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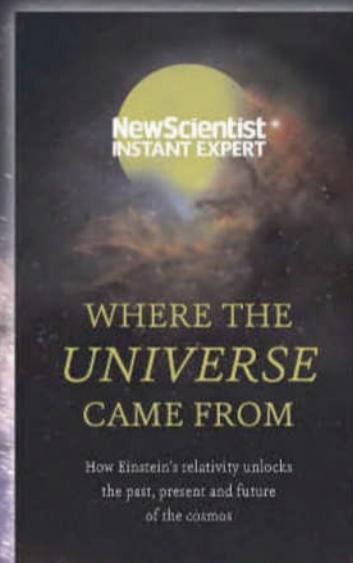
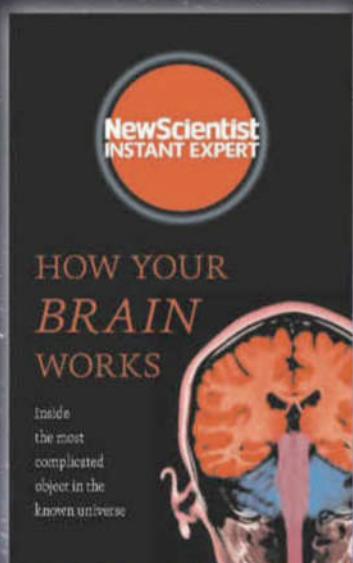


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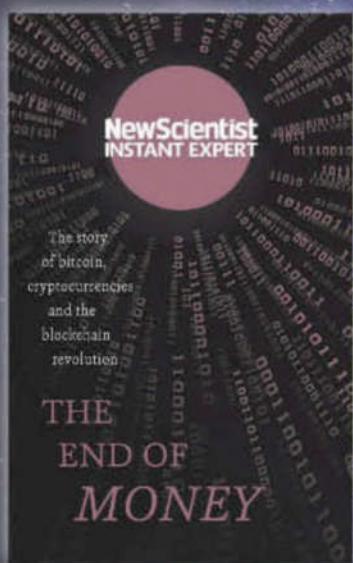


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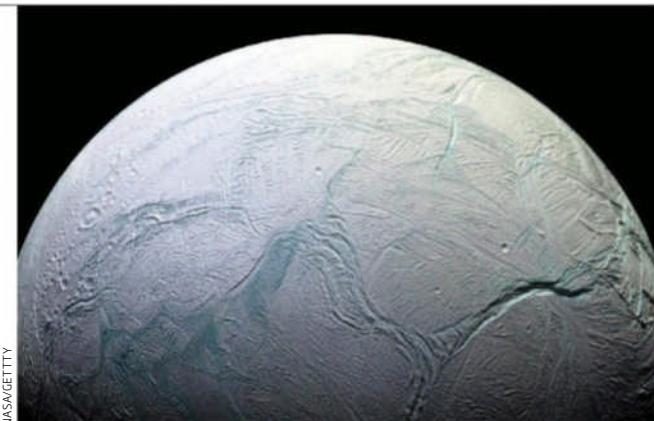
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DAMIR SAGOL/REUTERS

Regional war, global fallout

Talk of a "localised nuclear conflict" is ignorant and dangerous

TWO and a half minutes to midnight. That was the time the Bulletin of the Atomic Scientists set their Doomsday Clock to just a few months ago – later than it has ever been except between 1953 and 1960, the height of the cold war H-bomb race. Among BoAS's concerns were bellicose sentiments from Donald Trump and North Korea's efforts to make its own nuclear weapons.

Those were prescient. Sabre-rattling prompted a North Korean official to warn this week that "thermonuclear war may break out at any moment". Given Trump's apparent casualness about such a war, including tweets threatening unilateral action, the world feels more on edge than it

has since the Cuban Missile Crisis.

An unwelcome development is the return of cold war chatter about "local" nuclear wars – the idea that a few warheads tossed around east Asia might be locally unpleasant but manageable on a planetary scale. This idea needs to be quashed. Quite apart from the difficulty in preventing a local conflict from growing into a large-scale multinational war, those who study nuclear war scenarios say millions of tonnes of smoke would gush into the stratosphere, resulting in a nuclear winter that would lower global temperatures for years. The ensuing global crisis in agriculture – dubbed a "nuclear famine" – would be devastating.

Needless to say that is a dismal

finding, albeit one that will probably be summarily dismissed by Trump and his cheerleaders as fake news. But even he is sensitive to global opinion: witness his sudden switch from an isolationist to interventionist foreign policy.

As BoAS points out, citizens now have powerful technologies at their disposal to make their views heard. It recommends demanding that the US engages with North Korea rather than provoking it. It might have added that we should all work to dispel the notion of a limited, regional nuclear conflict. There is no such thing – and we cannot afford to let the clock tick closer to midnight and find that out the hard way. ■

We stand together

WHAT does the March for Science really stand for? That question has been asked ever since the idea was first aired, with some critics being irritated by the lack of a coherent answer from organisers. Others have decried the inclusion of issues they consider irrelevant, such as identity politics.

That lack of coherence is likely to persist among those who turn up this weekend to march in

Washington DC, or at any of the 500+ satellite events around the globe. To draw numbers worthy of public attention, the events will have to attract a broad coalition of supporters with disparate views on the proper role of science.

The tone of the march will also matter. When it comes to dissent, scientists turn more often to the studied language of the academy than to chants and slogans. But of

late, that has been like arming yourself with a duelling pistol when your adversary is wielding a machine gun. Decry this state of affairs if you will, but in these populist times, scholarly debate alone is unlikely to win over hearts and minds – least of all in the White House.

Diversity of concerns and voices is a strength, not a weakness, when it comes to mass protest. Decide for yourself what science stands for, stand up for it – and stand together. ■

Rain colours California

GOVERNOR Jerry Brown has declared the end of California's drought emergency, and parts of the state are carpeted in flowers, but that doesn't mean its water problems are over.

After the five driest years on record, which required Californians to limit water use, the state has been deluged by storms that overflowed dams and helped the snowpack in the Sierra Nevada mountains rebound from unprecedented lows. On 13 April, measuring stations in the Sierras recorded 89.7 inches of rainfall, beating the 1983 mark of 88.5 inches.

The reprieve has kicked off a "superbloom", a wildflower burst that has transformed brown desert slopes into brightly coloured fields. But drought persists in four counties

where 10 million people live, many reliant on wells that have dried up.

"If there's a perception that because we've had a wet winter, that means everyone that felt the effect of this drought is now out of the woods, that's simply not accurate," says Noah Diffenbaugh of Stanford University.

The drought led to the death of 100 million trees and soil compaction that reduced storage capacity in aquifers. And communities in central California are still dependent on emergency drinking water.

"For many residents of California, this drought has been about access to reliable clean water, rather than what kind of landscaping is appropriate for outside of one's home," Diffenbaugh says. "Those issues are not going to go away with one wet winter."



Lush, but not off the hook

Mental distress

MORE Americans are in serious psychological distress than ever before. According to a study of data up to 2014, more than 8 million adults in the US between the ages of 18 and 64 have mental health issues.

The US Centers for Disease Control and Prevention has conducted an annual national health survey for the past 60 years. Respondents are asked how often over the past month they had certain feelings, such as being so sad nothing could cheer them

"If we increase mental health care access, we can save a generation from psychological distress"

up, or that everything they did was an effort. The frequency of such feelings gives an indication of whether someone is in serious psychological distress (SPD).

An SPD score is highly correlated with mental health issues, such as depression and anxiety. It's also linked to lower socio-economic status and

to a reduced lifespan.

Judith Weissman at the NYU Langone Medical Center studied the survey data from 200,000 respondents between 2006 and 2014. She found that SPD has risen, and is more prevalent in women than in men, in middle-aged adults versus younger adults, and in Hispanic and black people versus white people (*Psychiatric Services*, doi.org/b5sw).

The recession from 2007 to mid-2009 may have contributed to the uptick in mental illness, says Weissman. After the recession, the number of people able to afford medications increased, but it rose more slowly among people with signs of mental illness. Between 2006 and 2014, access to mental health services got worse for people with SPD, despite improving for people who didn't score highly for psychological distress.

"There is a generation of middle-aged adults that are really suffering right now. If we increase access to mental health care and coverage for mental health care, we can save the next generation," says Weissman.

Distant Dwarf

A FARAWAY rock nicknamed DeeDee could be big enough to be a dwarf planet.

Astronomers define dwarf planets as worlds that are massive enough for their gravity to make them spherical, but not big enough to clear debris from their orbits. Our solar system has five officially recognised ones – Pluto, Haumea, Makemake, Eris and Ceres – and probably hundreds more in its outer reaches.

DeeDee, short for Distant

Dwarf, is officially called 2014 UZ224. Among objects beyond Neptune it has the second farthest confirmed orbit, taking about 1100 Earth years to orbit the sun just once.

Now, observers at the Atacama Large Millimeter Array (ALMA) in Chile have measured its size: it is about 635 kilometres across (*Astrophysical Journal Letters*, doi.org/b5sx).

That makes it larger than most objects in the asteroid belt but still smaller than Ceres, the tiniest of the dwarf planets.

Coal contamination controversy

A SHOCKING Australian coal "spill" may be nothing of the sort.

Last week, footage emerged that appeared to show a spill at the Abbot Point coal terminal in Queensland polluting wetlands and beaches.

The controversial terminal is set to service the biggest coal mine in Australia, once multinational firm Adani finalises the mining deal with the Australian government.

In the wake of Cyclone Debbie last month there were suggestions that

the terminal had discharged water containing coal dust above the legal limits, though Adani, which operates the facility, said it had acted within the requirements of its licence.

Then, last week, environmental groups released footage claiming to show coal-laden water extending into more areas. But the Department of Environment and Heritage Protection said that the black smudges could be minerals in sand, which it will now sample.

60 SECONDS

Space junk cascade

SWARMS of cheap CubeSats set to deliver internet access to every corner of the globe could cause a 50 per cent rise in catastrophic collisions with other satellites, unleashing hazardous space junk.

"Debris fragments could collide with other spacecraft, causing a chain reaction"

There are currently only 1300 working satellites orbiting Earth. But from 2018, firms such as OneWeb, SpaceX and Samsung plan to beam internet services around the globe using thousands of tiny satellites.

Hugh Lewis at the University of Southampton, UK, and his colleagues used a supercomputer to simulate 200 years of possible orbits for 300 different scenarios.

The results, presented this week at a European Space Agency conference on space debris in Darmstadt, Germany, suggest that these megaconstellations boost the risk of a catastrophic collision – in which a satellite is destroyed – by 50 per cent.

Worse, the CubeSats lack motors or any other ability to avoid collisions. Debris fragments could collide with other spacecraft, causing a chain reaction.

Stricter rules are needed on when and how to de-orbit satellites at the end of their lives, says Lewis.

PIUS UTOMI EKPEI/AFP/GTY



Bed nets helped curb malaria

WHO vector plan

MOSQUITOES beware. The World Health Organization is preparing a global "vector control" plan to track the movements of disease-spreading organisms worldwide.

"The idea is to prevent outbreaks of disease instead of simply reacting to new ones," says Raman Velayudhan, head of vector control for neglected tropical diseases at the WHO.

The plan particularly focuses on the *Aedes* mosquitoes that can

"Zika was a real wake-up call - we need to control *Aedes* mosquitoes wherever they live"

carry the viruses that cause Zika, dengue, chikungunya and yellow fever. *Aedes* have massively expanded their range in recent years – before 1970, they were a threat in seven countries, but have now reached 140, says Velayudhan.

Now the WHO wants to control their numbers. "Zika was a real wake-up call – we need to mobilise mosquito control measures wherever *Aedes* mosquitoes live," says Velayudhan.

This plan will build on the success of bed net and insecticide spraying programmes that have helped curb malaria. Since 2000, cases of this mosquito-borne disease have halved.

DEANSEWELL/OCULI/AGENCE VU/CAMERA PRESS

The fight will focus on dense urban areas, where *Aedes* mosquitoes tend to breed. The plan, which will come up for approval at the World Health Assembly in May, will call on all countries to step up surveillance and control efforts and to improve diagnostics so that they can identify any outbreaks during the early stages.

