums of money to the

treatment of a small number of patients if it means that a larger population faces adverse health outcomes from funding cuts elsewhere in the NHS?

This is the debate swirling around a proposal from the National Institute for Health and Care Excellence (NICE), a body that decides which treatments the NHS funds. It wants to change the thresholds for financing drugs to treat rare conditions.

In broad terms, it recommends

"It is a reflection of us as a society that we continue to recognise the suffering of those with rare conditions"

automatically funding them up to £100,000 per Quality-Adjusted Life Year (QALY), a way of judging the cost-effectiveness of a treatment. Although those above £100,000 may still be considered, critics say they would be much less likely to get through. The Bio-industry Association opposes the proposals, and says many treatments for rare diseases already in use have a QALY cost of £500,000 or more. It fears the threshold will simply stop the flow of such medicines.

As general care improves and populations age or grow, people with rare conditions are likely to be more numerous and live

confinement for months (a UN expert called it tantamount to torture). At trial, Manning was not allowed to present evidence of acting in the public interest and the US military later repeatedly denied the treatment she needed to assist in her gender transition.

Amid Edward Snowden's startling disclosures about US mass surveillance, Manning's crushing 35-year jail term was clearly meant as a deterrent to others who might want to blow the whistle on state human rights abuse and other hidden crimes.

So the long-overdue decision to commute the sentence was a relief. I'm pleased Amnesty played a part in this, mobilising thousands of people to send online appeals to the White House via our urgent action network.

But let's not lose sight of the fact that the perpetrators of US war crimes in Iraq, Afghanistan and elsewhere have been pursued with a fraction of the vigour with which the US military went after Manning. Most remain free and unworried about prosecution.

Meanwhile, until 17 May, Chelsea Manning will remain behind bars in Kansas. ■

Rebecca Dallison is Amnesty International UK's urgent action coordinator

longer. The number of drugs available to treat such diseases is also likely to rise with advances in life sciences and related research focusing on new therapies.

It is a reflection of us as a society that we recognise the suffering of those with rare and debilitating conditions and continue to invest in life-improving treatments for them.

This must hold true even when we are faced with difficult choices and finite resources. The price that we place on ourselves and our loved ones must be the one we place on others too. ■

Zara Aziz is a family doctor in Bristol

INSIGHT Flight MH370



We must learn from failure

A dark day for aviation can have a silver lining

Paul Marks

IT BEGAN with confusion and ended with a shrug. After nearly three years, the joint Chinese, Australian and Malaysian deep ocean search for the missing Malaysian airliner, flight MH370, was called off last week.

Despite harnessing the best drone submarines available and searching 120,000 square kilometres of ocean, the fuselage of the Boeing 777 with 239 on board has not turned up.

It is a crushing blow to hopes of closure for the families and friends of passengers and crew. But the failure of the search will be no real surprise to anyone who has followed the case.

The tragedy began in the early hours of 8 March 2014. The airliner took off from Kuala Lumpur shortly before 1am and headed north for Beijing. But after the plane's transponder ceased broadcasting its position and the crew failed to make contact as expected, a massive air and sea search began in the South China Sea. That was rendered pointless after a few days, when Malaysian military radar data showed that the plane had inexplicably turned west.

As a later analysis of satellite pings would show, it then headed south over the remote Indian Ocean. The assumption is that it crashed into the water around 2500 kilometres west of Australia when the fuel ran out.

The mystery deepened when the Malaysian authorities said the aircraft had not transmitted any routine in-flight maintenance data, known as ACARS signals. However, *New Scientist* discovered that the engine-maker Rolls-Royce, which can monitor the health of all its engines wirelessly from its base in the UK, had received at least two ACARS messages from

"Air safety improves because we glean knowledge as a result of incidents and accidents"

the plane before it disappeared. Getting accurate information from the airline remains an issue.

Even so, hopes of finding MH370 were high at first because a similar search for Air France flight 447, which crashed in the Atlantic in 2009, was eventually successful in 2011 thanks to autonomous submarines.

Aviation watchers, myself included, confidently predicted that this would probably be repeated in the case of MH370 – but we were wrong. With only sparse satellite data, it wasn't possible to get a precise fix on the aircraft's position.

Some external parts of the plane have been found washed up by ocean currents, along with a sliver of an internal fuselage partition. That hints that the plane's body disintegrated, making the deep ocean search even harder.

Aviation safety improves because we glean knowledge as a result of incidents and accidents. While the exact cause of this disaster is still not known – the leading theory remains that cabin depressurisation rendered all on board unconscious – many lessons have been and must continue to be learned. These include the need for constant aircraft-tracking over remote ocean areas and for underwater acoustic pingers that are louder and longer-lasting, to help in the event of a post-crash search.

Action is under way already on the first of those: on 14 January, US rocket launch company SpaceX put 10 satellites into orbit that will make that constant tracking possible via a global service called Aireon. If there is a silver lining to this dark tale, it is this.

Of course, none of this will be of any real comfort to relatives and friends of those missing in one of modern aviation's biggest mysteries. ■

APERTURE





Bird banquet

WELCOME to "crane central". At a tiny village in north-west India, 20,000 demoiselle cranes stop to feast on gifts of grain each year.

Khichan, which lies in Rajasthan 100 kilometres from the Pakistani border, only became a major attraction for the cranes in the 1980s when local Jain priests began leaving them grain as they rested after gruelling annual migrations to India from Eurasia.

Within years, the practice caught on with other village residents and now swarms of birds arrive to gorge on as much grain as they can eat. The cranes can stay in Khichan from August right through to March the following year before making their return migration.

To get this shot, photographer Yashpal Singh Rathore buried his camera and operated it remotely. "I dug a small hole in the ground and placed my camera inside it with a fisheye lens," he says. "The cranes came in droves, exploring the lens and pecking at it."

It was a challenge getting pictures from this "grain's point of view" because it didn't take long for the lens to become covered in dust, feathers and footmarks that made further shots unusable. In all, it took week-long trips over three successive months for Rathore to get this and other stunning images of the majestic birds. Andy Coghlan

Photographer

Yashpal Singh Rathore

naturepl.com

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THE SECRET SCIENCE
IN YOUR HOME

Diaper tech: inspired by babies

All you need to aim to create the driest, most comfortable diapers is a lab full of playing babies and some bright minds



NOT many research facilities have walls decorated with giant bumble bees and paddling ducklings. Nor do they tend to distract their study subjects with colourful slides and miniature shopping carts.

Pampers - the first brand to widely introduce disposable diaper technology - has been understanding the needs of parents and babies to create new innovation for over 50 years. At the P&G Diaper Research and Development Centers in the US and Germany, around 250 researchers, part of a global team of over 800 scientists, ranging from dermatologists and chemists to material engineers, are designing the diapers of the future. The creative power of this team has enabled P&G to file more than 5000 diaper-improving patents.

Babies in motion: 3D scanning

Disposable diapers have changed beyond measure since their beginnings in the late 1940s. Their chief purpose, however, remains the same: to minimize leaks and keep skin dry and healthy and babies comfortable.



To help achieve this, babies and toddlers are regularly invited to the child-friendly research suite in Germany. The shape, fit and movement of their diapers are observed as they play. Detailed measurements are made in a large 3D scanner, consisting of 20 synchronized cameras arranged around a platform. Down the corridor is a specialized lab where dermatologists measure skin pH and loss of water from the skin as part of their efforts to minimize skin irritation.

Researchers also give packets of diapers to 1,200 families a week. These may be experimental designs or existing products. Parents are asked to keep a diary of how each performs, detailing such things as leaks, shape changes and dryness and condition of the skin.

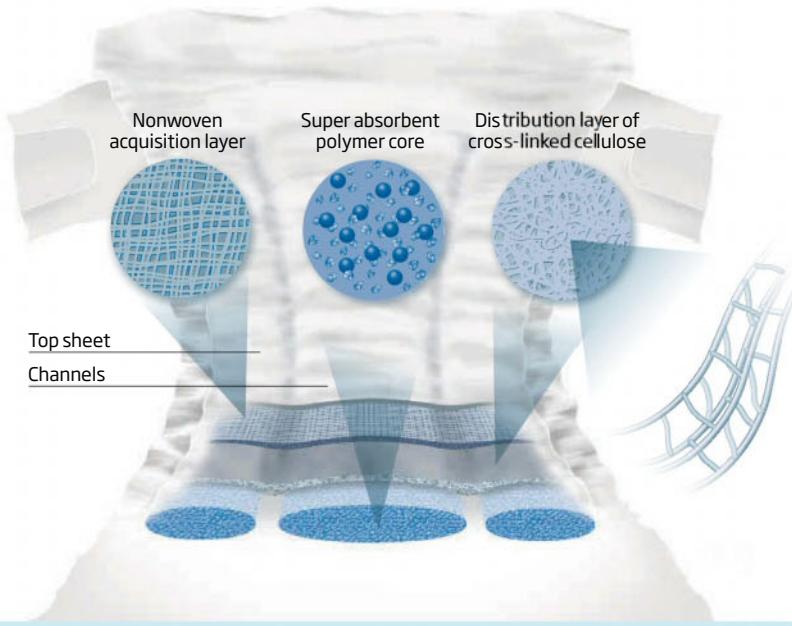
This feedback is combined with the properties of materials in diapers, such as elasticity and absorbency, to create computer models of new designs. These are used to calculate the chances of a leak or excessive sagging, for example. "We can assess 20 virtual diaper prototypes and eliminate all but two or three," says Dr Frank Wiesemann, P&G Principle Baby Care Scientist. "We then test those fully, rather than testing all 20."

Channelling innovation

Germany plays a key role in delivering major innovations in diaper design. Below the permeable sheet next to the baby's skin, for example, most diapers have a polymeric "acquisition layer" that draws urine away from the skin. P&G's scientists have added a second "distribution layer" to Pampers diapers, which disperses liquid around the diaper so it can be absorbed more efficiently. This is mostly made of cellulose, long thin fibers extracted from wood pulp. P&G treats them to create short "cross links" that strengthen the fibers (see graphic). This helps the diaper absorb quickly, even when a child sits on it when it's full.

Liquid flows along gaps between the closely bound cellulose strands which act like capillary tubes. "You need active distribution of the urine, whichever position the baby is in," says senior P&G scientist Dr Ute Fröhlich. "Capillary forces between the cellulose fibers are high, so urine can move rapidly even against gravity."

Most of the liquid then passes to the absorbent core layer of the diaper. Until recently, the core of a Pampers diaper resembled those of some other brands: a mixture of cellulose and particles of super absorbent polymer capable of soaking up huge amounts of liquid relative to its own weight. The idea was that the cellulose initially soaks up the urine and the super absorbent polymer dries out the cellulose. However,



From waste to worth: towards a circular economy

FOR over 25 years, Pampers has been integrating sustainable thinking into its R&D and manufacturing programs. The result is thinner, lighter diapers that give babies greater manoeuvrability and have less environmental impact.

Nevertheless, 170 billion diapers are thrown away annually and Pampers is

committed to diverting diapers away from landfill. Which is why P&G has joined forces with its Italian partner, Fater, to develop a plant that recycles disposable diapers with other absorbent hygiene products (AHPs). The plant, in Treviso, Italy, can process 10,000 tonnes of waste a year. That's 65 million diapers. AHP waste is fed

into a chamber where pressurized steam sterilizes it and neutralizes odors. Cellulose and super absorbing polymers are then separated for reuse in other industries. "It is the only such recycling site in Europe and the most advanced worldwide," says Dr Ioannis Hatzopoulos, P&G Sustainability Communications.

it is impossible to dry out the cellulose completely, so urine can be released back to the skin under pressure.