US may quit Paris

SCOTT PRUITT, the head of the US Environmental Protection Agency, said on 14 April that the US should back out of its commitment to the Paris climate agreement, the landmark global plan to curb greenhouse gas emissions in an effort to limit global warming to below 2 °C.

"It's a bad deal for America," Pruitt told cable news show *Fox & Friends*. "China and India had no obligations under the agreement until 2030." In fact, China and India have already taken action to reach the goals they have set for 2030, which include cutting greenhouse gas emissions by a higher percentage than the US committed to.

President Trump said on his campaign trail he would "cancel" the Paris climate agreement. The decision will be made before the next G7 summit in May, and possibly as early as this week.

Chinese supply mission

China is getting ready for its first mission to bring supplies and fuel to its Tiangong-2 space lab, a step toward a planned Chinese space station. The cargo spacecraft, Tianzhou-1, is expected to launch aboard the Long March 7 rocket between 20 and 24 April.

Croc-like dino

A dinosaur relative that lived 245 million years ago looked more like a crocodile than its dino cousins. Bird-like dinosaurs and crocodiles come from two branches of the Archosauria group, but there are few specimens of early ancestors on the dinosaur side. *Teleocrater rhadinus* had four short legs, a long neck and tail, despite being on the bird side of the split (*Nature*, doi.org/b5s3).

Fossilised faeces

Droppings layered among volcanic ash suggest that eruptions repeatedly devastated gentoo penguin populations on Deception Island in Antarctica. Scientists drilling cores on nearby Ardley island found penguin fossils from three distinct periods over the last 8500 years (*Nature Communications*, doi.org/b5s5).

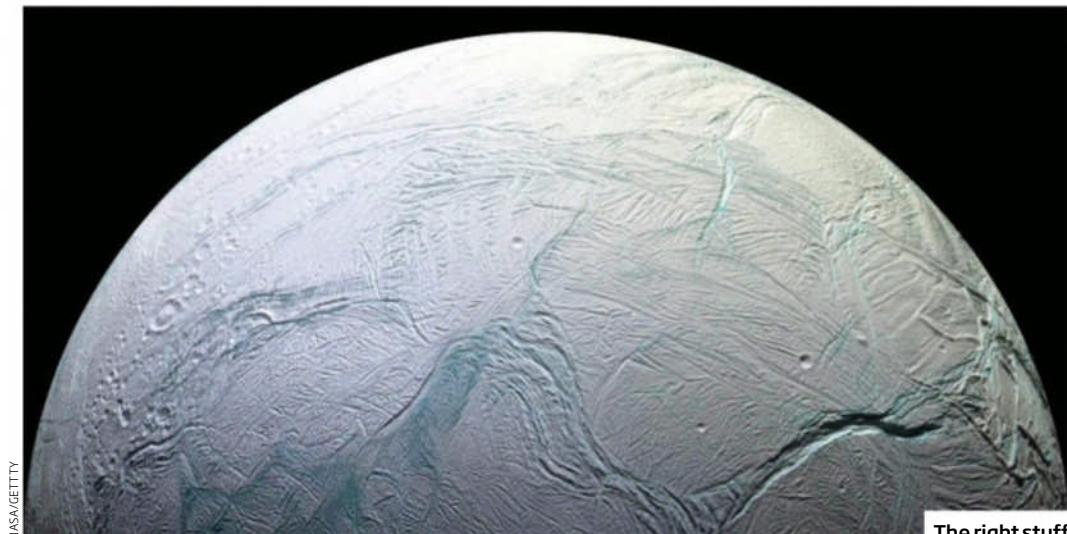
Dust counter

The LISA Pathfinder spacecraft may be able to measure minuscule grains of asteroid dust, NASA has said. Its tiny thrusters fire in response to disturbances from sunlight or cosmic dust. Data from these thrusts could characterise the dust particles, turning useless "noise" into useful data about interplanetary debris.

Facebook ad hoax

Hoax adverts on Facebook featuring celebrities are leading users to scam websites, the Press Association has found. The paid-for ads appear in the "sponsored" section of the Facebook newsfeed and draw users in with doctored images or fake news claims. The company says it has now removed the ads.





NASA/GETTY

The right stuff

Enceladus is ripe for life

Last-ditch attempt to find hydrogen is a triumph, reports **Leah Crane**

TO PROTECT any life on Saturn's ocean moons, we will have to destroy the only tool we have to find it. NASA can't risk its Cassini spacecraft crashing into Enceladus, especially since we've just discovered a potential food source for alien ecosystems.

In its final pass through the liquid plumes of the icy moon, Cassini found molecular hydrogen, indicating favourable conditions for life in the moon's subsurface sea. But Cassini has run out of time.

The spacecraft is low on fuel. To protect Enceladus and Saturn's other potentially habitable moons from contamination, Cassini will crash into Saturn after a series of daring swoops between the planet and its rings. This so-called Grand Finale begins on 23 April, and will end with Cassini's demise on 15 September.

For over a decade, Cassini has been exploring Saturn and its moons, sending back the best pictures and measurements of the system we've ever had. The craft dropped off the Huygens probe at hazy Titan, scrutinised the

structure of Saturn's rings and discovered that Enceladus was much stranger than anyone expected.

The moon's south pole has strange, warm fractures, and plumes of liquid water from a subsurface ocean many believed was impossible in such a small, cold world. The plumes also contain enticing compounds like organics and carbon dioxide, all necessary for life as we know it.

But until now there was no evidence of an energy source to feed potential life. In extreme environments on Earth,

hydrogen can play that role.

"What was missing to complete the story of habitability was an energy source," says Chris McKay at NASA's Ames Research Center in California. "This completes that story."

Cassini did detect hydrogen in early trips through the plumes, but there was a problem. When particles from the plumes entered the spacecraft's Ion and Neutral Mass Spectrometer (INMS), they interacted with its titanium walls, producing the same sort of hydrogen as hydrothermal processes would create

HUNGRY FOR HYDROGEN

Some of the oldest microorganisms on Earth, called methanogens, are often found near hydrothermal vents like those we suspect also exist on Enceladus (see main story).

In Earth's most extreme environments, deprived of the oxygen, sunlight and food sources most life forms need, methanogens convert carbon dioxide and hydrogen into methane.

Molecular signatures in ancient rocks show the microorganisms may have existed on Earth around 3.5 billion years ago, producing some of the greenhouse gases needed to stabilise the early Earth's climate. Their hardiness and particularly their ability to survive without sunlight and oxygen make them model microorganisms for subsurface ecosystems on other worlds.

under Enceladus's ocean.

"We didn't know we were going to do this experiment when we launched Cassini," says Hunter Waite at the Southwest Research Institute (SwRI) in Texas. So Waite and his team put the INMS in a new mode that measured the molecules without letting them touch the walls.

They found the molecular hydrogen they were looking for—and too much to be stored long-term in tiny Enceladus's ice shell or ocean. That means it must be continuously produced there, probably by hydrothermal reactions similar to those that occur near hot vents at the bottom of Earth's oceans (*Science*, doi.org/b5s9). Near those vents on Earth, there are microorganisms called methanogens (see "Hungry for Hydrogen", below).

"If you were to take methanogens from Earth's ocean and transport them to Enceladus, they would have all the food they need," says Waite. "This is like candy for microbes."

Cassini found the right conditions for life on Enceladus – but the mission has run out of time"

Enceladus is looking more and more like our best bet for finding alien life. "If we're looking for life in the solar system, then Enceladus has a lot of potential to be the place that we could find it," says team member Kelly Miller at SwRI.

We won't have any more molecules from Enceladus's plumes for a long time, though. Even if a mission to that moon were to be selected in NASA's next round of New Frontiers funding, it wouldn't reach the Saturn system until the late 2020s at the earliest. While Cassini did not have the tools to directly look for life, the next spacecraft certainly will.

"To address whether there is life, we'll have to go back," McKay says. "Two decades can go by pretty fast." ■

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Shamanistic brew eases hard-to-treat depression

IT TASTES foul and makes people vomit. But ayahuasca, which has been drunk in South America for centuries in religious rituals, may help people with depression that is resistant to antidepressants.

Tourists are increasingly trying the hallucinogenic brew during holidays to countries such as Brazil and Peru, where the drug is legal. Shamans traditionally prepare the bitter, deep-brown drink using two plants native to South America. *Psychotria viridis* is packed with the mind-altering compound dimethyltryptamine, while the ayahuasca vine (*Banisteriopsis caapi*) contains substances that stop this compound from being broken down before it reaches the brain.

Now the first randomised clinical trial of ayahuasca for treating depression has found it can rapidly improve mood. In the trial, led by Dráulio de Araújo at the Federal University of Rio Grande do Norte in Natal, Brazil, 14 people with treatment-resistant depression got single doses, while 15 people with the same condition had a placebo.

To fool placebo recipients into

thinking they were getting the real thing, de Araújo and his team concocted an equally foul-tasting brown drink. They also carefully selected participants who had never tried ayahuasca or other psychedelic drugs before.

A day before their dose, the participants filled in standard questionnaires to rate their depression. The next day, they

spent 8 hours in a quiet, supervised environment, where they received either the placebo or the potion, which produces hallucinogenic effects for around 4 hours. They then filled in the questionnaires again one, two and seven days later.

Both groups reported improvements after one and two days, with placebo scores often as high as those of people given the drug. In trials of new antidepressants, it is common for as many as 40 per cent of participants to respond positively

to placebos, says de Araújo.

But after a week, 64 per cent of people who had taken ayahuasca felt the severity of their depression fall by 50 per cent or more. This was true for only 27 per cent of those who drank the placebo (*bioRxiv*, doi.org/b5q7).

"The main evidence is that the antidepressant effect of ayahuasca is superior to the placebo effect," says de Araújo.

"The findings suggest a rapid antidepressant benefit for ayahuasca, at least for the short term," says David Mischoulon of Massachusetts General Hospital in Boston. "But we need studies that follow patients for longer periods to see whether these effects are sustained."

If they are, ayahuasca could be a valuable new tool for helping people with treatment-resistant depression. An estimated 350 million people worldwide experience depression, and between a third to a half of them fail to improve when given standard antidepressants.

Ayahuasca isn't the only psychedelic drug being investigated as a potential treatment for depression. Researchers have also seen some benefits with ketamine and psilocybin, extracted from magic mushrooms. Andy Coghlan ■



LUNA PARRA/REUTERS

Mood-enhancing mix

Surgeons train to kill pain with a haptic syringe

AS MY syringe presses against the skin and muscle surrounding the patient's knee joint, I feel a brief resistance. A gentle increase in pressure, though, and the needle pops through, ready to inject the drug. But neither patient nor syringe are real - they're virtual.

I am taking part in a training simulation created by London-based firm FundamentalVR. It allows me to view a patient in virtual reality and perform knee surgery with a stylus

that gives haptic feedback, so I can feel the different layers of tissue. The simulation is designed for surgeons who must learn how to properly inject a drug during surgery to provide post-operative pain relief.

"[The drug] stays exactly where you inject it, so you need to put it in the right places," says FundamentalVR co-founder Richard Vincent. "That's what this system teaches [you] to do."

The simulation will soon be used in US hospitals by surgeons training to perform knee replacement surgery. This requires about 20 injections of the painkiller at six different stages.

Motors in the stylus exert increasing resistance when the virtual syringe pushes against skin, muscle

and bone. There are two buttons on the side, one to inject the virtual drug and the other to withdraw the needle. The system knows the ideal injection pattern for the drug and gives surgeons a score based on how accurately they have administered it.

The simulation runs on off-the-shelf equipment, such as a high-end computer and an HTC Vive headset. That means it is more affordable than existing simulators like those used to practise keyhole surgery, which require bespoke equipment.

"The system knows the ideal injection pattern for the drug and scores surgeons for accuracy"

FundamentalVR claims that all the necessary hardware can be bought for less than £5000.

The company now plans to make other simulations that will teach a range of surgical techniques using the same hardware.