To deal with this, P&G developed a new super absorbent polymer that absorbs urine more quickly, letting them eliminate cellulose from the core. This has cut the weight of a single Pampers by around 5 grams, or 16 per cent, which is good for children. In a study funded by P&G, psychologists at New York University showed that, compared with cloth diapers, thin disposables help toddlers to keep their feet, reducing stumbles and falls.

Some super absorbent polymers can take up hundreds of times their own weight in liquid, but P&G has constrained the new version to absorb between 20 and 30 times its weight. As a result, the particles do not merge into a single jelly-like blob. They stay as individual spheres even when saturated, so that any extra urine can flow past them to be absorbed elsewhere.

Innovation doesn't end there. Some diapers

leak as a result of losing their shape when worn by active infants. To minimize this, P&G recently shaped the core into three channels to help the diaper keep its shape.

Finally, feces are trickier to deal with than urine. Clinical studies have shown that the enzymes in feces can be aggressive on baby skin, especially when activated by high pH urines. So quick removal of feces from the skin reduces the risk of diaper dermatitis. To improve performance, a Pampers Premium Protection diaper has a top sheet that has little conical apertures, allowing feces to get into the core instead of spreading on top. This reduces feces contact with the skin.

"When I chose to study chemistry I didn't set out to become a poo and pee expert," says Fröhlich. "What I didn't realize then was quite how much amazing science there is in the modern diaper." ■

More at: www.us.pg.com

Why am I here?

Having a purpose to what you do could help you live longer – and better, finds **Teal Burrell**

SOMETHING to live for. This simple idea is at the heart of our greatest stories, driving our heroes on. It is the thread from which more complex philosophies are woven. As Nietzsche once wrote, “He who has a why to live for can bear almost any how”.

As human beings, it is hard for us to shake the idea that our existence must have significance beyond the here and now. Life begins and ends, yes, but surely there is a greater meaning. The trouble is, these stories we tell ourselves do nothing to soften the harsh reality: as far as the universe is concerned, we are nothing but fleeting and randomly assembled collections of energy and matter. One day, we will all be dust.

One day, but not yet. Just because life is ultimately meaningless doesn't stop us searching for meaning while we are alive. Some seek it in religion, others in a career, money, family or pure escapism. But all who find it seem to stumble across the same thing – a thing psychologists call “purpose”.

The notion of purpose in life may seem ill-defined and even unscientific. But a growing heap of research is pinning down what it is, and how it affects our lives. People with a greater sense of purpose live longer, sleep better and have better sex. Purpose cuts the risk of stroke and depression. It helps people recover from addiction or manage their glucose levels if they are diabetic. If a pharmaceutical company could bottle such a treatment, it would make billions. But you can find your own, and it's free.

The study of how purpose influences our health largely began with Viktor Frankl, an Austrian psychiatrist who survived four Nazi

concentration camps. He noticed that some of his fellow prisoners were far more likely to survive than others. “Woe to him who saw no more sense in his life, no aim, no purpose, and therefore, no point in carrying on. He was soon lost,” he later wrote. After the second world war, Frankl dedicated his work to understanding the role of purpose and developed a therapy based on his findings.

Beyond happiness

Today, researchers define purpose as a sense of direction in life – a long-term goal set around one's core values, that makes life worth living, and shapes daily behaviour. It is a component of broader measures of subjective well-being or happiness (see “How do you measure purpose?” page 32), in which there has been a surge of interest in the past two decades. That's why, in 2012, then United Nations secretary-general Ban Ki-moon commissioned the first ever *World Happiness Report*, which has been updated annually since.

Measures of happiness can reflect broader social issues such as inequality, but when researchers look at the individual elements that make up well-being, they find purpose on its own has a unique influence on health.

Of course, teasing out whether it is actually purpose itself, and not the fact that purposeful people may exercise more or eat better, can be difficult. But over the past 10 years, the findings about the health benefits of purpose have been remarkably consistent – revealing that, among other advantages, alcoholics whose sense of purpose increased during treatment were less likely to resume heavy ➤



CARLO GAMBARESI



drinking six months later, that people with higher purpose were less likely to develop sleep disturbances with age, and that women with more purpose rated their sex lives as more enjoyable. These findings persist "even after statistically controlling for age, race, gender, education, income, health status and health behaviours", says Victor Strecher, a public health researcher at the University of Michigan in Ann Arbor and author of the book, *Life on Purpose*.

In an analysis of 7000 middle-aged people in the US, even small increases in sense of purpose were associated with big drops in the chances of dying during a period of 14 years. A study of more than 9000 English people over 50 years old found that – even after

adjusting for things like education, depression, smoking and exercise – those in the highest quartile of purpose had a 30 per cent lower risk of death over nearly a decade compared with those in the lowest quartile. Other studies show higher purpose cuts risk of heart disease by 27 per cent, stroke by 22 per cent and Alzheimer's disease by half.

The only reason purpose isn't a top public health priority, says Strecher, is because it somehow feels too vague or ephemeral. "It's not a construct that feels scientific enough," he says. "If this were a physical issue or a new drug or a gene, you would see lots of funding going into it."

Some of the scepticism has to do with concerns that purpose is merely a stand-in for opportunity in life, or wealth. Indeed, in recent research, Patrick Hill, now at Washington University in St Louis, did find that people with a stronger sense of purpose tended to have more money to begin with, and earn more over the period studied.

HOW DO YOU MEASURE PURPOSE?

To determine whether purpose affects health and longevity, you first have to measure it. To do this, many researchers turn to a set of scales developed in the 1980s by the psychologist Carol Ryff at the University of Wisconsin in Madison.

Ryff's scales measure six different aspects of well-being: autonomy; environmental mastery (the feeling of being in control in your everyday environment); personal growth; positive relations with others; purpose in life and self-acceptance. For each item, people read a series of statements, and select one of six responses ranging from "strongly disagree" to "strongly agree". These types of scales are often used to assess national levels of well-being.

For purpose, the statements include things like, "My aims in life have been more a source of satisfaction than frustration to me", or, "In the final analysis, I'm not sure that my life adds up to much".

Higher scores are based on stronger agreement with purposeful statements such as: "Some people wander aimlessly through life, but I am not one of them", and disagreement with remarks such as: "I live life one day at a time and don't really think about the future".

People who score in the bottom 25 per cent are considered to have low levels of purpose. A person with a high degree of purpose – someone who falls into the top 25 per cent – is characterised as someone who "has goals in life and a sense of directedness, feels there is meaning to present and past life, holds beliefs that give life purpose and has aims and objectives for living".

Health benefits

But a 2007 Gallup poll of 141,000 people in 132 countries found that, even though people from wealthier countries rate themselves higher on measures of happiness, people from poorer nations tend to view their lives as more meaningful. Shigehiro Oishi at the University of Virginia in Charlottesville, who analysed the poll data, suspects this is in part because people in developing countries have more concrete things to focus on. "Their goals are clearer perhaps: to survive and believe. In rich countries, there are so many potential choices that it could be hard to see clearly," he says.

Could it be that purpose is just another term for religious faith? Oishi's study did find that nations with the highest ratings of meaning in life were also the most religious. And religious people do tend to report having more purpose. But efforts to disentangle the two have revealed differences. Religiosity doesn't predict a lower risk of heart attack or stroke, for example. And certainly many non-religious people have high levels of purpose.

In fact, few of us rank on the very low end of the scale. "We tend to focus on the utter meaninglessness of the world," says Samantha Heintzelman at the University of Virginia. But, "for the most part, people feel like their lives are pretty meaningful".

So how does that meaning, that sense of purpose, actually improve your health? In part, it may be because greater purpose makes people more conscientious about maintaining



their health. But Steven Cole at the University of California, Los Angeles, thinks there's more to it. "If people are living longer, there's got to be some biology underpinning that," he says. Cole has spent years studying how negative experiences such as loneliness and stress can increase the expression of genes promoting inflammation, which can cause cardiovascular disease, Alzheimer's or cancer.

In 2013, Cole examined the influence of well-being instead. He focused on two types: hedonic, from pleasure and rewards, and eudaemonic, from having a purpose beyond self-gratification. These two aspects were measured by having participants note down their well-being over the previous week, how often they felt happy (hedonic) or that their life had a sense of direction (eudaemonic), for example. Although scoring highly in one often meant scoring highly in the other and both correlated with lower levels of depression, they had opposite effects on gene expression. People with higher measures of hedonic well-being had higher expression of inflammatory



Full circle: having goals that benefit others may provide particularly strong benefits for you

called the ventral striatum, an area activated when people are told to focus on things of value. Cole has found in as-yet-unpublished research that people with more activity in this area show similar patterns of gene expression to those with high levels of eudaemonic well-being. Focusing on something positive and bigger than yourself may activate the ventral striatum, which can inhibit areas like the amygdala, which usually promotes the stress response. Another indication of this comes from research showing that higher scores on a scale of purpose correlated with less amygdala activation.

And one study indicates that people with higher eudaemonic well-being have both increased activity in the ventral striatum and lower levels of the stress hormone cortisol. "Things that you value can override things that you fear," says Cole.

An alternative theory for how purpose could affect biology is by preserving telomeres, caps on the ends of chromosomes that protect DNA from damage, but that shorten with age and stress. A study on stress reduction through meditation has found that it could defend telomeres. But close analysis showed that the benefit was down to a change in sense of purpose, not the meditation directly: the greater a person's purpose became, the more of the protein telomerase they had to protect their telomeres.

Because of findings like these, some researchers think purpose should be more of a public policy priority, shifting away from traditional measures of economy like GDP, and narrowing the focus of happiness campaigns. Doing this would reduce early mortality, give us better overall health and cut the need for medical help, says Michael Steger at Colorado State University in Fort Collins.

It may also help us all get along. Hill has found that people who report higher levels of purpose are less distressed in situations where they are in the minority. It makes sense: people on a mission must accept that achieving their aims requires getting along with others. "Whether goals are focused on helping others or not, it's very rare that our life goals don't involve others at all," he says.

This is all well and good if you're already brimming with direction, but how can people boost their sense of purpose if it is lacking? There are several different strategies. As the study on telomeres indicates, meditation can have an effect. And other research has shown



ALEX WEBB/MAGNUM

genes and lower expression of genes for disease-fighting antibodies, a pattern also seen in loneliness and stress. For people scoring highest on eudaemonia, it was the opposite. "There were surprises all around," Cole says. "The biggest surprise being that you can feel similarly happy but the biology looks so notably different."

Cole suspects eudaemonia – with its focus on purpose – decreases the nervous system's

"If people with purpose live longer, there must be some biology underpinning that"

reaction to sudden danger that increases heart rate and breathing and surges of adrenaline. Over-activation of this stress-response system, as you see with chronic stress, causes harmful inflammation. "There may be something saying 'be less frightened, or less worried, anxious or uncertain,'" says Cole.

That something could be a brain region

that eudaemonic well-being is strengthened by carrying out random acts of kindness. Cole has found that having a purpose that benefits others may be particularly helpful. But striving for something that isn't necessarily constructive, like climbing a mountain, may be enough to create the health-boosting biology he sees in his studies.

To identify or strengthen your sense of purpose, Steger suggests starting small, by focusing first on making work more meaningful or becoming more invested in relationships. Strecher recommends setting a different purpose for each of four domains in life – family, work, community and personal – and acknowledging that your focus will shift between them over time, and the goals themselves can shift too.

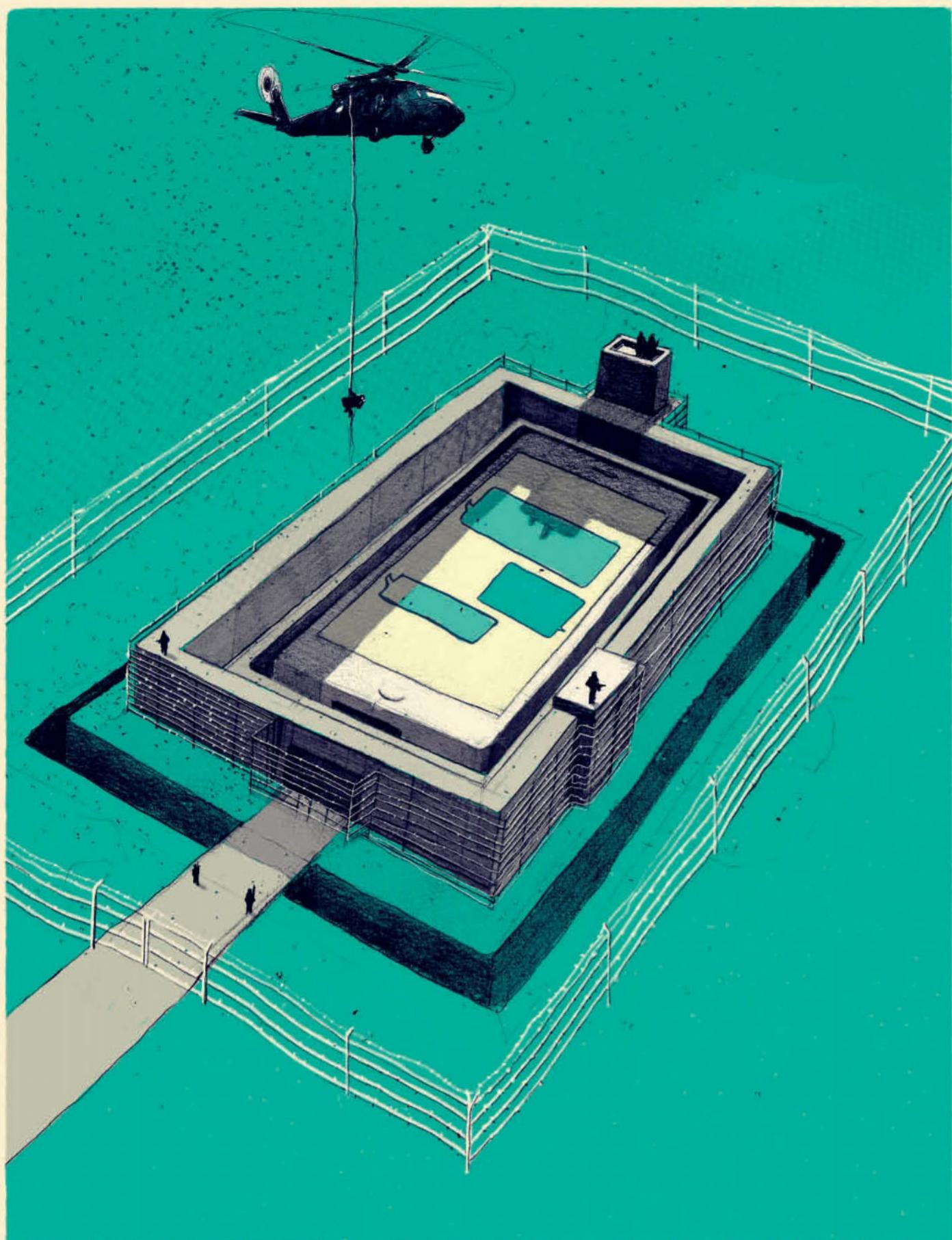
Purpose pills

Strecher says to consider what you would like to be said about you at your memorial, or to identify people you would like to emulate. He is also developing an app called Jool that he hopes can eventually serve as a kind of "purpose pill". Users begin with an assessment, and then get encouragement and guidance as they go on. It is currently being tested by companies to help employees hone their sense of purpose – and boost productivity. His team has been following an initial group of users for over a year, and they will begin randomised studies in the coming months.

There are also more formal therapies that foster purpose and meaning in life for people with conditions such as depression. For example, Dolores Gallagher-Thompson at Stanford University in California, has found that cognitive behavioural therapy can promote meaningfulness. She encourages patients to consider their legacy and how they might provide a good example for children and grandchildren.

Purpose isn't a fixed entity – it waxes and wanes with changes in life. Many people experience a drop in purpose following retirement, for instance, but can regain it by engaging in the community, helping others and remaining sociable. And, as Hill found, the health effects of purpose are apparent whether someone is 20 or 70. "To me, that's evidence suggesting that whenever one finds a purpose it can still imbue benefits," he says. In other words, it's never too late to start seeking the meaning of life. ■

Teal Burrell is a writer based in Richmond, Virginia



CODE THROUGH THE AGES

THE ORIGINS OF
CURRENT ENCRYPTION
METHODS LIE
CENTURIES BACK



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Phoney war

Does making our personal data private really undermine public security? Chris Baraniuk investigates

GABRIEL YEW was walking along a quiet residential street in north London when the police swiped his iPhone. He could only watch as an officer frantically tapped at the screen to unlock the secrets within.

It wasn't the device the authorities were after – it was data. Yew was sentenced last November to five-and-a-half years in jail for his part in a huge fraud involving fake credit cards, in large part thanks to messages contained on his phone.

The case illustrates a problem exercising law enforcement and security agencies across the world. Increasingly, our personal devices store and exchange data in an encrypted form, so that only the user can make it readable, by tapping in a passcode or through fingerprint identification or some other means. That's great for keeping personal information safe, say if our phone is lost or stolen. But it can also be a boon to criminals and terrorists.

And so we have entered the latest round in a long-running spat about how best to balance personal privacy and public security. This time, the focus is on the booming business of personal data encryption. While techies praise secure data for all, many politicians take a dimmer view. Legislation that would limit or perhaps even fatally undermine encryption has been discussed in many places, including

the US. In the UK it might already exist, depending on how you interpret new laws.

The techniques people have used to keep private messages private have evolved over time (see "Code through the ages", over the next few pages), but the core idea of encryption remains the same. You convert plain text into gobbledegook so that only you, and anyone else you care to share your secrets with, can unscramble it.

Back-door bombshell

Digital encryption has long been part of the internet's furniture. Take the "s" in the "https://" that you might see prefacing a web address in your browser. This indicates that any data shared with that website should be transmitted in a secure form, using an encryption system originally developed for e-commerce. Nowadays, nearly half the world's web traffic is encrypted, thanks to moves such as that by the streaming service Netflix, which announced in 2015 that it intended to move to the https standard.

Just recently, there has also been an explosion in the encryption of personal data. That's largely down to a bombshell in documents leaked by Edward Snowden in 2013, which exposed that the US National

Security Agency and its UK equivalent, GCHQ, had back doors to access data stored on iPhone devices and BlackBerry and Android phones, including notes, location information, text messages and emails. The security services appeared to be reserving the right to silently access the personal conversations of millions, and without any oversight.

Tech companies quickly responded. Apple's iOS 8 operating system, introduced in 2014, extended passcode protection to all personal data on a phone – hence the police officer's frantic tapping on Yew's iPhone to keep it unlocked. Google's Android operating system, the most popular in the world, offers device encryption as standard, too.

Beyond that, end-to-end encryption – a system that ensures no one besides the participants in a conversation, not even the provider of the service, can read it – has been enabled by default since 2016 in the world's most popular messaging system, the Facebook-owned WhatsApp. End-to-end encryption is also available on an opt-in basis for users of Facebook Messenger, the next most popular messaging app. The ins and outs of encryption may still be a recondite subject for geeks, but many of us are now using it unknowingly all the time.

Both WhatsApp and Messenger rely on ➤

FIRST CENTURY BC

SHIFT CIPHERS

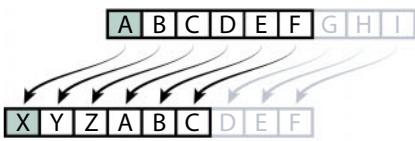
Roman dictator Julius Caesar encoded military orders by simply shifting individual letters in a message up or down a certain number of characters.

Message:

ATTACK AT DAWN

Code:

XQZXH XQ AXTK



16TH CENTURY

VIGENÈRE CIPHER

Shift ciphers like Caesar's can be cracked by trial and error. Letters also appear at a consistent frequency in longer messages, making them easy to break by analysing character frequency. French mathematician Blaise de Vigenère increased code complexity by introducing a "key" word ("LEMON" below) that produces a variable shift on each letter. Only those holding the key can easily decrypt such a message.

Message:

ATTACK AT DAWN

Key:

LEMONL EM ONLE

Code:

LXFOPV EF RNHR

Key	
A	E F G H I J K L M N O P Q R S T U V W X Y Z
B	B C D E F G H I J K L M N O P Q R S T U V W X Y Z
C	C D E F G H I J K L M N O P Q R S T U V W X Y Z
D	D E F G H I J K L M N O P Q R S T U V W X Y Z
E	E F G H I J K L M N O P Q R S T U V W X Y Z
F	F G H I J K L M N O P Q R S T U V W X Y Z
G	G H I J K L M N O P Q R S T U V W X Y Z
H	H I J K L M N O P Q R S T U V W X Y Z
I	I J K L M N O P Q R S T U V W X Y Z
J	J K L M N O P Q R S T U V W X Y Z
K	K L M N O P Q R S T U V W X Y Z
L	L M N O P Q R S T U V W X Y Z
M	M N O P Q R S T U V W X Y Z
N	N O P Q R S T U V W X Y Z
O	O P Q R S T U V W X Y Z
P	P Q R S T U V W X Y Z
Q	Q R S T U V W X Y Z
R	R S T U V W X Y Z
S	S T U V W X Y Z
T	T U V W X Y Z
U	U V W X Y Z
V	V W X Y Z
W	W X Y Z
X	X Y Z
Y	Y Z
Z	Z

Message

A T T A C K A T D A W N

1940s

JENIGMA

During the second world war, the Nazis' Enigma machines provided a complex variable shift and the ability to change the key every day. With some 160 billion billion settings, cracking the Enigma code, as Alan Turing and his colleagues eventually did, was a heroic computing achievement.



technology originally developed for an app called Signal, which was created in 2014 by Open Whisper Systems, a non-profit group based in San Francisco. As the company revealed last year in response to a subpoena demanding information on two of the app's users, all it had on them was the date one had installed the app and the last time both had used it. "It's the only government request that we've ever received," says Moxie Marlinspike, Signal's lead developer. "I don't anticipate that we would receive many more."

That sounds a little like wishful thinking. Encryption became headline news early in 2016, when the US Federal Bureau of Investigation (FBI) announced that it had failed to unlock an iPhone used by Syed Rizwan Farook, a jihadist who together with his wife had killed 14 people in a centre for people with disabilities in San Bernardino, California, where they both worked. Investigators called on Apple to create a special version of the phone's operating system that would make it easier to crack a user's passcode by trial and error. The company repeatedly declined, arguing it would compromise the security of all iPhones.

Quite right too – or was it? The fact is, we have never had cast-iron guarantees of privacy before. Even open democracies have laws allowing the authorities, with the

appropriate warrants, to search private premises for evidence where criminality or a threat to public safety is suspected. Wiretaps and bugging can be authorised under certain circumstances. Our expectation has been that invasions of our privacy will be proportionate to any threat. But the authorities' overreach revealed in the Snowden files has led to us being granted total privacy by default.