Shafi Ahmed, a surgeon at the Royal London Hospital, has tried out the simulation. "It's a nice model, very elegant," he says. "It demonstrates the value of virtual reality in training."

In future, says Ahmed, surgeons may benefit from more sophisticated haptic feedback that can deliver the sensation of temperature as well, for example. More realistic graphics could also help to heighten the sense of immersion. Chris Baraniuk ■

Wounded soldier ants rescued by comrades

IT'S an ant-help-ant world. Ants have been seen carrying wounded comrades back to the nest after raids on termite colonies.

The ants don't help their comrades out of the goodness of their hearts, however: the wounded soldiers are needed and are soon back in action.

Megaponera analis, a species found in sub-Saharan Africa, feeds only on termites. It sends armies of 200 to 500 individuals to raid their nests. However, the raiders often sustain serious injuries. Ants that lose limbs are severely handicapped immediately after the injury. But if they are carried back to safety they adjust within a few hours and can run almost as fast as uninjured ants.

"At first, they kept tripping over, because they thought they [still] had six legs," says Erik Frank at the University of Würzburg, Germany. "Inside the nest, they were safe to adapt and change their locomotion."

Frank and his colleagues observed 54 raids by these ants in Comoé National Park in Ivory Coast, using infrared cameras to see inside their nests. On average, three ants were carried back after

each raid. Most had a termite clinging on to them, and some had lost a limb.

"It was completely new and unexpected," says Frank.

The researchers marked the injured ants with acrylic paint to monitor their recovery. Ninety-five per cent of those that

were carried back took part in subsequent raids, sometimes less than an hour after the injury.

Rescuing behaviour appears to be stimulated by a pheromone produced in the mandibular gland of injured ants. When the researchers dabbed an extract onto healthy ants, their nestmates carried them home.

Termites aren't the only threat to the injured ants. When the researchers forced some injured ants to return alone, a third of

them died, mostly from predation by spiders. The team estimates that carrying home their wounded allows the colonies to be 29 per cent larger than otherwise (*Science Advances*, DOI: 10.1126/sciadv.1602187).

Frank thinks that several traits of this species made this behaviour likely to evolve: they hunt in groups, they have a high injury rate, and they have very small colonies, which means each individual is valuable.

"There are other species that hunt termites in small groups, where this behaviour could evolve, and I would like to look for this," he says.

Under these circumstances, the behaviour makes a lot of sense, says Sara Helms Cahan at the University of Vermont. "We often think about ants as being kind of like trees with leaves: every individual doesn't matter very much because there are so many of them. But if you have a small colony, that's actually a pretty important investment."

The idea of ants helping their comrades isn't so remarkable, she says. "Ants do many things that could be considered helping. But this type of behaviour – where individuals are cared for after they're injured – is a new element in the arsenal of ant-helping behaviour." Sam Wong ■



Carry me home

ERIK T. FRANK

Music tools tailor tunes to help you sleep

A BABY may fall back asleep at 2 am to a gentle lullaby, but new compositions designed to help adults relax sound rather different to *Rock-a-bye Baby*.

Boston-based start-up Sync Project uses biometrics to tailor music to your mood. Its Unwind app measures your heart beat via your smartphone's accelerometer and uses this to tweak an ambient track by UK band Marconi Union. After listening, you take a brief

survey on how relaxed you feel.

"Music can be used for everyday wellness as well as for clinical applications," says Sync Project co-founder Ketki Karanam. Sleep and relaxation was an obvious place to start. "We felt that was one area where people were using music to calm themselves down or relax," she says.

As well as gathering data via the app, the firm plans to collect biometric readings from those at an overnight performance of composer Max Richter's 8-hour album *Sleep* – designed to help people nod off – in London next month. Attendees will

be invited to wear activity-tracking OURa rings, which also monitor heart rate and body temperature. The Sync Project team will analyse the readings for insights into how the music might affect sleep and relaxation.

Ultimately, the company aims to develop artificial intelligence-based tools that will use music to improve general well-being and even treat clinical conditions.

But neuroscientist David Eagleman

"The firm plans to collect biometric data at an overnight performance of the 8-hour album *Sleep*"

at Stanford University in California, who was an adviser to Richter on the *Sleep* album, is sceptical. "Music has certain obvious ways it can excite or relax us, but there are limits and it certainly can't replace real treatments," he says.

Music can be a useful distraction, which can help with insomnia or pain relief, says Kevin Morgan, director of the Clinical Sleep Research Unit at Loughborough University, UK. "That said, if the presenting insomnia is so 'mild' it can be effectively managed with Spotify, it's unlikely to have been a major clinical issue in the first place," he says. Nicole Koble ■

One in a trillion odds Tasmanian tigers still alive

WHAT are the odds that Tasmanian tigers still exist? About 1 in 1.6 trillion, according to a mathematical model.

Tasmanian tigers, or thylacines (*Thylacinus cynocephalus*), were marsupial carnivores native to Australia. The last known individual died in captivity in 1936, but sporadic claims of sightings have fuelled hopes that a few might still exist in a remote wilderness. Now Colin Carlson at the University of California, Berkeley, and his colleagues have used data on confirmed and unconfirmed sightings from 1900 onwards to model the extinction of thylacines. Under the most optimistic scenario, they calculate that thylacines could have clung on until the late 1950s (*bioRxiv*, DOI: 10.1101/123331).

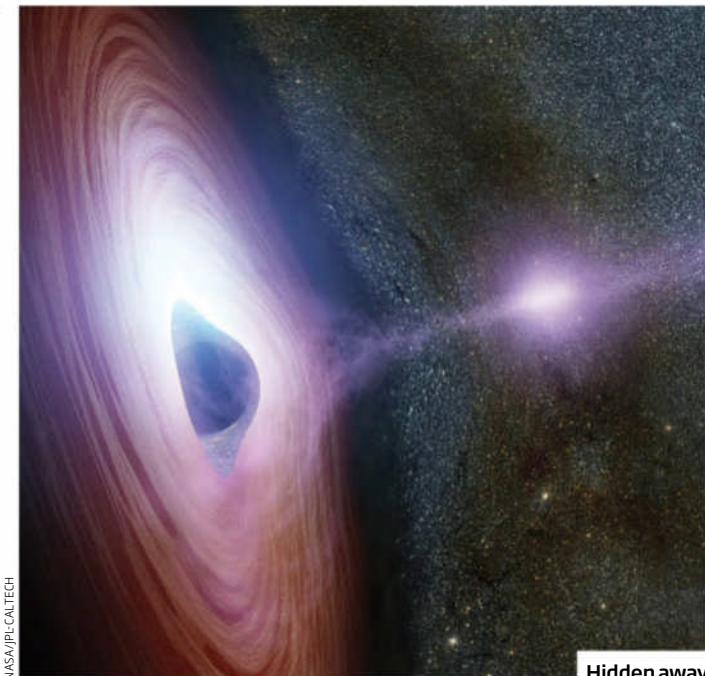
Brendan Wintle at the University of Melbourne, Australia, has developed an alternative model that includes data on previous searches in remote regions, as well as aspects of the animal's biology and behaviour. This model concludes that the latest possible extinction date is 1983 (*Global Change Biology*, DOI: 10.1111/gcb.13421). "Unfortunately, we have also drawn the curtain," says Wintle.

Tasmanian tigers hit the headlines recently after Bill Laurance at James Cook University in Queensland and his colleagues announced plans to search for them in the remote Cape York peninsula at the northern tip of mainland Australia, where there were two alleged sightings in the 1980s.

Laurance says he welcomes these modelling studies for "injecting a note of sobriety into the discussion". "We agree that it's exceedingly unlikely [that thylacines still exist] - we've been saying that from the outset," he says.

But even if the search fails to find Tasmanian tigers, it will still be worthwhile, Laurance says. The team is planning to lay camera traps in areas accessible only by helicopter, which will reveal much about local wildlife.

Alice Klein ■



NASA/JPL-CALTECH

Hidden away

Quantum cloaks for singularities

Leah Crane

BREAK out the censor's black bars for naked singularities. Quantum effects could be obscuring these impossible predictions of general relativity, calculations show.

Albert Einstein's general relativity describes gravity and space-time fairly well. But with the most extreme objects, such as black holes, it runs into problems.

Among these is its prediction of naked singularities: theoretical points in space-time where gravity becomes infinitely large, but without the "blackness" of regular black holes. This is caused by an event horizon, a boundary within which the gravitational force of a singularity is so strong that light can't escape. Naked singularities lack such a cloak.

But naked singularities streaking through space challenge physics as we know it, which assumes we can predict the

evolution of systems based on their initial conditions. However, near a naked singularity, which is basically an abrupt puncture in space-time, that predictive power collapses. This creates an area rife with paradoxes, where anything could happen without warning.

That is an issue for the universe as we know it. "We live in a rather classically predictable

"We live in a rather classically predictable world and we don't see infinities everywhere"

world and we don't see infinities everywhere," says Marc Casals at the Brazilian Center for Research in Physics in Rio de Janeiro.

This same problem is thought to arise in regular black holes too, but their event horizons protect us, ensuring we can never observe the infinity of a singularity or the implosion of our ability to

describe sequences of events.

"Physicists believe that although there are these bizarre solutions to Einstein's equations, once we add all the complications, these weird properties will disappear," says Ivan Agullo at Louisiana State University in Baton Rouge. "But actually proving that is very difficult."

Now, calculations by Casals and his colleagues show that quantum effects may force naked singularities to clothe themselves in event horizons just like regular black holes (*Physical Review Letters*, doi.org/b5p8).

"If, by some evil means, somebody created a naked singularity, it would quickly cease to exist," says Casals. "These quantum fields would very quickly turn the naked singularity into a black hole." His team's calculations show that including quantum fields also eliminates the regions in black holes where physics breaks down.

Although this still allows singularities to exist within event horizons, it protects the universe outside them from their weird physical effects.

These calculations come with a caveat: although we live in a four-dimensional world, they apply to a simpler universe with only three dimensions, two of space and one of time. But the maths in two-plus-one dimensions is usually a good starting point for studying the real world, says Robert Mann at the University of Waterloo in Ontario, Canada.

It is also a step towards understanding how gravity and general relativity, which operate on huge scales, interact with the quantum nature of matter, which is most evident in small systems. Many physicists hope the two will eventually be combined into a single theory of quantum gravity.

"There is this belief that quantum gravity will solve these undesirable features of classical space-time," says Casals. "Our calculations show that this may be true." ■



Real exoplanets, virtual universe

Tom Fenwick, Reykjavik

IF YOU enjoy navigating distant galaxies, leading intergalactic alliances and fighting off space pirates, you might want to take on a fresh challenge: discovering planets.

The space-based online game *EVE Online*, which bills itself as “the world’s largest living work of science fiction”, is delving into science fact by asking players to help search for planets outside our solar system. Details of the citizen science challenge – part of an initiative called Project Discovery – emerged at the game’s annual Fanfest event in Reykjavik, Iceland, earlier this month.

A mini-game launching later this year within the virtual universe will present players with data from the now defunct COROT space observatory. They will be looking at luminosity curves, representing the change in a star’s brightness as a planet passes in front of it. Besides revealing the presence of exoplanets, the variations can reveal information about their orbit and atmosphere.

Although the COROT mission ended in 2013, there are still mysteries to unlock, says project member Michel Mayor, an astrophysicist at the Geneva Observatory in Switzerland. Mayor and his colleague Didier Queloz discovered the first exoplanet, 51 Pegasi b, in 1995.

“The people behind [COROT] still believe there might be nine

If gamers have the mind to fight battles in distant galaxies, then they will love astronomy”

planets undetected in the data,” Mayor says. Data from the Kepler space observatory and the Next-Generation Transit Survey in Chile will be added to the game at a later date.

Players will receive small amounts of in-game currency for each observation they make and may also earn special credits. This could create a risk of data being over-interpreted, but Mayor says there are processes to reduce false positives. If many people come up with the same

result, scientists will consider it more closely.

The project is a collaboration between Mayor, *EVE Online* creator CCP Games, Swiss-based start-up Massively Multiplayer Online Science (MMOS), and the universities of Reykjavik and Geneva. It is the second citizen scientist challenge to be hosted by *EVE Online*. Project Discovery previously set players the task of analysing high-resolution slides of human cells to look for patterns linked with proteins. Their findings contribute to the Human Protein Atlas, a database used by medical research groups.

The gaming approach proved a big success, said Attila Szantner, CEO of MMOS, at Fanfest. “A huge problem in citizen science is that people are interested in the research, but the reality isn’t engaging enough. However, with this, CCP’s designers can make an engaging game which works on both levels.”

Mayor is keen for a gamer to experience discovering a planet, like he did. “Hopefully, if they have the mind to fight battles in distant galaxies, then they will love astronomy,” he says. But he points out that by the standards of the *EVE Online* universe, the worlds they will be looking for are practically in our backyard. ■

First neuron activity map for an entire animal

THE firing of every neuron in an animal’s body has been recorded, live, for the first time. The animal was a hydra – a tiny, transparent relative of jellyfish. Instead of a brain, it has the most basic nervous system in nature, a net of neurons spread throughout its body. Even so, we know almost nothing about how the hydra’s few thousand neurons create behaviour.

To find out, Rafael Yuste and Christophe Dupre at Columbia University, New York City, genetically modified hydra so that their neurons glowed in the presence of calcium. Since calcium ions spike when neurons fire a signal, Yuste and Dupre were able to relate behaviour to activity in glowing circuits of neurons.

When the animal opened its mouth to feed, for example, a circuit that seems to be involved in digestion activated. It may be a forerunner of our gut nervous system, the pair suggest.

They also found that no neuron was a member of more than one circuit (*Current Biology*, doi.org/b48d). This suggests the animal has evolved distinct networks for each reflex – a primitive arrangement compared with our interconnected nervous system.

The hydra work is the first step towards breaking the “neural code” – the way that neural activity determines behaviour, says Yuste. “Hydra have the simplest ‘brain’ in the history of the earth, so we might have a shot at understanding those first and then applying those lessons to more complicated brains,” he says.

Yuste was one of several neuroscientists, including George Church at Harvard University, who in 2012 launched the Brain Activity Map Project to record the firing of every neuron in the human brain. The hydra is now the first animal to have such a map created.

The work is an “awesome milestone worth celebrating”, says Church. But scaling this up to rodents or primates will be very challenging, he says.

Niall Firth ■

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Editing the seeds out of our fruits

By Alice Klein

DON'T like seeds in your tomatoes? You might be pleased to know that seedless ones have been created by gene editing.

The technique could create a wide range of seedless fruits, but few may ever reach supermarket shelves if regulators decide to treat gene-edited crops in the same way as genetically engineered ones.

Several seedless fruits, from bananas to grapes, are already available, but have mostly come about by luck rather than design. And although there are a few seedless varieties of tomato, they have taken breeders many years to create.

Now it can be done very rapidly, as Keishi Osakabe at Tokushima University in Japan has shown. His team used the CRISPR gene-editing technique to introduce a mutation into tomatoes that increases levels of a hormone called auxin. This stimulates fruits to develop even though no seeds have begun to form (*Scientific Reports*, doi.org/b5rf).

"We haven't tasted them yet, but in theory they should taste

the same," says Osakabe.

The precision with which CRISPR works means that no mutations were introduced into other parts of the plant genome. The only obvious difference is that the mutant plant's leaves had less intricate shapes than normal, because higher auxin levels also affect the growth of leaves.

There have been a few attempts to create seedless tomatoes using earlier genetic-engineering techniques, which typically involve splicing DNA from other organisms into a plant's genome. These methods are clunky and time-consuming compared with CRISPR, which merely tweaks a plant's own genome.

Some "seedless" fruits just have very small seeds, and still require pollination. But completely seedless – or parthenocarpic – fruit like the edited tomato do not require pollination at all. Such plants could improve food security by reducing our reliance on declining bee populations, says Saul Cunningham at the Australian National University. Many commercial fruit growers currently hire or buy bees to pollinate their crops.



Pip pip, go away!

There is a downside for farmers, however. Seedless plants usually have to be grown from cuttings, which can be more labour-intensive than planting seeds.

CRISPR could be used to develop other types of fruit that don't require pollination, as well as introduce beneficial mutations that improve traits such as stress tolerance, says Osakabe.

But to make it on to shop shelves, gene-edited plants may have to meet the same criteria for approval as genetically modified plants, which would greatly increase costs. Some argue that where gene-editing is used to introduce mutations already found in some of the plants we eat, it should not require such strict regulation. ■

Unprotected sex upsets vaginal bacteria

SEX can disrupt the balance of bacteria in the vagina, and might put women at risk of infections.

The microbial communities of healthy vaginas tend to be dominated by a particular type of bacteria. Women with higher levels of other bacteria are more likely to get urinary tract infections, or even give birth prematurely. But it is unclear whether

these bacteria are a cause or a result of these problems.

To find out if sexual activity can affect vaginal bacteria and, potentially, women's health, Lenka Vodstrcil at Melbourne Sexual Health Centre in Australia and her team tracked the bacteria in 52 volunteers' vaginas. Each woman was asked to swab their vagina every three months for a year, and to keep a record of any sexual activities and whether they used condoms. The women were all young students, and 19 had not yet had penetrative sex at the start of the study.

Vodstrcil's team found that women

who had unprotected penile-vaginal sex were much more likely to have a vaginal microbiome dominated by the species *Gardnerella vaginalis* and *Lactobacillus iners*. Those who started having penile-vaginal sex during the study tended to go on to have more of these two strains (*PLoS One*, doi.org/f9q97m). Both species have been linked to bacterial vaginosis, a poorly understood condition causing

"The risk lies in having sex with a new partner, which is a microbial assault on the vagina"

abnormal discharge and odour.

It is very likely that sex alters the vaginal microbiome, says Janneke van de Wijgert at the University of Liverpool, UK. Her research has found a link between unprotected sex, imbalanced vaginal bacteria and an increased risk of contracting an STI.

But sex isn't always bad for the vagina. Van de Wijgert thinks the microbiome probably adapts to the bacteria on the penis of a long-term partner. "The risk lies in having sex with a new partner, which is a microbial assault on the vagina," she says. Jessica Hamzelou ■

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Creative people perceive more

Alice Klein

IF YOU relish adventure, you may literally see the world differently. People who are open to new experiences can take in an exceptional amount of visual information and combine it in unique ways.

Openness to experience is one of the “big five” traits often used to describe personality. It is characterised by curiosity and an ability to do well at tests that ask people to come up with creative ideas, such as new uses for everyday objects like bricks.

There's evidence that people who score highly in assessments of openness also have better visual awareness. For example, when focusing on letters moving on a screen, they are more likely to notice a grey square appearing elsewhere on the display.

Now Anna Antinori at the University of Melbourne in Australia and her team have found that people who score higher for the openness trait “see” more possibilities.

The team gave 123 university students a binocular rivalry test, in which they simultaneously saw a red image with one eye and a green image with the other eye for 2 minutes. Usually, the brain can only perceive one image at a time, and most participants reported seeing the image flip between red and green. But some people saw the two images fused into a patchwork of red and green.

The higher the participants scored for openness on a

“It seems that openness alters the filter of consciousness, and we'd like to know how”

personality questionnaire, the more they experienced this mixed perception (*Journal of Research in Personality*, doi.org/b5q4). “Their brains are able to flexibly engage with less conventional solutions,” Antinori says. “We believe this is the first empirical evidence that they have different visual experiences to the average individual.”

Personality can affect what you see

The results could explain why people with a high degree of openness tend to be more creative and innovative, Antinori says. “When they come up with all these crazy new uses for bricks, it might be because they really perceive the world differently.”

The findings also hint at why extremely open people can be prone to paranoia and delusions, says Niko Tiliopoulos at the University of Sydney, Australia. “At those levels of openness, people may actually see reality differently,” he says. “For example, they may ‘see’ spirits, or misinterpret signals.”

There are similarities between high levels of openness and the experience of taking magic mushrooms, says Antinori. Her team has shown that the chemical psilocybin in magic mushrooms increases a person's openness scores and experience of mixed perception in binocular rivalry tests. Some forms of meditation also increase mixed perception.

Antinori wants to see if similar neural processes are involved in mixed perception, creative thinking and the shifts in visual perception caused by psilocybin and meditation. “It seems that openness alters the filter of consciousness, and we'd like to know how,” she says. ■

Drone maps unsafe mines to find minerals

DRONES fly through a mysterious tunnel complex creating a detailed 3D map of the caverns in minutes. No, this isn't a scene from *Prometheus*, but a plan to explore parts of old mines that are unsafe to visit.

The remotely piloted drones will be able to carry out safety checks and search for valuable mineral deposits that may have been missed. Based on a commercial quadcopter, they will have powerful LED lights, cameras and sonar. The drones are being developed by Craig Lindley and his colleagues at the Commonwealth Scientific and Industrial Research Organisation, Australia's government research agency.

Initially, the researchers tried flying a drone through underground passages using its on-board camera to guide them, an approach known as first-person-view piloting. But this isn't ideal for navigating labyrinthine mines on long journeys without hitting the walls.

So the team developed computer software called VoxelNet, which creates a 3D model of the surrounding area based on video imagery sent from the drone to a laptop. This gives the navigator a virtual view of the drone in its environment.

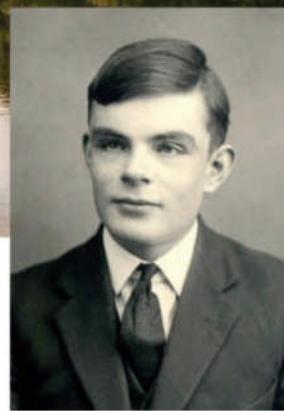
It takes 20 minutes to map a 10-metre stretch of tunnel using the video data – but there may be a more efficient way. “Most recently, we have explored the use of sonar,” says Lindley. Sonar sensors, which use sound waves to detect objects, produce less data than video cameras and so can create a 3D model more quickly.

It may be a challenge to reliably operate such a drone though, says Joshua Marshall at Queen's University in Ontario, Canada. Mapping in these environments without a solid global navigation system like GPS – which can't penetrate deep underground – can be tricky, he says. “So the challenge is to do this robustly.”

David Hambling ■

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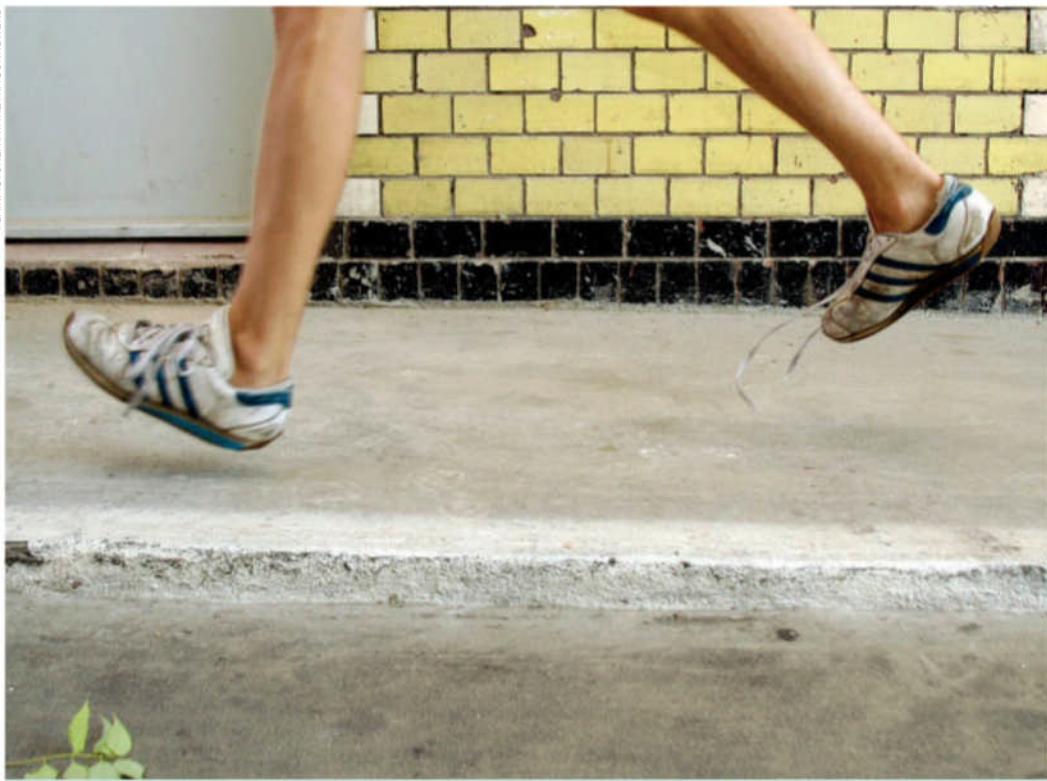


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Physics of shoelaces shows why they come undone

A COMBINATION of stomping and whipping explains why your shoelaces seem to come untied all by themselves.