Not everyone is happy. WhatsApp has been blocked – and unblocked – three times in Brazil by judicial fiat. The German Federal Intelligence Service, the BND, reportedly

"We expect that any invasions of privacy should be proportionate to threat"

wants to spend €150 million in an effort to crack WhatsApp's encryption. In the US, a draft bill, the Burr-Feinstein law, would force tech companies to assist the government when it wants access to encrypted data.

That bill is now considered largely dead in the water, and last month the US House of Representatives Judiciary Committee issued a report highly critical of government attempts to weaken encryption, arguing they were against the national interest. But Donald

Trump's criticism of Apple's position in the FBI stand-off means many are expecting his administration to renew scrutiny of encryption. Ironically, Marlinspike thinks fears of Trump's supposed authoritarian tendencies were behind Signal's daily downloads increasing fivefold after he was elected president. "If you're a journalist, you might be worried about the privacy of your communications," says Marlinspike.

In the UK, the die may already have been cast. Last year, the then prime minister David Cameron asked, "In our country, do we want to allow a means of communication between people that even in extremis, with a signed warrant from the home secretary personally, we cannot read?" Sections 253 to 256 of the UK Investigatory Powers Act, which came into force last November, seem to give the answer "no": it requires operators to remove "electronic protection" applied to data when asked by the home secretary. There are also provisions for intercepting communications.

Such an ability is needed if we want security, argues David Omand, a former director of GCHQ. "There will be some circumstances in which some form of equipment interference or placing of malware will be justified on a case-by-case basis," he says. "You have to allow the intelligence agencies to think about how, in a targeted way, they can overcome the

1970

PUBLIC KEY CRYPTOGRAPHY

1971

BLOCK CIPHER

Traditional "symmetric" cryptography depends on two people sharing one encryption key. If this key is intercepted, the code can be cracked. In public key, or asymmetric, cryptography each user has two linked keys, a "public" key for encryption and a "private" key for decryption, but only the public keys are ever exchanged (see diagram, below).

1976

RSA ALGORITHM

Developed by German-born cryptographer Horst Feistel, the block cipher is a powerful way to encrypt blocks of text as a whole, rather than character by character. It became the basis of the US National Security Agency-approved Data Encryption Standard, which was used well into the 2000s.

This method for generating public and private keys, widely used on the internet and in banking security, was developed by Ron Rivest, Adi Shamir and Leonard Adleman at the Massachusetts Institute of Technology. It multiplies together two large prime numbers to make a shared public key, while using the same two primes to calculate a private key for decryption. Finding the prime factors of a large number is notoriously difficult even for a computer, so even if the public key is intercepted, it cannot be exploited on its own to decrypt messages.



Public key cryptography

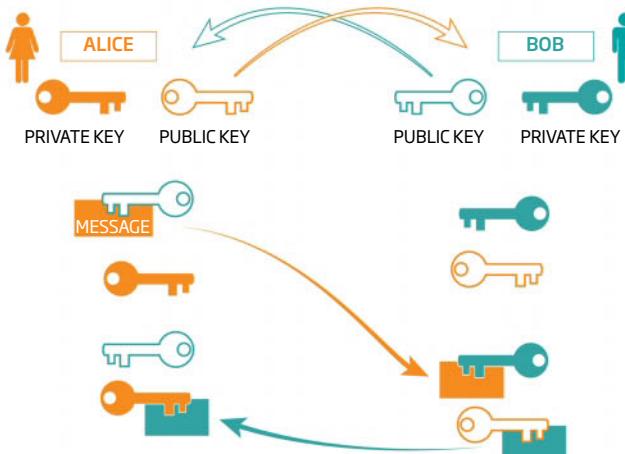
In methods such as RSA cryptography, messages are encoded using a public encryption key. Decrypting them requires a related private key, which only the intended recipient has

Alice and Bob create mathematically related public and private keys. They exchange public keys, but keep the private keys

Alice uses Bob's public key to encrypt a message and send it to him

Bob uses his private key to decrypt Alice's message. He then uses her public key to encrypt his reply which she can decrypt

Messages can be decoded by both parties without the decryption (private) keys ever being exchanged



difficulty of end-to-end encryption."

But some argue that the wording of the act mandates the creation of back doors, and that these could be misused by the authorities or exploited by criminals or other nefarious third parties. Alan Woodward, a security expert at the University of Surrey, UK, and a government consultant, thinks criticism that

the act threatens encryption is overblown. "I am aware of no one in any business being approached and told, 'You have to weaken your encryption product,'" he says.

Others are not so sure. Ross Anderson, a cryptographer at the University of Cambridge, UK, thinks that the new law is "disastrous". "If you are providing some cryptographic

product or service out of the UK, you can be secretly ordered to betray your customers and not tell them about it," he says.

In 2015, Anderson co-authored a report on encryption, *Keys Under Doormats*, that looked at how the authorities might get access on demand to secure communications, and what consequences that might have. There might be a master set of decryption "keys" held by the authorities that could unlock private messages – a system known as key escrow. Or technology companies might hold such master keys for their services and provide them on request.

The report raises a long list of security and ethical issues with both strategies that, in the authors' view, make them currently unworkable. The argument that terrorists or criminals could be using encryption to hide from the law fails to move Anderson. "Sorry, that's just tough. Freedom isn't free, right?" he says. "Freedom costs. That should be clear to anybody with any brains and if we're going to restrain some state power, there will be costs in terms of civilian casualties."

Another co-author of the report was Phil Zimmermann, the inventor of Pretty Good Privacy (PGP), a program that helped to popularise encryption in the 1990s. Today, he develops security products used by US Navy SEALs, and says that schemes to weaken

1991

PGP

Generating secure, random public keys when constantly sending messages back and forth is computationally intensive. The PGP (Pretty Good Privacy) protocol developed by Phil Zimmermann uses block ciphers and a user's private key to make a "session" key for a batch of messages. The session key is changed frequently, keeping the conversation private. Available for free, PGP is widely used by the security conscious to encrypt emails and texts.

CRACKED BY QUANTUM?

One innovation could blow current notions of cryptographic security out of the water: quantum computers. Modern-day encryption techniques rely on mathematical operations that are relatively easy to do one way but take an unfeasible amount of time the other way – multiplying two large prime numbers together versus factoring the result, for example.

Quantum computers promise to harness the fuzzy logic of quantum theory to make such calculations much easier. They already exist in basic forms, with one successfully factoring the number 56,153 in 2014. That's nowhere near big enough to render cryptography redundant – but it might only be a matter of time. "There is a threat that people will be able to build large-scale quantum computers soon," says information security expert Kenny Paterson from Royal Holloway, University of London. "If the technology exists, everybody can use it to break other people's crypto."

Some propose fighting fire with fire, by developing quantum cryptographic algorithms immune to quantum cracking. Such algorithms have already been used to secure information on small-scale networks, but there are currently severe limits on how much data can be transmitted securely and over what distance. Many researchers are trying instead to develop classical cryptographic systems immune to quantum hacking – although it remains to be seen whether that approach can succeed, says Paterson. "What computation is possible on a quantum computer is still an evolving story, so this is not an easy endeavour."

1990s

https://

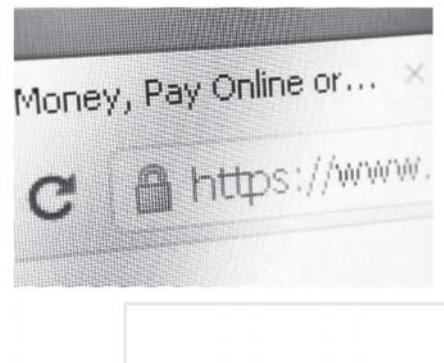
Using symmetric cryptography to encrypt data and public key cryptography to establish users are who they say they are, this secure protocol, originally developed for e-commerce, now covers almost half of all connections made on the web.

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1 1 1 1 0 1 0 1
0 1 0 0 0 0 0 1
0 0 0 0 1 1 1 0
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1 1 1 0 1 0 1
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2010s

END-TO-END ENCRYPTION

End-to-end encryption methods developed for messaging services combine complex algorithms for distributing public and private keys with "forward secrecy", a property ensuring that even if a private key is compromised, messages previously encrypted with it cannot be read by a third party.



cryptography put everyone at risk. "If you're going to make body armour, well, you want it to stop bullets," he says. Cryptography should be similarly bulletproof. "Making it more difficult for the bad guys to get in also makes it more difficult for the good guys to get in. And there's no way to avoid that."

Hacked off

But perhaps there is a third way. Rather than weakening encryption for everyone, some think law-enforcement agencies should hone their skills by breaking device encryption on a case-by-case basis. That's apparently the route the FBI eventually took with Syed Farook's iPhone: in April 2016, FBI director James Comey admitted paying a private company \$1.3 million to hack into the device for them.

This approach might be expensive and time-consuming, but you'll usually find a way in, says Robert Graham of Errata Security, a company based in Atlanta, Georgia, that legally hacks devices to test their security. "Almost always, you find bugs in how they do encryption that allow us to break through." Many devices, for example, have "back-door passwords" that can be reset even if you are otherwise locked out.

But Graham certainly isn't advocating that FBI hacking become commonplace. "It doesn't

change the argument that having our devices spy on us is a bad idea," he says.

Having reached fever pitch following the Apple versus FBI spat last year, official rhetoric against encryption seems to have calmed a little. But few expect things to stay that way. "The FBI director has already said he wants us to restart this debate this year," says Matthew Green, a computer scientist at Johns Hopkins University in Baltimore, Maryland. "I'm sure we're going to see a renewed push on this." Graham, for one, is prepared to fight back. "If my government mandates crypto back doors, I'm leaving the country and hacking back against the government," he says.

People who sign up to what he calls a "cyber revolution" might target the FBI or politicians, "getting all their secret emails", he suggests. It's not clear whether that would be in anyone's interest. But with an unprecedented wealth of potential evidence just a cryptographic key away, the debate will continue to raise hackles on both sides. On the one hand, encryption is crucial for the security of websites, financial transactions and corporate enterprises. On the other, we share a desire to be kept safe. For now, it seems tolerating the occasional officially sanctioned "mugging" on the street is about the only option we have. ■

Chris Baraniuk is a journalist based in London

Early learners

Fetuses of all species take in an incredible array of things before they are born, discovers Guy Lewy



I spy with my fetal eye: a cuttlefish embryo, watching

NEWWLY hatched turtles head straight for the sea and tadpoles recognise a predatory salamander the very first time they see one. But what may, on the surface, appear to be a primordial instinct can sometimes hide a deeper, stranger truth: that our first lessons in life come before birth itself.

Over the years, studies of young animals belonging to a range of species have pushed back the known onset of learning. "We tried earlier and earlier," says Ludovic Dickel, who studies cuttlefish at the University of Caen Normandy in France. "In the end, we questioned embryos."

From this research, a trend is emerging. Birds in the egg are listening to their mothers; lambs, like human babies, can be taught about food before birth; and some embryos watch the world through their still-developing eyes. And because these are all examples of acquired knowledge, not instinct, they can also be manipulated.

Take taste. Stories of human babies developing a preference for certain foods while still in their mother's womb aren't uncommon (see "Is my bump wise to the world?", page 40). Perhaps the best illustration of this is that we tend to be more tolerant of spicy food if our pregnant mothers ate a diet full of such cuisine.

Likewise, Konstantinos Fegeros's team at the Agricultural University of Athens in Greece has shown that if a pregnant sheep is ➤



BERTRAND MEUNIER/TENDANCEFLUO

IS MY BUMP WISE TO THE WORLD?

Human fetuses glean information from the world on the other side of their mum's tum. By looking at how newborns move their heads and speed up or slow down their sucking on a rubber sensor when presented with stimuli, you can tell what grabs their attention and deduce from this what they've already become familiar with before birth.