Although many studies have examined the durability of various knot configurations, none had really focused on the physics of why a knot comes undone on its own.

Oliver O'Reilly at the University of California, Berkeley, decided to study spontaneous unknotting after noticing that his young daughter could never keep her shoelaces tied. He and two graduate students ran real-world experiments to investigate further.

Team member Christine Gregg, an avid runner, jogged

on a treadmill so her colleagues could film her shoes in slow motion to capture the details of the unravelling.

They found that the culprit is a combination of the inertial forces generated while running. A knot is held together by the friction at its centre. Each turn adds to this friction, so more turns means stronger knots.

But the repetitive downward stomp of each foot while running exerts an acceleration at the base of the knot, while the laces whip back and forth with each stride, tugging on the ends like an invisible hand. Eventually, the knot hits a tipping point where the acceleration trumps the internal friction, and it comes undone all at once (*Proceedings of the Royal Society A*, doi.org/b5p5).

The work could shed light on other knotty structures, such as knots used in surgery, or DNA and proteins.

Mars hosts mysterious airborne metals

MARS'S atmosphere harbours layers of electrically charged metal atoms, and they aren't behaving as expected.

Metallic dust and rock fills the space between planets in our solar system. This debris burns up in planets' atmospheres, leaving behind particles of metals like iron and magnesium. On Earth, those particles stream along magnetic field lines to form thin

layers in the atmosphere.

But Mars lacks a global magnetic field. So it was a surprise when NASA's MAVEN spacecraft found layers of atmospheric metal ions (*Geophysical Research Letters*, doi.org/b5nf). These layers should not form this way, and our models can't explain them.

"Something is causing these layers; something is pushing them around. But we don't know

what," says Joseph Grebowsky at NASA's Goddard Space Flight Center in Greenbelt, Maryland.

The iron and magnesium are also blended much higher up in the atmosphere than expected, given that iron is much heavier.

"This is neat because it shows us that the Martian atmosphere is an atmosphere all by itself," says Dean Pesnell, who is also at NASA Goddard but was not involved in this work. "It's not just another Earth that's a little different."

Just add heat to make 4D objects

IT'S a clever method of printing objects that can change their shape, but so-called 4D printing is often laborious, too. Now there's a way to do it in minutes.

Zhen Ding at the Singapore University of Technology and Design and his colleagues devised the technique using a commercial 3D printer and a heat source. They printed strips of a shape-memory polymer paired with a rubbery polymer called an elastomer.

When heated to 45°C, the shape-memory polymer relaxes and allows the elastomer to bend into a new configuration. The team applied this to make a flower that closes its petals and a star that morphs into a dome.

The method could be used to design flat-pack furniture that assembles itself, or medicine capsules that break open when body temperature rises, says Geoff Spinks at the University of Wollongong in Australia.

Volleyball players take on robot arms

TOP volleyball players are honing attack skills with the aid of a robot that moves faster than they do.

The "block machine", developed by the Japanese Volleyball Association and the University of Tsukuba, has three pairs of robotic arms that move side to side in front of the net. These represent blockers – players who defend against "spikes" from the attacking team that send the ball forcefully over the net.

A coach can program the machine for different drills, for example positioning the robot arms to mimic the playing style of past or future opponents.

The work will be presented at the IEEE International Conference on Robotics and Automation in Singapore, which starts in May.

Defended by a cloud of jaws

THE collector sea urchin has a most extraordinary defence: it releases hundreds of tiny jaws that can bite and release venom even after they have separated from the sea urchin's body.

Nestled among the long spikes of all sea urchins are shorter stalks topped with jaws known as pedicellariae. They attack predators that get too close, and one type also releases venom as the jaws bite. "The globiferous pedicellariae are minute and terrifying," says Hannah Sheppard-Brennan at Southern Cross University in Coffs Harbour, Australia.

The collector sea urchin, found in the Indian and Pacific oceans, goes even further: it releases some of the biting heads when attacked, so they form a defensive cloud around it.

It can take up to 50 days for the heads to regrow, but the urchins don't unleash them all at once. They usually only release dozens at a time, says Sheppard-Brennan, though a single individual can emit hundreds in just 30 seconds.

The venom seems to play a crucial role, her team has found. Fish given food that contained pedicellariae rejected it, both in the lab and in the wild. But when the venom was removed by soaking the pedicellariae in alcohol, there was much less of a deterrent effect (*The American Naturalist*, doi.org/b5ps).



HANNAH SHEPPARD-BRENNAND

Gene editing adapted to detect Zika virus

CRISPR has another trick up its sleeve. The system that sparked a revolution in gene editing can also be used in fast and cheap tests for pathogens.

A tool based on CRISPR has been shown to detect the Zika virus in blood, urine and saliva. It has been developed by Omar Abudayyeh and colleagues at the Broad Institute in Cambridge, Massachusetts, who call it SHERLOCK – for Specific High Sensitivity Enzymatic Reporter Unlocking.

So far, the CRISPR system has

mostly been exploited as a gene editing tool, but it may also prove useful for medical testing. "Once we realised how the enzyme works, we saw that it could have unlimited applications in diagnostics," says Abudayyeh.

As well as Zika virus, the team has also used SHERLOCK to detect antibiotic resistance genes in *Klebsiella pneumoniae* bacteria, and health-related gene variants in human saliva (*Science*, DOI: 10.1126/science.aam9321). They say the system has advantages over some other tests: it's able to

detect single molecules of genetic material among mixed samples, and can distinguish between genetic sequences that differ by only one letter. It's also fast, working in about an hour, and can be adapted as a paper test costing only 61 cents – cheap enough to be used in a wide variety of settings.

"As the next epidemic or viral threat comes up – for example, the next Zika or Ebola – we think there's a lot of utility in using this for better surveillance for those outbreaks," says team member Jonathan Gootenberg.

Tar fillings found in prehistoric teeth

HATE seeing the dentist? Imagine if they drilled with stone tools and used tar to fill the hole. Thanks to two front teeth found in Italy, we now know that such fillings were invented at least 13,000 years ago.

The teeth were discovered at the Riparo Fredian site near Lucca. Each has a large hole extending down into the pulp chamber deep in the tooth. "It is quite unusual, not something you see in normal teeth," says Stefano Benazzi at the University of Bologna.

Horizontal marks on the walls suggest the holes were drilled out, probably using tiny stone tools. The marks resemble those Benazzi and his colleagues found in teeth from another site in Italy, dated to 14,000 years ago – the first known example of dentistry in humans.

The latest find also contains traces of bitumen, with hairs and plant fibres seemingly embedded in it for some unknown reason. Benazzi thinks this is evidence of the earliest known filling (*American Journal of Physical Anthropology*, doi.org/f9v8qz).

The dentist would have drilled out the cavities and filled the holes to reduce pain and keep food out of the pulp chamber, like in modern dentistry, says Benazzi.



MICHIGAN STATE UNIVERSITY

Water telescope hunts new pulsars

WE MIGHT have found a novel way to spot pulsars, the rapidly spinning corpses of massive stars – and the process may have uncovered a new species of these objects.

Pulsars emit powerful beams of radio waves that sweep across space like a lighthouse, but radio telescopes only notice these if Earth is in their path. Thus there could be thousands of invisible pulsars in our galaxy waiting to be discovered.

Now Tim Linden at Ohio State University in Columbus has thought up a way to find them. His idea was to use the High-Altitude Water

Cherenkov observatory – made up of 300 water tanks on a Mexican mountaintop – to detect gamma radiation produced when charged particles emitted by pulsars interact with the gas between stars.

To test the technique, Linden and his colleagues observed the sky around two known pulsars and found that the gamma emissions matched up (arxiv.org/abs/1703.09704).

These emissions also seemed to reveal the existence of a new type of pulsar whose wind of charged particles streams out further than expected, says Linden.

WHY ARE DOGS' NOSES WET?

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Will a ban bee enough?

A ban on neonicotinoids may be imminent in Europe, but that alone won't help pollinators, says **Anthony King**

SPRING brings the hum of bees, and this year it heralds further rumours of their demise – and the spread of the pesticide that seems to be to blame.

Neonicotinoids, already subject to temporary bans in the EU, UK and parts of Canada, are under intense scrutiny. Regulators in Europe are poring over hundreds of studies to guide whether these temporary restrictions will become an outright ban.

But what effect will a ban actually have? These compounds aren't just in pesticides – you might find them in products for your pet. And from many sources, they have leached into the environment, and seem to show up wherever we look, including last week in US drinking water.

Although a ban seems like a rational response, it may lead to worse problems. So what are the right lessons to take from the neonicotinoid saga?

Systemic attack

When these neurotoxins were introduced in the 1990s, they were heralded as the future of pesticides. If coated onto a seed, they spread through the growing plant. When sucking pests like aphids eat any part of the plant, the neonicotinoid gums up the same receptors that nicotine targets in the brain, killing the insects. It was thought the toxins could target pests without doing much harm to beneficial insects like bees, and neonicotinoids quickly became the most widely used pesticide in the world.

Then lab studies began to suggest they weren't as harmless for pollinators as advertised.

Bees fed a neonicotinoid diet had fewer queens, compromised reproductive systems, and were worse at finding food and navigating their way home. Their foraging trips were longer but they collected less pollen. Were these effects to blame for reports of colony collapses?

Years of toing and froing ensued, with many claiming the lab studies were overblown and

"Using neonicotinoids is like taking antibiotics all the time to fight against a potential infection - crazy"

gave the bees a higher dose than that found in fields. The trouble was, no one really knew at what levels neonicotinoids were hanging around in the plants or the general environment.

"Everyone knows insecticides can kill bees," says honeybee biologist Francis Ratnieks at the University of Sussex in Brighton, UK. "The question is do the levels of contamination cause harm."

The conversation continued to go in circles as industry-funded studies came up with contrasting findings, even as the EU instituted a temporary ban on the use of the

pesticides for some plants (see timeline). The European Food Safety Authority was tasked with deciding whether to keep the ban after a two-year review.

Then, amid the buzz, it became clear that we should be looking at more than just honeybees. When ecologists cast a wider net, they found clear evidence of harm to other pollinators. One study examined crops of oil seed rape. On Swedish farms, the use of neonicotinoids showed no impact on honeybees – but alarming declines in survival and reproduction in wild bumblebees.

"Wild bees tend to show more negative effects," says Richard Pywell at the UK Centre for Ecology & Hydrology. His research suggests a rise in population extinction of wild bees that forage on oil seed rape in the UK.

For other pollinators, the evidence started to come thick



and fast. A 2015 study found that neonicotinoid levels in milkweed could harm monarch butterfly caterpillars.

Troubled waters

Next came the birds. A Dutch study found that birds needing plentiful insects in the spring to raise their chicks declined more in areas with higher surface-water concentrations of the neonicotinoid imidacloprid.

And the more imidacloprid in surface water, the lower the numbers of aquatic species like caddisflies, aquatic worms and mayfly larvae. Christy Morrissey at the University of Saskatchewan, Canada, says neonicotinoids are regularly found in Canadian wetlands at "concentrations exceeding levels that would cause harm to aquatic invertebrates".



Not the whole story

Yet another report found that neonicotinoids were also harming microbes, lizards, earthworms, birds and even coastal shellfish.

How had the chemicals spread to all these environments? It seems the compounds break down more slowly than early tests suggested, and spread further. Perhaps 5 per cent makes its way from seed to plant, with the rest leaching into the soil and waterways.

The problem is made worse by their prophylactic use. "Farmers are fighting pest problems before they exist," says Menzel. "This is crazy. It's like taking antibiotics all the time to fight against a possible infection."

Neonicotinoids aren't just found in industrial pesticides. In the UK, they also show up in products like ant killer and flea treatments for cats and dogs: a "fair amount" of neurotoxin for your pet, says Dave Goulson, a bee ecologist at the University of Sussex, UK. But much of it will wash off in the rain.

In the US, they are likely to be in your garden. "You can buy flowers at the garden centre with 'bee-friendly' logos," he says. "These actually have neonicotinoids."

In urban areas in the southern UK, most bees have multiple types

"I've seen what the earlier insecticides did to bees. There were heaps of dead bees outside my hives"

of the chemicals on their bodies.

Then, earlier this month, chemists in the US detected three neonicotinoids in treated tap water in Iowa. They concluded that Iowa is far from alone.

Many ecologists believe that a continued or strengthened ban is on the way in Europe. Recently leaked European Commission documents point to a total ban except in greenhouses – even though the European Food Safety Authority has delayed its recommendation, citing an overwhelming number of studies. The date is now set for November.

The big question is what would replace neonicotinoids. Growing oil seed rape without agrichemicals isn't viable, says the UK National Farmers Union, and it is the only crop that can be profitably rotated with wheat. Production of it has already dropped in the UK since the ban.

The most likely way to control aphids – and the diseases they carry – will be to spray pyrethroids. "These broad spectrum insecticides are like using a hammer to crack an egg," says Julian Little, spokesperson for Bayer Crop Science. Worse, resistance to them is increasing.

Upping the use of such chemicals would hardly help bees, says Ratniek. "I've seen what the earlier insecticides did to bees. I saw heaps of dead bees outside my hives in the 1980s."

If the ban is extended beyond flowering crops, Little says people will need to accept reduced yields of food crops and higher food prices. This would probably lead Europe to import more crops from places that still use neonicotinoids.

And for all that, a ban won't even reverse the decline in pollinators in Europe. For one thing, it will only apply to agrichemicals, not to any of the pet and home uses. But that could be missing the point. "The major threat is conventional agriculture becoming more intensive and the effects of climate change," says Adam Vanbergen at the Centre for Ecology & Hydrology. But intensification of agriculture and declining biodiversity don't grab headlines in quite the same way.

"If neonicotinoids were banned tomorrow, it wouldn't help much," says Goulson, who thinks we will never break the cycle of pesticides coming to market and science playing catch-up to uncover the harm they could do.

Many think any new ban should involve an assessment of the effect on pollinators. Had this already been in place, much infighting might have been avoided.

SOWING CONFUSION

1994 - Neonicotinoids introduced in the UK and US

1999 - After reports of "mad bee disease" French government bans the neonicotinoid imidacloprid

2007 - Colony collapse disorder found in 27 US states

2011 - International Union for Conservation of Nature sets up task force to review neonicotinoid safety

2013 - The EU imposes a two-year moratorium on three neonicotinoids on flowering crops; UK Food and Environment Research Agency finds no evidence of harm for bees

2014 - Landmark study finds negative effects on shellfish and lizards

2015 - US refuses approval on new neonicotinoid; Ontario restricts them; UK lifts ban in some areas

2016 - Wild bee declines in UK linked to neonicotinoids; industry study in Germany says no ill effects for bumblebees

2017 - Canada considering countrywise restrictions; European Food Safety Authority delays ruling on whether to lift EU moratorium; EU will decide whether to make the temporary moratorium permanent

Others hope the neonicotinoid saga will help drive fundamental changes in farming. "Farming assumes the answer always comes in a bottle," says Goulson. "We need to be clever in how we manage pests." Many ecologists argue for integrated pest management, which looks to nature to help control pests, reserving chemicals for emergencies.

Unless we change the way we farm, new pesticides will come along and it will all start again. And eventually spring won't bring any buzz at all. ■

Move to a different beat

The March for Science will be over in a flash, but its message is all about taking the long-term view, says **Dave Levitan**

A WEEK is a long time in politics. Science, however, is in it for the long haul. Whether planning for rising sea levels or isolating proteins in fruit fly nerve cells so that many years down the line we might have a new drug for Parkinson's, it does not square with the day-to-day, fixed-term imperatives of government.

This produces obfuscations from some politicians. They back fracking ventures that quickly create jobs, but talk down long-term pollution. Others take credit for renewable energy progress, conveniently ignoring the decades of work to get there. The slow march of scientific progress does not match well with politics even on a good day. And today is not a good day.

Preliminary budget outlines from US president Donald Trump have shocked the science community. Everything from the



National Institutes of Health (NIH) to NASA's earth science missions would get a buzz cut. In a way this makes perfect sense.

The impulsivity and lack of long-term thinking that places science at odds with politics seems less a feature and more a tenet of Trump's view. Why fund the NIH properly, helping to produce the medical advances of 2030, when you can't see past your next tweet? If politics couldn't handle science's tortoise pace years ago, it should be no surprise to see this disdain reach a new peak in a faster-moving age.

On the bright side is the response of scientists and the public. That includes open letters from thousands of scientists, political action committees aimed at bringing expertise to government – and of course 22 April's March for Science in Washington DC and other cities

Anthropocene now

The impact of industrial societies boils down to a worrying equation, says **Owen Gaffney**

HOMO SAPIENS now rivals the great forces of nature. Humanity is a prime driver of change in the Earth system. Industrialised societies alter it on a scale akin to an asteroid impact. This is how the Anthropocene is often described – the proposed new geological period resulting from our impact on Earth.

Is it possible to formalise this mathematically? I think so and doing this, I believe, creates an unequivocal statement of the risks industrialised societies take.

With Will Steffen from the Australian National University I drew up an Anthropocene equation by homing in on the rate of change of Earth's life support

systems: the atmosphere, oceans, forests and wetlands, waterways and ice sheets, and diversity of life.

For 4 billion years, the rate of change has been a complex function of astronomical and geophysical forces plus internal dynamics: Earth's orbit around the sun, its gravitational interactions, solar heat output, colliding continents, volcanoes and evolution, among others.

That rate of change has been

"The rate of change of the Earth system is now a function purely of industrialised societies"

anything but steady of late. For most of the last 7000 years, global temperature fell at 0.01°C per century. For the past 45 years, that rate is +1.7°C per century.

Carbon emissions are arguably the highest for 66 million years. Rapid biodiversity loss prompts claims we are in a third phase of the biosphere's evolution, after the microbial stage 3.5 billion years ago and the Cambrian explosion 650 million years ago.

We say that the rate of Earth system change is now a function of industrial societies alone. Astronomical and geophysical forces tend towards zero due to their slow pace or rarity, as do

in the US and around the world.

The march, viewed one way, is a bit of a paradox. It is one day aimed at making people understand how unimportant one day actually is. Rather than having a specific bill or reform in mind, participants are simply trying to drum up greater appreciation for evidence, scientific rigour, methodology and expertise.

It is a march that calls attention to another march: that of slow, steady, incremental progress.

All the cuts Trump proposed would have an immediate effect – less spending by the government. But their long-term outcomes, be they delayed development of life-saving drugs or seas rising to swallow Miami, apparently don't move the needle for any number of elected officials.

There is a chance such cuts will accelerate the pace of impacts until it becomes impossible to ignore them. Of course, some of the damage would be irreversible.

Whether the march can wake us all up before that happens remains to be seen. ■

Dave Levitan is a science journalist, and author of *Not A Scientist: How politicians mistake, misrepresent, and utterly mangle science* (W.W. Norton). Find him on Twitter at @davelevitan

internal dynamics, for now. They still exert pressure, but on orders of magnitude less than humans.

For the last 2.5 million years, Earth rocked between ice ages and warmer eras. Far from being a deeply resilient planet, we live on one with hair triggers. Industrial societies have been given a false sense of security by the deceptive stability of the Holocene, the last 11,700 years. Now we have ejected Earth from the interglacial envelope and are heading into uncharted waters. ■

Owen Gaffney is an Anthropocene analyst and communicator at the Stockholm Resilience Centre, Sweden

INSIGHT Australia's coral



GREENPEACE/TOM JEFFERSON

Not the best neighbour for a reef

Adding insult to Great Barrier Reef injury

Alice Klein

MORE bad news about Australia's iconic Great Barrier Reef emerged last week: two-thirds of its coral has now been bleached following the scorching summers of 2017 and 2016.

The scientific consensus is clear: the increased frequency of mass bleaching events is being driven by global warming – both directly by warming water and indirectly by extreme weather that ravages corals. The only way to save the precious remains of the reef is to rein in our carbon dioxide emissions.

So it might come as a surprise that the Australian government seems hell-bent on doing the opposite. Last Monday – the same day the latest reef report card was released – Prime Minister Malcolm Turnbull was in India finalising a deal with multinational conglomerate Adani to build the largest coal mine in Australia – just 300 kilometres from the Great Barrier Reef. Will this seal the reef's fate?

The emissions certainly won't help. Coal from the A\$22 billion (US\$16.5 billion) Carmichael mine will go by rail to the Abbot Point coal port in the

central section of the reef and shipped to power stations in India, where it will pump out more than the annual carbon dioxide output of New Zealand.

The coal will also have a more direct effect: dust blowing from shipments at Abbot Point is likely to poison nearby coral. Coal dust exposure can kill coral in as little as two weeks. Perhaps the worst damage will be from the linked expansion of the Abbot Point port, which will involve dredging 1.1 million cubic metres of seabed. This will choke nearby reefs as plumes of sediment prevent light from getting to the coral. It could also get into the gills of the

"When a senator raised concerns about the coal mine, the ruling party told him he needed a hanky"

reef fish crucial to coral restoration.

When a senator from the Australian Greens party raised concerns in parliament about the recent mass bleaching of the Great Barrier Reef, those from the ruling Liberal party told him he needed a hanky.

The majority of Australians are opposed to the Carmichael mine on

environmental grounds, even though it will create an extra 1400 jobs and provide a A\$4 billion boost to the economy: they are aware that what coal would give, the death of a tourism industry would swiftly take away.