LANGUAGE

Babies start responding to different sounds from 20 weeks. Our mother's voice is the one that's loudest inside the womb, and we are born preferring it to others, and our mother's tongue to other languages. The melody of our first cries are even characteristic of the local language. And studies reveal that children born to bilingual mothers seek out both languages equally.

MUSIC

Your musical tastes may have begun to develop in the womb. In one study, third trimester babies were repeatedly played *Twinkle Twinkle Little Star*. They were played the tune again at birth and four months later, but this time with some wrong notes introduced. Babies who had been trained in the womb responded much more than others who hadn't.

TASTE

Strong flavours from spicy or garlicky food diffuse into the amniotic fluid, which fetuses start swallowing at nine weeks, sampling it with their developing taste buds. And they remember these tastes: newborns offered garlicky food for the first time will accept it with gusto if their mothers ate garlic during pregnancy, but will balk otherwise.

fed oregano, after birth its lamb is more likely to choose food flavoured with the herb than if its mother is fed a regular diet.

Even chicken fetuses locked away inside eggshells get a dose of their mothers' diet. Aline Bertin of the French National Institute of Agricultural Research in Nouzilly fed chickens a diet that was enriched with either a fish oil or soybean oil. She found that chicks born from the first group were more likely to eat unfamiliar foods after hatching if they were

laced with the now familiar fish oil.

This kind of habituation is a very basic form of learning – an example of how animals change their behaviour based on information they gather from their environment. Studies in rats show a more complex form of learning happening in the uterus.

Unlike humans, many other animals can walk, run or swim almost from the moment they are born. That makes sense. Being able to flee a predator right from the get-go is an

obvious advantage in the wild. But it looks as if we can no longer put this down to instinct. Ultrasound images show that rat fetuses move their limbs in a coordinated manner, which suggests that they may be practising for the day they enter the world.

Scott Robinson at the University of Iowa in Iowa City took the demonstration one step further. He performed delicate surgeries on pregnant rats to tie two legs together on each fetus, and then monitored them using ultrasound. Regardless of which limbs Robinson paired, the fetuses learned new, coordinated movements within 30 minutes.

Other experiments have accomplished a more fundamental kind of reprogramming in birds. Christopher Harshaw at Indiana University in Bloomington and Robert Lickliter at Florida International University in Miami played recordings of Japanese quail song to the eggs of American quail (pictured right). When the chicks hatched, they had a choice. From one direction, a loudspeaker played the song of American quail – the calls their mothers would have made had she been present; from the other came the warblings of a Japanese quail. The chicks' prenatal experience trumped whatever instincts they might have had: they preferred to spend time near the calls of the wrong species.

Life or death

Experiments such as these underline how critical prenatal information-gathering is. In Australia, superb fairy wrens must either learn something while stashed away inside the egg or face certain death. Their nests are plagued by parasitic cuckoos that lay their own eggs inside a wren clutch a few days before it hatches. Diane Colombelli-Negrel at Flinders University in Adelaide showed that to thwart the invaders, mother wrens sing a unique password song to their eggs. Her own eggs have weeks to learn the song, but the cuckoo chicks don't, and that's their downfall: the mother wren will leave to die most chicks that don't integrate the password into their own song once they hatch.

You might think that none of this is as impressive as the learning demonstrated by Ivan Pavlov's dogs, who famously learned to associate the sound of a bell with food. "After a few sessions, the dogs started salivating as soon as they heard it, even though no food was presented," says Maud Ferrari at the University of Saskatchewan in Canada. Ferrari and her colleagues recently

demonstrated this classic form of associative learning in unhatched frogspawn.

"Many species get scared when they smell that one of their own was attacked," says Ferrari. "They can smell chemicals leaching out of the injured body. So to teach a prey about a predator, we can pair the alarm cues with the cue of a specific predator. The next time it detects the predator cues, it knows to be scared of it."

Ferrari's team wanted to see if wood frog embryos, safe inside their gelatinous eggs, could do the same as adults and associate a smell with danger. Every afternoon for five days, they exposed frogspawn simultaneously to the smell of crushed tadpoles and the odour of a tiger salamander. Later, when the tadpoles were a couple of weeks old, they exposed them again to the salamander smell. Despite never having met a salamander, the tadpoles that had been exposed to the cues while in the egg froze – a typical response seen in frogs to avoid being noticed by predators. The others did not.

But this wasn't the limit of their abilities. "The fact that they learned per se wasn't that surprising," says Ferrari. "Cool, but not really unexpected. Lots of embryos learn things. What was more surprising was how sophisticated their learning can get."

Salamanders usually hunt during the afternoon, when air temperatures and their bodies are warmer, so to make the

**Quail chicks learn
their mother's song
in the egg**



SUPERSTOCK

SEEDS OF CLEVERNESS

Learning has been spotted throughout the tree of life – and not just in animals. A recent study seems to show that pea seedlings can match Pavlov's dogs for learning to associate two things with each other.

Seedlings were planted in Y-shaped pots with two possible openings to grow out of. For a few hours on three consecutive days, the seedlings were trained with a light source and a fan. In some pots, the fan and light were aimed at the same opening, in others, at different openings. Control plants were grown with just a light source. Then the lights were switched off and a fan was aimed at one opening. Control plants ignored it and grew towards the light's last position. But most trained plants grew according to their previous experience of the fan: plants that were used to wind coming from the same direction as the light grew towards the fan; those used to opposite cues grew away from it.

The authors say this shows that plants are capable of associative learning. "We have a lot to learn about learning," says Monica Gagliano at the University of Western Australia.

experiment realistic, the researchers exposed the embryos to the predator cues at that time of day. Later, these tadpoles froze only if they were faced with salamander cues in the afternoon. But if eggs were "trained" in the morning instead, the tadpoles would only respond to the cues in the morning. "To learn that something only shows up at a certain time of day, you need repetition, time to find a pattern.

"Rat fetuses learned new movements within 30 minutes"

So to learn after just two or three exposures, that's pretty amazing," says Ferrari.

Some embryos even watch the world go by from the safety of their eggs. That's the case with late-stage cuttlefish embryos, whose eggs are transparent. "The embryo is very reactive," says Dickel. "When you move your hand in front of it, it changes its colour."

Dickel and his team left eggs to develop alongside live crabs, with the two species separated only by a transparent pane of glass. The team had previously shown that newly hatched cuttlefish prefer shrimp to all other foods, but when Dickel's hatched subjects were given a choice of prey, they lunged at the crabs instead. The team believes that the cuttlefish spy on the crabs through their embryonic eyes. To confirm this, the group plans to repeat the experiment with videos of crabs, instead of live ones.

"In the last week of development, they're changing the colour of their skin into different camouflage patterns," says Dickel. "It's probably a kind of practice: in the egg they're protected from predators, so they can make mistakes. They can learn to detect, to feel, to smell."

Experiments like these show that unborn creatures are taking stock of the environment they will soon inhabit. As their senses come online, they process and remember the cues that filter through the walls of their embryonic nursery to give them vital preparation. So be careful what you do around frogspawn – it's taking note. ■

Guy Lewy is a freelance writer based in London

To read the studies mentioned in this article, see the online version at newscientist.com/issue/3110

You had me at hallå

Proficient in about 50 languages, **Alexander Arguelles** is among the most multilingual individuals of all time. He reveals what it's like to live with a handful of disparate tongues

Can you give me a potted history of your language journey?

I'd learned French, German, Spanish, Latin, Greek and Sanskrit by the end of college. In graduate school, I added medieval literary languages such as Old Norse, Old French and Middle High German. Then, living in Berlin, I added more medieval Germanic dialects, Dutch and a bit of Frisian, Swedish and other Scandinavian languages, as well as Italian, Portuguese, Occitan and Catalan. After that, during an intensive 10-year "monastic" period in Korea, I learned Korean, Japanese, Mandarin and Classical Chinese, but also Russian, Arabic, Persian, Hindi, Turkish, Swahili, Irish Gaelic, Modern Greek and most of the Romance, Germanic and Slavic languages.

I know you don't like being asked how many languages you speak, but I'm afraid I have to...
I don't count; it's very hard to say. Some languages are so close to each other it feels like cheating to count them separately. And what about my dead languages? Altogether I've studied maybe 60 or 70.

Where did your love of languages come from?

I was raised a monoglot but my father is a polyglot and I travelled around a lot as a child. Then there was my maternal grandmother. She was a German immigrant's daughter in the Midwestern US, so she grew up bilingual in English and German, and somehow she fell in love with Spanish. So she taught herself Spanish as a young girl, then Portuguese. She became a professional translator and interpreter of four languages. I always knew I was destined to be a polyglot.

How do you motivate yourself to keep learning?

I approach polyglottery as a sport, as athleticism, mental exercise. Playing games

is fun, right? There are many things out there that can make you happy but, take it from me, the most fun thing in the world is autodidactic learning.

Do you find at all that languages interfere with one another when you are learning them?
Absolutely not. When I am speaking one of my weaker languages, a stronger relative may sometimes jump in with vocabulary or structure, but that is more assistance than interference. However, when I was in my intensive learning phase and studying dozens of languages simultaneously, they never interfered with each other.

So your brain doesn't feel full?

I don't think the human brain can get full like we'd say "this box is full". The problem is there are only so many hours in a day. Give me total freedom of time like I had during my intensive learning years, and I could conceivably do 100 languages. But these days that wouldn't fulfil me as much as getting to read the literature of these many cultures. I want to take languages that have richer cultural literatures and really develop my knowledge of those. The brain is not full but the clock is full.

What drives you to learn new languages?

I think when most people hear an unknown language, their reaction is "oh, it's foreign, I don't understand it", and then they shut it off. It becomes background noise. I hear it and think – what's that, I want to identify it at least. It's irritating to me if I can't figure out what language the sound – or shape if you're talking about script – belongs to. It's basic curiosity.

Tell me about your key technique for learning a new language, and how it works

I call it shadowing. I shadow the audio of the target language by listening to it through

PROFILE

Alexander Arguelles teaches history at American University in the Emirates, in Dubai, United Arab Emirates. His research focus is on foreign language study skills

earphones and speaking along with it as simultaneously as I possibly can. I've found the best way to do this is while walking outdoors as swiftly as possible, maintaining a perfectly upright posture and speaking loudly. My students find it a challenging form to learn, but I have found it to be very effective. It helps me to internalise, and in the end memorise, a representative chunk of the language. That's a firm start. Of course, much study follows.

It's said that people adopt cultural stereotypes when speaking a foreign language. Do you feel more romantic when speaking Portuguese?
No, I don't.

But do thought patterns change with language?

While I don't agree that you have a different personality when using different languages, it's true that the structure of your thought sometimes has to be different. Because in Korean, for example, you don't conjugate verbs according to person at all, but rather according to a wide variety of different "respect" levels that have to do with age, the nature of your relationship to the person





you're speaking with, and so on. Behind it all is a Confucian concept that if someone is six months older or younger than you, they have to be addressed differently than if they are the same age as you.

Do you cherry-pick favourite expressions?

Not consciously. Maybe it's because I spent last summer in St Petersburg, Russia, but these days, if I like something, I say "*eto khorosho*" – that's good, that's nice. When I lived in Germany I made a conscious effort to block English, to switch my whole mental operating system over to German. After that, in Korea, I still automatically thought in German and I still often do. I curse in German. *Scheisse*.

People say German language structure is more precise. Does that make you less likely to blather on, like we do in English?

You can blather on in German! Your brain just functions in a different fashion: the verb's going to come at the end and that's that.

Has being a hyperpolyglot given you any insight into there being an overarching language of thought, a mentalese?