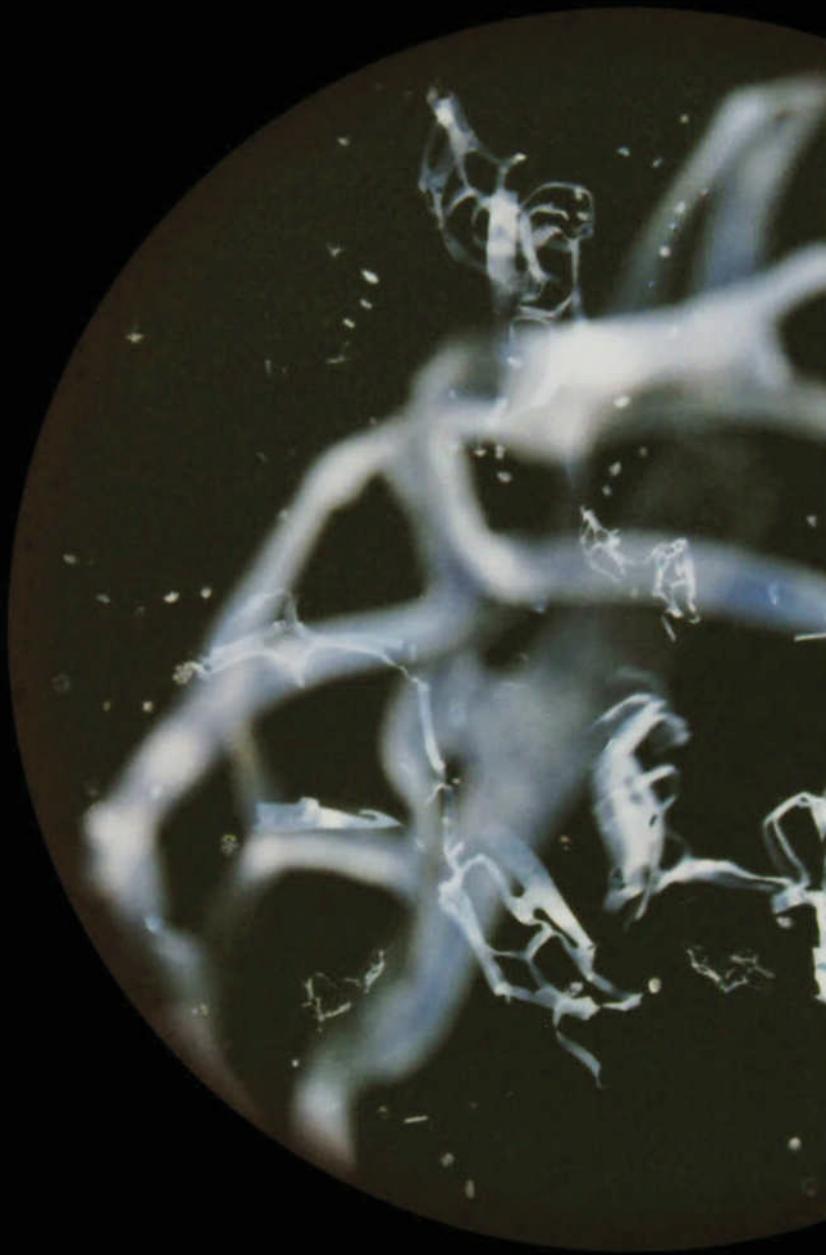
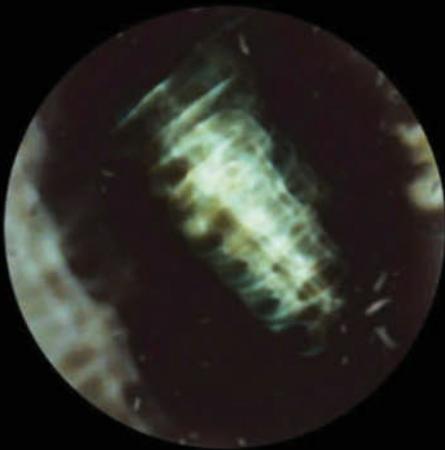
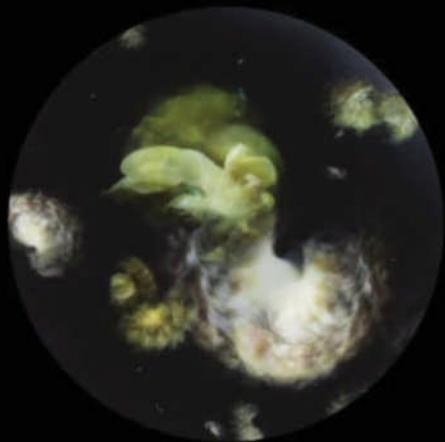
Conservation organisations and Indigenous groups have already launched at least 10 legal challenges against the mine. Although these have mostly failed, they have managed to continuously delay its construction since it was first proposed in 2010.

Although the Turnbull government plans to overturn the latest legal obstruction, it's possible that all these delays will stall the plant for long enough to see India's coal appetite wane.

Because while the Australian government has insisted that India needs coal to power the lives of 100 million impoverished people, the Indian government has plans to move away from fossil fuels. Last last year, it announced it would harvest 60 per cent of its electricity from renewable energy sources by 2027. The rapidly falling price of solar energy is making it an increasingly attractive alternative to coal for India and other lower-income countries.

It may be too late to bring the Great Barrier Reef back to its former glory – but action on emissions could certainly save at least parts of this natural wonder. If, that is, we can find wily ways to thwart politicians' short-term priorities. ■

APERTURE



Animal or mineral?

You have seen *Copeopod langisticus* (left, main image) before – but it didn't look quite like this. The faux-Linnaean title, along with the expired film stock and doctored camera on which the image was shot, serves to veil a common object: the plastic binding from a six-pack of beer.

Mandy Barker photographed this in a style that suggests a plate from a 19th-century natural history, and has gone on to fashion a book of such plates (inset below). Other objects featured here include a Barbie doll's arm, plastic flowers and a tricycle wheel; all are scavenged from the coastline of Cork, Ireland. The place is significant for Barker, for it was here, in 1816, that marine biologist John Vaughan Thompson was posted as a military surgeon. In Cobh harbour, he became the first person to observe the small, immobile organisms known as plankton.

Plankton ingest plastic particles, mistaking them for food, and because many larger creatures depend on plankton as a crucial source of food, the toxic load exerted by plastic on the marine environment increases year on year.

"The aim of my work is to create a visually attractive image that draws the viewer in, then shocks them with what is represented," Barker explains. "This contradiction between beauty and fact is intended to make people question how their shoe, computer, or ink cartridge ended up in the sea."

The project has seen Barker shortlisted for this year's Prix Pictet photography prize. Nominated work on the theme of "space" is on show at the Victoria and Albert Museum in London from 6 to 28 May. Simon Ings



Photographer

Mandy Barker

mandy-barker.com

COVER STORY





YOUR TRUE SELF

WHO ARE YOU? AN ENTITY CONTINUOUS IN TIME, AN INDIVIDUAL WITH A PERSONALITY, A UNIQUE BUNDLE OF MEMORIES?

ONLY NOW ARE WE TRULY GETTING TO GRIPS WITH WHAT OUR SENSE OF SELF IS – AND ISN'T

Mercurial you

You are not the person you were as a child, or even last year, but the fact that our personalities change can be liberating, finds Emma Young

AS a child, Wendy Johnson was extremely shy. "One of my report cards said: 'Wendy is so shy, it's painful to watch'." She's not like that now. "I am definitely a person who learned to overcome overt shyness," says Johnson, a psychologist at the University of Edinburgh, UK. She says shyness is an indicator of a low level of extroversion, a key measure of personality, which she studies. So does this mean Johnson has changed her personality? Undoubtedly, she says.

That answer might surprise you. Most of us consider our personality to be an integral and unchanging part of who we are – perhaps the essence of that thing we call the self. In 1887, psychologist William James went so far as to argue that it becomes "set like plaster" by the age of 30. His idea stuck. Psychologists have long debated how to measure personality, settling eventually on the "big five" traits (see "What are you like?", page 30). But at least they were able to agree on a definition: personality refers to an individual's thought patterns and behaviours, which tend to persist over time. Now mounting evidence is undermining that notion. Personality is far more mutable than we thought. That may be a little unsettling.

But it's also good news for the almost 90 per cent of us who wish our personalities were at least a little different.

There's no doubt that personality is partly genetic. What's less certain is how much is down to our genes and how much to nurture. Newborn babies don't have personalities as such, but do have characteristic ways of behaving and reacting, something

psychologists call "temperament". This includes persistence in the face of setbacks, and "reactivity". Very reactive babies are shy and avoid novel situations. Temperament is often viewed as the biological basis of personality, but it is far from innate. Genes and environment interact to influence it even before birth. For example, there's evidence that mothers who are stressed during pregnancy are more likely to have an anxious child.

Experiences in childhood also shape our personalities. Research shows that young children become more extroverted and work harder when surrounded by other kids with these traits. Parental behaviour has an impact too. Jerome Kagan at Harvard University, who pioneered research on reactivity, found that if parents encourage reactive infants to be sociable and bold, they grow up to be less shy and fearful. This might help explain why temperament doesn't always predict later ratings on big five traits. Smiley babies don't necessarily go on to be extrovert, for example. And Kagan found that only 25 per cent of highly reactive infants were extremely shy, anxious, timid or cautious by the age of 15.

By adulthood, genes seem to account for ➤

NOT FEELING YOURSELF

Some conditions make us lose crucial pieces of what we view as our selves



DEPERSONALISATION DISORDER

Ever felt detached from yourself, as if observing from afar? For people with depersonalisation-derealisation disorder, that feeling is persistent. They feel as if they have lost control of their thoughts and actions, like they are an automaton or they are living in a movie.

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WHAT ARE YOU LIKE?

Personality is an easy concept to grasp, but a difficult one to measure. Psychologists have tried various systems over the years but most now use the “big five” model. This encapsulates personality in five independent traits: openness to experience, conscientiousness, extroversion, agreeableness and neuroticism (or emotional stability). These are generally assessed separately through an inventory asking you to indicate the extent to which you agree with statements such as “I am the life of the party” (to assess extroversion) and “I worry about things” (to assess neuroticism).

Despite being widely accepted, there are still questions over the big five model. For a start, people’s scores aren’t that good an indicator of how they behave when faced with real pressures and the consequences of their actions. Behaviour varies considerably depending on the circumstances.

More fundamentally, we are coming to realise that five traits aren’t

enough. “They leave many things out – particularly, anything that isn’t socially desirable: aggression, alienation, cruelty, manipulativeness,” says psychologist Wendy Johnson at the University of Edinburgh, UK. “Even assertiveness isn’t covered well.” Agreeableness, for example, measures how we react to others, but it doesn’t address the behaviours we initiate, such as stealing from the workplace or taking advantage of someone else’s cooperativeness. This has led to calls for a sixth trait, honesty-humility, to measure a person’s Machiavellian tendencies.

Elaine Aron, a psychologist based in Marin County, California, believes the big five method ignores another important aspect of personality. She has pioneered the concept of the “sensitive” personality trait to describe people who are more physiologically reactive to their environments. They are not necessarily neurotic, but are more likely to pause and reflect before acting, rather than rushing in.

about 40 per cent of the variation in each of the big five traits – at the level of the general population, rather than for any individual. But it would be wrong to assume that genes and the environment are acting independently to influence personality. “They never are,” says Johnson. Another way to consider the genetic influence is to ask how many genes have been identified that are clearly linked with any one of the five traits. “Zero,” says Johnson. “Every time we find something that looks like it’s associated with one, well, it’s associated with a whole pile of other traits, too.”

In other words, genes and environment interact in complex ways to shape our personality. But where’s the evidence that this process stops when we reach 30? Well, there isn’t any. In fact, once psychologists got over the intuitive appeal of the idea, they began finding plenty to contradict it.

The first direct challenge came from studies following adults over long periods. Research published in 2003 revealed that as we get older, we tend to become significantly more agreeable, conscientious and emotionally stable. An intriguing link with physical changes in our ageing brains has emerged recently. Roberta Riccelli at Magna Graecia University in Catanzaro, Italy, and her colleagues found an association between greater neuroticism and a thicker, less wrinkly

cortex. With age, the cortex becomes thinner and folds more, the team notes. It remains to be seen whether there’s a causal connection.

This year, Petar Milojev at Massey University in New Zealand and his colleagues published a study refining the picture of how personality morphs with age. They looked at data on nearly 4000 people aged 20 to 80 and found that personality is least stable in young adulthood, and also after about age 60. This makes sense if changes in the environment can influence personality, says Milojev, because young and older adulthood are periods when people tend to experience maximum change.

What’s becoming clear is that major life events can have long-lasting impacts on personality at any age. Embarking on romantic relationships can reduce levels

of neuroticism. Going through a divorce makes women more extroverted and more open to experience, while men become less conscientious, according to one US study. Although a German study has found that both genders become less extroverted.

The effects of becoming unemployed can be more dramatic. We already know that it has a major effect on well-being. “It’s probably the life event that has the biggest impact,” says Christopher Boyce at the University of Stirling, UK. And he has found that the impact of unemployment on personality is twice as big, with it tending to make people less conscientious and less agreeable. Working

“PERSONALITY IS LEAST STABLE IN YOUNG ADULTHOOD, AND ALSO AFTER ABOUT AGE 60”

can shape your personality too. Nathan Hudson, now at Michigan State University in East Lansing, found that people who have invested heavily in their jobs tend to show an increase in conscientiousness. Even moving to a new town or country might influence your personality – people living in New York tend to be highly neurotic, for example, while Londoners score low on agreeableness.