I do believe there is a mentalese. Sometimes I prohibit my mind from accessing other languages, to force it to stay in one, and under those circumstances my thought process will not stop when I don't know a word, the way it would if I were conversing, but rather will only pause and then register the concept namelessly in mentalese before moving on.

Do you have any language ambitions left?

I've put a moratorium on new languages, because I've studied too many to take them all to a high level. So at this stage I'm trying

"I don't think the human brain can get full like we'd say 'this box is full'"

to get to a higher level with Arabic and Russian, and in my reading of a few others. I consciously aborted Chinese, Japanese, Turkish and Swahili, all of which I studied to a very high degree. I have a peek every now and then to make sure there's something still there, and there always is. Then there's another set of languages that I didn't

consciously abort, but which I'm not getting to spend any time with. So if I had an ambition it's not to learn Tibetan or Quechua, but to get my Persian or Hindi back.

Are there subsets of polyglots who want to become obscurists?

Yes. As the polyglot community grows, people want to stand out, so they take on novel challenges. The ultimate would be to learn a non-scripted language that no anthropologist has studied. On one hand, you would have no grammar, but on the other hand if you have a knack for it, if the native speakers accept you, you could go and live with them and it would be sink or swim.

Are your kids following in your footsteps?

Yes, they're having a different experience to me. I speak French all the time with my sons, and I'm teaching them Latin, German, Spanish and Russian. I love my father very much, and he never encouraged me nor forced me to learn languages. I'm not that kind of father. ■

Interview by Rowan Hooper

The power of Moore

A lone prediction can change the world, says **Regina Peldszus**

The Long Arm of Moore's Law: Microelectronics and American science by Cyrus C. M. Mody, MIT Press



SOME of humanity's finest acts of collaboration are carried out by people in special suits – the full-body kind, which protect them from radiation, lethal pathogens, extreme temperatures and aggressive substances. But then there's the reverse, where the suit helps to protect delicate objects from human contamination.

The clean room is the par excellence example. Decked out with powerful fans and filters to remove airborne contaminants, clean rooms are some of the most controlled environments we have. For the past half-century, collaboration in these spaces has fuelled progress, facilitating the best of semiconductor research and development – and as a result, profoundly influencing US science policy and practice.

These labs were not only a

locale of experimentation, but also the products of “institutional experiments”, as science and technology historian Cyrus Mody explores in *The Long Arm of Moore's Law*. The institutions are “social technologies”, distinct from but co-evolving with “physical technologies”. Based on archives and interviews, as well as his time spent researching alongside nanotechnologists at Rice University in Texas, Mody charts the highs and lows of developing

“Interpretations of Moore's law range from a law of nature to an intentional coordinating mechanism”

integrated circuits, or microchips.

In meticulous case studies, Mody traces the unprecedented interdisciplinary collaboration between universities, manufacturers and government funding agencies during and after the cold war. The space and arms race, which had spawned civilian microelectronics in the 1960s, was decelerating and, in its place, global competition to build better chips was picking up – fast.

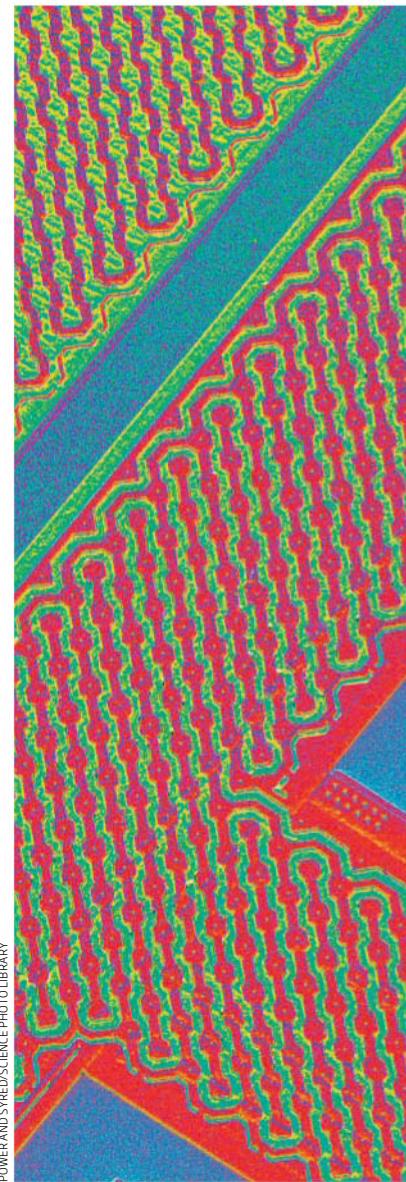
Research groups formerly financed by the military looked to civilian agencies such as the National Science Foundation or the Environmental Protection Agency. In turn, the agencies began developing their own applied research programmes. Giants like Intel and IBM increasingly shared the huge financial burden of research with universities and national laboratories.

As the development of innovative microchips became ever more complex and costly, other kinds of large-scale hybrid partnerships were forged. These brought together industrial, government and academic players in consortia, shared R&D centres and eventually meta-networks of organisations.

At the heart of all this was Moore's law, the observation-cum-dictum that the density of microchips doubled at intervals: initially 12 months, then 18, now close to 24 months. The “law” took its name from a 1965 paper by Gordon E. Moore, a co-founder of the mighty Intel.

His law came to predict the exponential miniaturisation of integrated circuits, and hence the increase in computing power that could economically fit on a single chip. Since then, there have been many interpretations of Moore's law. These range from seeing it as a sort of natural law (due to the physical behaviour of materials such as silicon) to a consciously coordinated mechanism – an engine for innovation that guides rather than predicts human activity.

Mody fully acknowledges the technological aspect, but approaches the law as a “social



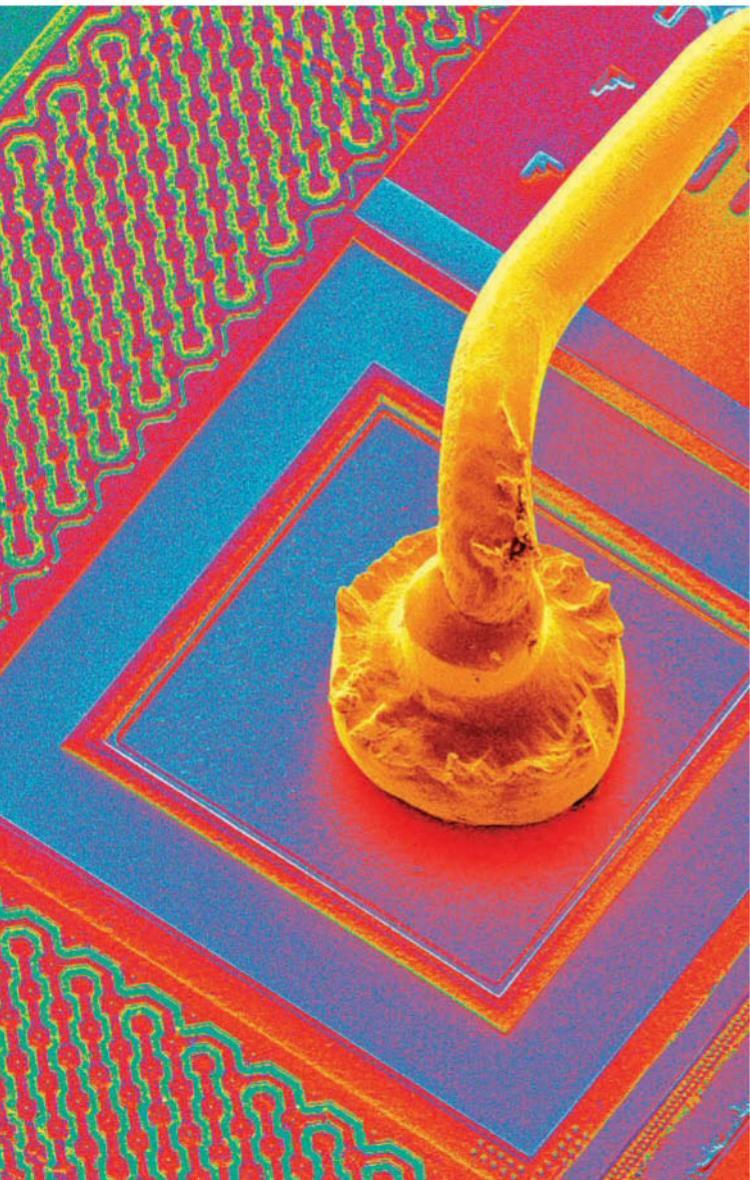
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Dual potential: integrated circuits are as easy to embed in a medical device as a reconnaissance satellite

fact”. He thinks of it as a human construct continually “enacted” by the likes of grant officers and programme managers applying it in journals and conferences, or through labs, national working groups and industry roadmaps. Fuelled by the needs of big science and government for ever greater computing power, and the desire for ever smaller consumer goods, this rule of thumb becomes a self-



NICOLÒ MINERBI/LUZPHOTO/EVEVINE



fulfilling prophecy we maintain and are subject to.

Mody's book concentrates on the mesoscale of organisations involved in developing microelectronics because he argues it helps us get a sense of how the semiconductor sector influenced scientific knowledge-making. He shifts fluidly between detail and contextual currents, capturing the coalescence of individuals and institutions into configurations. These groupings splinter, disband and regroup after massive or minute changes,

like IBM's foray into circuits involving superconducting materials, the drying up of funding sources or the exit of a key team leader.

From that vantage point, Mody zooms into the nanoscale of materials and zooms out to the macro-scale of global economics and national security. While the two scales were increasingly linked by policy-makers, in fact the civilianisation of computing gained traction. Chip technology always had dual-use potential: microchips could be embedded

just as easily in a reconnaissance satellite as in a medical device.

Mody's book offers a wide range of important issues providing food for thought on the R&D behind our modern systems. Amid the different models of innovation, and approaches to technology management, civilianisation was as pertinent to the advent of semiconductors as it is today.

To illustrate this, Mody evokes student and faculty disquiet at the relationship between the military, industry and academia at Stanford University, California, in the late 1960s. Administrators there had to communicate the dual potential of microchips, emphasising military or civilian advantages depending on who they talked to. This reassured security customers while diffusing criticism against the military's role, and winning over researchers who would not otherwise have considered a career in defence systems.

It is a compelling thought, highlighting not only the application of a technology after its conception, or a debate that may occur while it is being conceived, but also its appeal to researchers and designers before they engage in its development.

Although the emphasis for microchip applications shifted significantly to civilian markets, defence and security players such as the Defense Advanced Research Projects Agency (DARPA) played a crucial part in addressing "network failures" in the growing semiconductor sector: the lack of trust, transparency and know-how exchange between different kinds of organisations.

The trick was to link stakeholders across time, distance and institution, to help them get to know each other and team up. The transparency and capability built by the networking efforts of government agencies (security, defence or civilian) was to prove vital in advancing microelectronics in the US.

Semiconductor technology today continues to depend heavily on R&D. If Moore's law helps drive technological foresight, it may also help us to develop responsible innovation and to figure out what we should do, rather than just what we may soon be capable of doing. We need to know if we can cope with the implications of the potential technologies the law churns out – not just in our daily lives, but also

"Increasing computing power is one thing, deciding in which devices to embed it is another"

with the impact this has on science and engineering sectors.

The Long Arm invites us to reflect on the technology we conceive, discover, develop, manufacture, consume and discard. We have to ask ourselves which technologies we regard as critical to national or global security. Who should develop these systems – corporate labs? Government? A partnership of both? How do we want to set up processes that devise our future technology? Are we looking at the right problems?

The journey doesn't end at the next milestone of doubled chip capacity. Increasing computing power is one thing, the small matter of what to do with all the extra capability is another. We must decide in which devices to embed it or what systems to build around it.

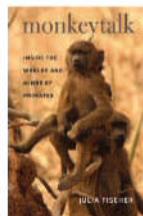
Last year there was a lot of publicity about Moore's Law being "dead". Mody sees such claims as not being strictly true or false, but as conditional prophecies that bring about changes to prevent the prophecy from coming true. Moore's law may be pervasive, but it is also plastic. And since we enact it, the law is literally in human hands. ■

Regina Peldszus is a research associate with the German Aerospace Centre Space Administration

Smarter secrets

Probing primate intelligence takes imagination, says **Alun Anderson**

Monkeytalk: Inside the worlds and minds of primates by Julia Fischer, University of Chicago Press



JULIA FISCHER is a leading primatologist best known to the public for her work with a dog called Rico that she spotted on a

German TV show.

Rico, it was claimed, could remember the names of some 70 toys and fetch them on command. Despite Fischer's initial scepticism, her experiments showed that the Border collie's talents were even greater than claimed. The story of Rico and the press frenzy that followed its publication in *Science* is retold in Fischer's new book *Monkeytalk*. It is a delight, especially when we learn that another Border collie has learned the names of 1022 toys.

But to Fischer, head of the cognitive ethology department at the University of Göttingen, Germany, the story has a deeper significance. A dog's range of barks, growls and whines is restricted, as are the vocalisations of monkeys: the vocal organs of these animals are simply not wired up to the bits of the brain that could provide the fine motor control needed.

That means the range of things an animal can communicate about vocally may tell us little about what it can think about and act upon. To get "inside the worlds and minds of primates", as the book's sub-title claims, requires us to put aside language-biased

preconceptions and to come up with imaginative experiments. Fischer's book is a wonderful, short guide to the ingenious and patient work that is giving us deeper insights into primate psychology.

I particularly loved the studies that reveal the secrets of monkey social life through broadcasting "audio dramas", created by cutting and pasting the recorded voices of members of a monkey group. Using some hidden loudspeakers, researchers created apparently scandalous goings-on and saw how their monkey audience reacted.

In one, a threat call from a low-ranking female chacma baboon was followed by the screams of a higher-ranking female from a

different family, suggesting that she was being attacked. This shocking breach of inter-family etiquette excited the listeners and showed how well they knew individuals and their place in society.

In another, a bachelor male heard the voice of a male grunting in the undergrowth and then his consort's mating call some way

"Monkeys react strongly to fake 'audio dramas' of other monkeys' shocking breaches of etiquette"

off. The bachelor's head spun: if the male and his consort were apart it might mean a break-up – and an opportunity. Moments later he "ambles nonchalantly

towards 'her'", Fischer writes.

These and many other experiments show that monkeys possess profound social intelligence and can solve problems in their own environment. But as we move towards more abstract intelligence and language, a gap opens up between them and us.

Fischer adroitly explores the big questions now being asked about primate minds. Can they understand the intentions of others? Are they able to "time travel" and plan for the future? How much can they learn by watching others? Are they capable of metacognition, of knowing what it is that they know?

Monkeytalk has its faults: it starts like a textbook and it takes a little time before you discover its unusual mix of science and insight, interspersed with funny anecdotes from African field work, including how to dress for "survival in the bureaucratic jungle". Pink pumps, a plastic handbag, lots of rhinestones and glittery appliqués were all needed for Fischer to meet local expectations of what a lady looked like – and obtain a vehicle permit.

The book ends on a serious note, though. The only way we will really understand our own origins is to explore the minds of other primate species along with the bewildering differences in the societies they live in, their ecology, neurobiology and genetics. But primate populations are being destroyed so fast that our close relatives may vanish from the wild before we can find out what made us human. ■



To understand our origins we must explore our close relatives



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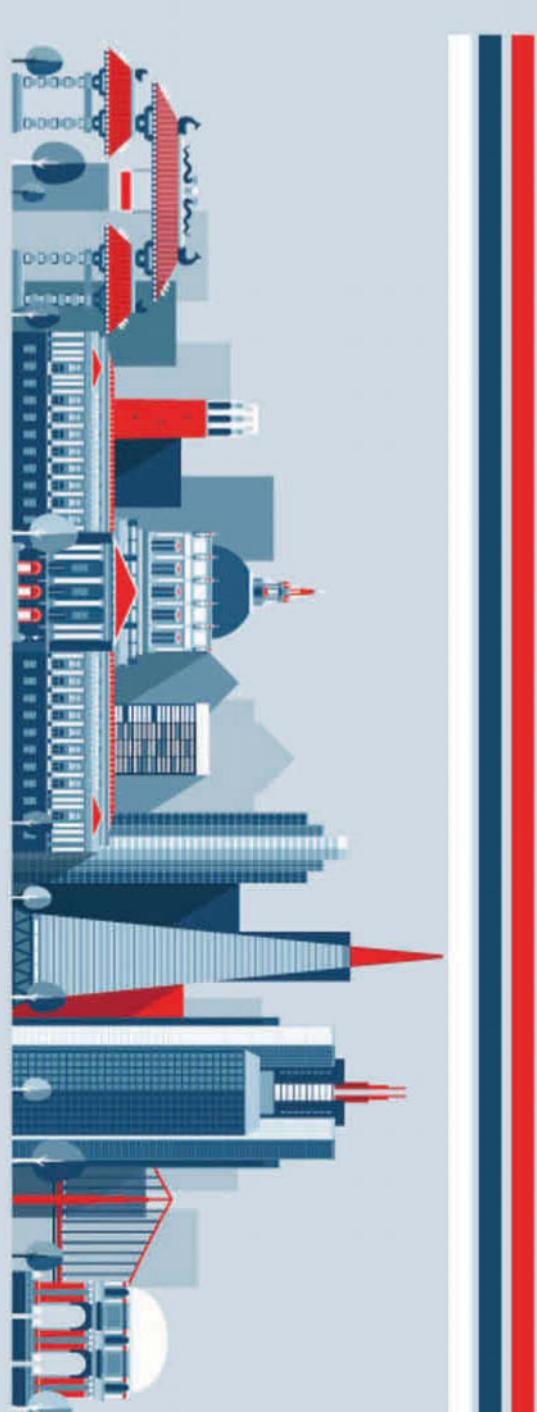
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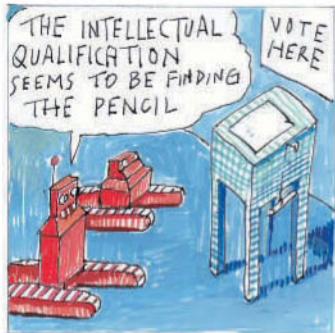
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EDITOR'S PICK

Could owning an AI amount to slavery?

From Robert Willis, Nanaimo, British Columbia, Canada

Zoltan Istvan discusses whether artificial intelligences should have the right to vote, but glosses over several issues that this would raise (17/24/31 December 2016, p 18). He fails to address the issue of defining "intelligence". How would we recognise

it in a novel life form when we can't agree on recognising it in life forms we know: whales, ants, crows?

Assuming that we manage to create a qualified AI, for it to vote we would need to have the will to grant it sociopolitical status equivalent to humans. That hasn't worked out well for those sentient species we have identified and experimented on.

If such an AI were truly conscious and self-aware we must grant it citizenship to avoid a human citizen controlling more than one vote by buying voting AIs, or corporations from voting by AI proxy. It would also help determine whether a vote counts for the location of the server or the AI if they are different.

The biggest issue, though, is that if an AI met the above requirements, owning it would constitute slavery.

In defence of organic food and carbon counts

From Charlie Janney,

Longmont, Colorado, US

Michael Le Page, arguing that we should ditch organic food, ignores the costs and benefits of organic agriculture and conventional agriculture, which uses pesticides, herbicides and artificial fertilisers (3 December 2016, p 21).

Healthy soil is a miniature ecosystem with microorganisms and invertebrates, fungi and organic matter. And fungi are important symbionts for crops.

Conventional agriculture degrades soil, promotes soil loss and decreases fertility. For example, when European immigrants began farming the US prairie, soils were fertile, up to 45 centimetres deep, and ecosystems were diverse. Now those soils are depleted, and

tonnes are lost from each hectare every year. Worldwide, 30 per cent of arable land is now so degraded it is unusable.

Prairie soils sequester huge amounts of organic matter. Organic farmers foster soil health. Increasing organic content is the best way to increase soil health, and doing so thus ameliorates global warming through carbon sequestration. Almost half the increase in atmospheric carbon dioxide has been caused by deforestation and release of carbon from sinks, including agricultural soils.

Soils managed using organic methods can also produce higher yields. Combined with the lower overheads of organic methods, as chemicals aren't needed, farmers can make profit from fewer acres.

Finally, pesticides and herbicides have potentially dangerous effects as oestrogen

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"You might find this interesting... And by interesting I mean... TERRIFYING"

Emma Smyth alerts a friend to the spread of infection resistant to all available antibiotics (21 January, p 20)

mimics. Reproductive cancers may be fostered by their action as endocrine disrupters.

*From Darran Messem,
Carbon Trust, London, UK*

Le Page mentions the opportunity of labelling the climate change impact of consumer products. At the Carbon Trust we now have a decade of experience in working with global businesses to do exactly this, and have experienced the practical challenges in communicating the relative carbon emissions of different consumer products.

The ability to compare carbon footprint claims is already proving influential in private and public sector procurement, where sustainability is becoming one of the key criteria for competition. Influencing the average shopper is undoubtedly more difficult.

Research shows that price

and quality remain by far the biggest influencers on purchasing decisions, but where all other things are equal then environmental concerns can tip the balance.

Antigravity would cause more problems than that

*From David Holdsworth,
Settle, North Yorkshire, UK*
Joshua Howgego describes work to check whether antimatter particles may have negative gravitational mass (7 January, p 28). If any do, this would raise an interesting question for particles that are their own antiparticle.

For the massless photon there is no problem, but the π^0 boson has inertial mass and is its own antiparticle. This can only be the case for bosons – particles with integer “spin”. It cannot for fermions, with half-integer spin,

which include electrons and protons. Could the gravitational mass of all bosons be zero?

It is difficult enough to measure the gravitational mass of an antiproton; the thought of trying to measure it for an inertially massive and unstable boson is mind-boggling.

Pushy males and brainy females' survival

*From Warner Haldane,
Whakatane, New Zealand*
Female mosquito fish grow bigger brains to help avoid the rough attentions of over-endowed males (17/24/31 December 2016, p 12). A few pages later you report brainy female wild red deer living longer and producing more offspring (p 15). Could there be a connection here? Time for the cervidologists to get out their measuring tapes, but not during the rut, I think.

Why might mothers cradle babies on the left?

*From Valerie Moyses,
Bloxham, Oxfordshire, UK*

Never mind the “contrasting talents of each half of the brain” as an explanation for mothers cradling babies on the left (14 January, p 10). There’s a much simpler explanation.

Having borne and brought up three babies, I have no doubt that this is the babies’ own preference. They settle more quickly on the left side, I believe, because there they can easily sense their mother’s heartbeat. This reminds them of the womb, and reassures them that their lifeline (their mother) is still functioning.

*From Jill Gigg,
Bathford, Somerset, UK*
There is perhaps a simpler reason for mothers to cradle their baby ➤

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on the left. The majority of women are right-handed and holding the baby with the left arm leaves the right hand free. It would be interesting to know if a left-handed mother prefers to cradle her baby on the right.

The editor writes:

■ Many readers offered thoughts about the introductory mention of human mothers' left-sidedness in our story about infants' preference in 11 mammal species. Researchers who have looked into this specific question find evidence in support of the hypothesis that it's all about mothers monitoring infants, and vice versa: see for example doi.org/bxhw.

Theory is broken, so the impossible is undefined

From Sam Edge,
Ringwood, Hampshire, UK

Certainly by our current understanding there is very little chance of circumventing the enormous problems of energy, distance and time involved in interstellar travel, as Geraint

Lewis writes (26 November 2016, p 20). But since we know that our current understanding is based upon two incomplete and conflicting descriptions – general relativity and quantum mechanics – there is an unquantifiable amount of doubt about this supposition.

Racism has roots in society and reporting

From Merlin Reader,
London, UK

Caroline Williams mentions the idea we are all "a little bit racist" (10 December 2016, p 26). This misses the point that we are brought up in a society where racism is entrenched in the media. Many of those convicted under anti-terror legislation in the UK are white racists, but they get little media coverage compared with the mere arrest of Muslims, which often doesn't lead to convictions.

No one is born racist, or "tribal" – we all learn that from the behaviour of those around us from an early age. You see who your parents socialise with, and

learn from their behaviour and that of others around you. Sadly, that also includes the media.

A sense of horses' endurance and stamina

From Gabriel Stecher,
Carboor, Victoria, Australia
Catherine de Lange describes humans being able to outrun horses (10 December 2016, p 33). My horse and I won the 1966 Quilty Cup 160-kilometre endurance ride in 11 hours and 24 minutes. The course climbs 2200 metres. The record time is now about 9 hours.

The horse's task in this race is roughly equivalent to an 80-kilogram runner doing four hilly marathons in a half day, with a 20 kg child strapped to their back. Horses' superior abilities are supported by the same cooling system we are endowed with: the ability to sweat.

From Brian Horton, West Launceston, Tasmania, Australia
De Lange says that humans can run faster and further, under a wide range of conditions, than

any other animal. But she only briefly mentioned walking, although humans are also very efficient at walking, a "mystery of evolution" that Kate Douglas has previously discussed (24 March 2012, p 36).

Running is fine when you have your prey in sight, but the ability to walk for hours is more useful when tracking your prey before you can see it.

Humans can also carry loads while walking long distances and it was our ability to carry all our household needs, day after day over great distances, that allowed us to spread throughout the world.

On the internet, nobody knows anything of you

From a reader

Sally Adey suggests that online we just need to relax and be ourselves, as faking it causes us stress (17 September 2016, p 22). The researchers perhaps made a poor choice in studying Facebook, as this particular social medium is usually used to keep in touch with people one knows in "real life".

It is often said that you can be who you want to be online – but the importance of this is felt primarily by those who cannot be who they truly are offline.

Other venues, such as web forums, are online homes for those of us who cannot express our real selves offline. In real life, I try to pass as far as possible as cisgendered and neurotypical. This is exhausting and isolating.

Online, I find communities where real-world norms are discarded and I can be my true agendered autistic self.

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TOM GAULD

INSIGNIFICANT MOMENTS IN SCIENCE





NIKOLAI GOLOVANOV/GETTY

Old phone, new tricks

An unloved smartphone makes a great remote eye

PERHAPS you've bought a new phone in the January sales. Maybe you were just due an upgrade. Either way, I bet plenty of you have a retired handset lying inert in a drawer somewhere. You could sell it, but tech trends shift so quickly that it's probably not worth the effort. Why not give it a new career as a remote eye?

First, grab your old device, be it Apple, Android or other. Then install a security camera app. There are plenty to choose from. Some let you watch your valuables, or just your fish tank, from anywhere in the world via a live video stream. Some do the watching for you: they send you a notification if the camera sees movement.

A not-so-Big-Brother use for that function could be to help correspondence chess players who like to play with physical pieces keep in touch. If each has a phone camera trained on their board, a notification would let them know not only that their opponent has made a move, but what it was.

But I prefer to customise with IFTTT (short for "If This Then That"). This easy-to-use

online service lets you automate actions with an ever-growing list of devices and apps. The principle is simple. You have a trigger and an action: once the first thing happens, IFTTT takes care of the second. You need a security camera app that notifies you of motion in a way that can act as the trigger - sending an email, say, or saving pictures to a Dropbox folder. Then you can make IFTTT respond any way you like.

For example, if you want to know how much time your dog spends in your bedroom while you're out, you just point your camera at the door and have IFTTT mark the time on a Google calendar whenever there's movement. That would give you a daily chart of Fido's comings and goings.

Or, surreptitiously point it at the cookie jar and have it send your partner an email to say you know they've been stealing the custard creams (you could even include the photographic proof). Don't blame us if it's the end of a beautiful relationship, though. Hannah Joshua ■

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PAUL MCDEVITT

PERHAPS hoping to attract a generation raised on Harry Potter, the Royal Bank of Scotland has unveiled the latest advance in recruitment: a sorting hat. Or, as *The Huffington Post* described it, the MindWave Mobile, a "portable brain scanner" that can reveal what role attendees to graduate recruitment fairs will find most appealing at the bank.

The headset measures prospective candidates' neural responses to 10 images flashed up on a screen, and makes its assessment accordingly.

It's only a matter of time before banks use this kit to reveal what customers really plan to do with their loans. Young wizards now have good reason to brush up on their Occlumency; Muggles among us will have to make do with tinfoil hats.

REGULAR readers will recall Mike Lavan's challenge to distil the essence of celebrities by spelling their names using only chemical symbols (7 January).

Keith Perring, who literally wrote the book on it (*An Elemental Philavery*), is excellently placed to respond. "I can add BONO and NICO to the list," he says, though he adds, "these are more like brands than names."

If we allow two-letter elements, the process becomes much easier, says Keith, "for example, FRANK SINATRA and LaURENCe OLiVIEr, and there are also quite a few science celebs such as FRANCIS CRICK and NIKOLA TESLA."

FEEDBACK has already reneged on its new year's resolution to do away with nominative determinism (perhaps we would fare better if we pledged to give up making rash promises).

Happily, though, our negligence allows us to bring news from Gordon Ross of Oakville, California, who writes about the man he and his wife once met during a hiking tour of the Dordogne.

While traipsing up and down the

Karyn Houssenloge reports that one of the sponsors of Australia's Hopman Cup tennis tournament is "Solid Gold Diamonds". They must have a very low carbon footprint, then

hills and gullies, Gordon writes, "we marvelled at the name of the local contact for the tour company - Cliff Walker".

NORTHERN Ireland is reeling from a catastrophically mismanaged green energy scheme, which paid businesses overly generous subsidies for switching to wood burners and is expected to run £490 million over budget. Deputy first minister Martin McGuinness has resigned, a move that has led to the collapse of the power-sharing government and triggered an election.

Rachel Cave notes that the UK's secretary of state for Northern Ireland, James Brokenshire, has perhaps found his calling.

AND lawmakers in South Dakota have recently voted against a proposal that would have forbidden sexual contact between politicians and their interns. Among those batting away the proposed rule was the Republican David Lust.

WHAT do physicists get up to in their spare time? Mike Lawrence sends us a report from the *Cambridge News*, relating that "four men wearing dark clothes and balaclavas used a teleporter to break through the wall of a bank in Kimbolton, near Huntingdon".

Feedback encourages scientists everywhere to stick with more traditional sources of research funding.

LIKE radioactive isotopes, the universe has deemed that paired socks exist in an unstable union, and will spontaneously decay into a single sock (what happens to the other sock is still hotly contested). Readers have been hard at work, it seems, developing strategies to cope.

Like Ron Petch before him, Michael Strelitz tells us that the number of matching pairs in 12 identical white gym socks quickly approaches zero once in use. "About 15 years ago I took to marking all new socks with a number underneath so that each pair would have the same history," he says.

And when one sock gets a hole, he creates lower-quality pairs labelled alphabetically.

Despite the sophistication of this longitudinal study, Michael says it is "impossible to explain to my wife and friends who don't understand the issue, and treat this marking as a type of obsessive compulsive disorder". Michael, where would we be if Darwin or Lister had given up in the face of the initial derision they encountered? Remember, first they laugh at you...

NEW year, no you? Anne Barnfield reports an alarming weight loss regime advertised in the window of her local "natural health" shop. The ad reads: "Lose all your weight for only \$20.17 with our programme!" Feedback thinks that NASA developed a similar programme in the 1960s, although it was marginally more expensive.



FINALLY, readers will no doubt recall that when Andrea Leadsom was made the UK's energy minister, she had to ask her departmental staff whether climate change was real. Leadsom's grip on her new portfolio - that of environment secretary - seems no tighter. Speaking at the annual Oxford Farming Conference earlier this month, the minister began by praising "an industry that's been around as long as mankind itself".

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

Ocean's lull

What is it about the sea lapping gently against the shore we find so calming? Is there an evolutionary explanation behind this pleasing phenomenon?

(Continued)

■ The Greeks actually have a word for this: *fisvos*.

John Hallett
Poole, Dorset, UK



Lunar landscape

I'm an astronaut and I've landed on the moon. I'd like to do a painting of the magnificent desolation I see before me, but in the interests of getting close to my subject, I'd like to paint while standing on the lunar surface, not looking through a window. How should I go about it?

■ Two main challenges will face you in trying to paint the lunar landscape without looking through a window. The first is that if you have no window between your face and the landscape, then you and your eyes will be exposed to a near-vacuum low pressure and all the moisture will rapidly boil off, leading to major organ damage and, eventually, death. The second problem is that the same moisture loss will happen to the paint, causing it to become a dry, crumbly solid.

Astronauts always have an impermeable barrier between their skin and the vacuum of space and normally look out through a face shield in their

spacesuit. Other than resorting to another kind of impermeable transparent barrier, the only option would be to release a very large flow of air in front of your face at a rate fast enough to keep the pressure on your face close to normal. But then you would be looking through a very noisy and

Astronauts always have an impermeable barrier between their skin and the vacuum of space"

turbulent wind flow. You would also have to make the air humid to prevent your eyes drying out, but then this moisture would form a fine mist of ice crystals, further compromising your attempts to get a pristine view.

For the paint, you could cheat

by putting the canvas and the paints inside a glass-fronted, pressurised box with sleeves and gloves mounted in it. However, now you would have a window between your eyes and the canvas, rather than between your eyes and the landscape.

Alternatively, you would need to use paints that remain liquid in a vacuum. These would have to be based on oil-like compounds with low volatility and very high molecular weight, but given their high viscosity it would be hard to paint fine detail with them. Or, of course, you could do a sketch with pencils. Ultimately, though, if you want an accurate recreation of the scene, stick to taking photos.

Simon Iveson
University of Newcastle,
New South Wales, Australia

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■ As water-based pastels and conventional oil-based paints will boil off very, very quickly, your intrepid exoartist must work with vacuum-tolerant materials and boards. They should go retro with charcoal sticks and coloured chalks, or use vacuum-grade silicone grease, designed to operate in low-pressure environments, to carry their mineral pigments.

Nik Kelly
Liverpool, UK

■ If you were a trained artist, you would make sketches, as pencil and paper would be fine in a vacuum for a short while, and you could also take written notes about the colours in the scene. Then you would use these as the basis for the artwork you would paint while back in the studio, either on Earth or on MoonBase 1.

John Davies
Lancaster, UK

This week's question

ROCK AND HOLE

While holidaying on the Greek island of Paxos, I came upon a pebble beach where many of the stones had apparently been "engraved" by some type of creature. This example (see photo) is roughly 50 by 60 millimetres, but the same sort of pattern was also present on much larger stones. What type of creature made these, and how and why?

Mick Groves
Oxhill, Warwickshire, UK

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