Other factors can lead to more transient shifts in personality. For example, Sebastian Schindler at the University of Bielefeld in Germany has found that inducing a sad mood in volunteers in the lab caused a 10 per cent increase in their neuroticism ratings, and a decline in extroversion of between 2 and 4 per cent. “These figures seem low, but remember we are talking about personality, which is defined as ‘stable and long-lasting’,” he says.

It’s not entirely surprising that your personality – your general patterns of thought and behaviour – is influenced by your emotions. However, the extent to which environmental factors shape our dispositions over a lifetime is remarkable. In work published last year, Johnson and her colleagues compared results from personality tests taken by people when they were aged 14 and again at 77. “Though measured crudely, we couldn’t find any evidence for stability in individual personality characteristics,” she says.

That’s not to say we are at the mercy of capricious environmental influences. There is also growing evidence that we can actively shape our own personality – and would benefit from doing so. In particular, there’s plenty of research linking low levels of neuroticism and high levels of extroversion with better health and subjective well-being.



BODY INTEGRITY IDENTITY DISORDER

Some people have the powerful sense that one of their limbs isn’t their own, sometimes so intense that they are driven to amputate the “foreign” part. Neuroscientists think it is down to a malfunction in the brain region involved in giving us a map of our own body.



COTARD'S SYNDROME

In this most extreme instance of a self gone awry, your brain tells you that parts of your body, or even your entire body, are dead. Some people with Cotard's syndrome plan their own funerals, or even starve to death because they feel they no longer need to eat.

What's more, Hudson has found that 87 per cent of people would like to see at least a little movement in their ratings on each of the big five traits. "The data are compatible with the intuitive notion that most people would ideally like to be a little more energetic and at ease socially, kinder and more loving towards others, more responsible and productive, less stressed and irritable, or more creative and thoughtful," he says.

One route to change is therapy. In January, Brent Roberts at the University of Illinois and his colleagues reported that four to eight weeks of psychotherapy (the specific type didn't seem to matter) can bring about changes in personality, most notably an increase in extroversion and a substantial decrease in neuroticism.

Then there are psychedelic substances. Research at Johns Hopkins University School of Medicine has shown that consuming magic mushrooms can have a big effect on personality. Even a single session increased the openness scores of volunteers. One year on, their heightened openness remained.

But magic mushrooms are illegal in many countries and psychotherapy is not for everyone. So what to do? Is there a DIY route to a different you? To explore this question, Hudson and Chris Fraley at the University of Illinois at Urbana-Champaign asked a group of student volunteers to write down the traits they would like to alter and then helped them identify specific behavioural changes that would help them achieve their goals. Broad goals are not very effective, Hudson notes.

Four months later, the volunteers reported substantial changes including increases in extroversion and conscientiousness and lower neuroticism. What's more, there was a virtuous circle in which alterations in behaviour led to changes in traits, which in turn led to alterations in behaviour.

Psychologists continue to debate the extent to which personality is plastic in adulthood, but there is now no doubt that it can and does change. And that's good news for all of us. Knowing that you are not "set" by 30 is empowering. "You can think: I'm not stuck with who I am. I can change," says Boyce. ■

Emma Young is a writer based in Sheffield, UK



TREN PARK/MAGNUM PHOTOS

The good delusion

We think of ourselves as moral beasts
– understand that and we can all get
along better, says Dan Jones

IN THE 1980s, evangelical Christian Mark Pierpont travelled the world preaching that homosexuality was a sin and promoting ways to resist gay urges. It was a deeply personal quest. He was himself wracked by the very yearnings he sought to excise from others – a contradiction he openly acknowledged.

So here's the question: which of Pierpont's attitudes reflected his true self? Was his message about the sinfulness of homosexuality a betrayal of his essential, gay self? Or did it reflect what he was deep down, freed from the distorting influence of more primal urges?

At first sight, it is a question of little scientific merit: psychologies are complex, individual things, and there's no part of the brain, and no aspect of our personality, that stands out as being the seat of the true self, so we're never going to discover a universally valid answer. "As a scientific concept, the idea

of a 'true self' is not tenable," says Nina Strohminger of Yale University.

And yet she and other psychologists have set out to study it. Most of us are convinced that something like a true self lurks beneath our surface attitudes and behaviour. It might be a delusion, but it informs how we view human beings, ourselves included. If we could better understand what that delusion consists of, we might learn to get along a little better with ourselves and others.

The question of the most essential element of self has troubled philosophers for centuries. In the 17th century, John Locke put memory front and centre, arguing that the self is grounded in the continuity of conscious experience. So long as you have a memory that can stitch together experiences into a coherent narrative, you have an enduring self.

It's an appealing idea, but modern science has given us reasons to doubt it. People with ➤

retrograde amnesia, for example, can lose memories from before the accident or illness that caused it while retaining the ability to lay down new memories. They do not feel as if their self has been wiped out, and nor do their caregivers.

Intuitively, though, Locke's idea of the essence of self as being something that endures across time makes sense. If it didn't, you'd have a series of fleeting selves at best, none of which was really you. There are indications things aren't quite that simple (see "The future is a foreign person", page 33). But take it as a starting point, and your personality would seem a prime candidate for providing that continuous sense of self – were it not for the discovery that your personality can itself change dramatically over time (see "Mercurial you", page 29).

So if not memory or personality, what then? These days, instead of speculating about the essence of the self, psychologists and experimentally minded philosophers have a new strategy: asking people. By presenting them with various scenarios about someone changing and looking at how far they intuitively feel that the person has strayed from their true self, researchers hope to get to grips with what we regard that true self to be.

In 2014, Strohminger teamed up with Shaun Nichols of the University of Arizona in Tucson to quiz people about the hypothetical case of Jim, the victim of a serious car crash whose only hope for survival is to have his brain transplanted to a new body. In different versions of this story, post-transplant Jim remains psychologically identical or



THE PETRIFIED SELF

An important part of selfhood is the ability to form and recall autobiographical memories, so it will come as no surprise that people who no longer have this power report an incomplete sense of self.

This "petrified self" might also explain why people with dementia are often not aware of their condition.

neurodegenerative diseases – amyotrophic lateral sclerosis (ALS), Alzheimer's, and frontotemporal dementia (FTD). ALS, the condition Stephen Hawking lives with, causes progressive muscle loss but leaves mental abilities intact; Alzheimer's gradually erases memories; FTD leads to changes in social and moral behaviour. Relatives of people with ALS felt the identity of their loved one had changed less than those caring for someone with Alzheimer's, but relatives of people with FTD reported seeing the greatest change.

The upshot is that when it comes to our perceptions of others, we see the moral self as the true self. That makes sense for us as a social species, says Strohminger. "We care about people's moral character because we want to know what they'll be like as social partners," she says. The very reason we see people as having a true self in the first place,



"THE GREATEST CHANGE IN IDENTITY IS PERCEIVED WHEN THE MORAL CONSCIENCE IS LOST"

selectively loses the ability to recognise objects by sight (a condition called visual agnosia) or his autobiographical memories (amnesia), for example.

When the transplant resulted in visual agnosia, participants viewed the change in Jim as minimal. Amnesia was seen to effect a much bigger change in his identity – in line with Locke's theory. But it was a third scenario that they regarded as having changed his self the most: when brain damage resulted in the loss of his moral conscience, so that he could no longer tell right from wrong, or be moved by the suffering of others.

The same seems to be true in the real world. In 2015, Nichols and Strohminger surveyed the family members of people with one of three

THE FUTURE IS A FOREIGN PERSON

she argues, might be the importance we attach to keeping track of social behaviour.

But there's a further intriguing twist to this. Given the plethora of self-serving biases that psychologists have uncovered, we might be expected to have a less generous view of the morality of others than we do of our own. Not so: it seems that we see everyone's true self as not only moral but also morally good, with "good" defined by our own moral outlook.

That much was clear from a series of recent studies by Yale University psychologists George Newman, Joshua Knobe and Paul Bloom. They told people the stories of Mark Pierpont, the conflicted preacher, and similar cases, and sought their reactions. A clear pattern emerged: those with liberal values were more likely to think Pierpont's gay self was his true self, and people of a more conservative bent thought the opposite.

Self improvement

More generally, if someone's behaviour is good in our eyes and accords with our values, we deem it an expression of the true self. If not, it is deemed to belong to a less fundamental, "superficial self". "I can think about who you are on the surface, and maybe see you're not such a perfect person," says Knobe. "But when I think about who you are deep down, there's this strong tendency to see you as morally good." The same effect has been seen in cultures across the world. It's even true of people profiled as being pessimists and misanthropes, who we would least expect to see virtue at the core of others.

Can this tendency to see people as morally good, deep down, be harnessed as a force for good? Perhaps encouraging such perceptions might help to reduce tension and prejudice between groups accustomed to eyeing each other with hostility.

It's a possibility that Julian De Freitas and Mina Cikara, both at Harvard University, have recently put to the test. We know that people tend to view members of their in-group – those they most identify with – more favourably than out-group members, especially those stereotyped as threatening. Two months after the Islamist-inspired shootings of December 2015 in San Bernardino, California, De Freitas and Cikara surveyed more than 1000 white US citizens online, assessing the extent of the fear and threat they felt in response to Arabs. They then presented them with stories describing someone changing for the better – either a white US citizen, an Arab in Syria, or an Arab immigrant to the US. Next they asked participants whether this change

Ten years from now, you will still be you, right? It depends on who you ask, and when. Present You, for one, is not so sure. That much is clear from several studies revealing that we often treat our future selves like complete strangers.

In one, Emily Pronin, a psychologist at Princeton University, asked people to make decisions about how much of a disgusting cocktail to drink. Some chose for themselves, some for the next participant and some for themselves in two weeks' time. When choosing for themselves, people opted for the smallest dose. But they went for a larger amount for another person – and for their future selves.

Brain imaging points in the same direction: thinking about your current self fires up different brain regions than does thinking about your future self, which activates the same areas of the brain as when we think about other people.

Another study focused on our tendency to value immediate rewards more highly than deferred benefits – what economists call "future discounting". It's the reason you struggle to save money or choose the healthy salad. The good news is that by getting better acquainted with Future You, you can make better choices in the here and now.

That was the upshot when Hal Hershfield at the University of

California, Los Angeles, teamed up with virtual reality expert Jeremy Bailenson of Stanford University to bring people face-to-face with how they might look aged 70. The idea was to make this future self a more concrete, real person. When asked to decide about current pension contributions, people who had met their virtual future selves saved more than twice as much, on average, than those shown pictures of their current selves. "The findings suggest that being able to sit down and visualise one's future self, and at least seriously consider who that person is, can help people frame their decisions about retirement," says Hershfield.

Getting to know your future self might even make you a better person. People who feel less strongly connected to their future self are more tolerant of dubious business practices than others, and show a greater willingness to lie and cheat. But simply asking them to think about themselves in 10 years' time, and listing all the ways they think they'll be the same person in a decade, makes them more disapproving of unethical behaviour.

So the next time you're wrestling with a decision to save or splurge, or to hit the gym or slouch on the couch, don't just think about yourself – think about Future You. They will thank you for it, eventually.

for the better was due to the person's true self or their superficial self.

Participants saw the moral improvement in the white US citizen as an expression of his true, morally good self – and had exactly the same view of the Arab cases. Despite being members of a stereotypically threatening out-group, they were still seen as fundamentally good as individuals. What's more, when



PSYCHEDELIC HAZE

Anyone can alter their sense of self using psychedelic substances such as LSD or psilocybin, the active ingredient in magic mushrooms. People under the influence often feel that the boundary between the self and the world melts away – a result thought to be down to a reduction in activity in the anterior cingulate cortex.

participants were encouraged to think about the out-group member's true self in the first place, they reported feeling less fearful. This intervention even changed behaviour: when thinking about the true self, subjects were more likely to donate a major share of a bonus payment to an out-group charity, in this case the Syrian Arab Red Crescent.

So it seems we have a pretty good handle at least on what others believe to be our true selves – even if their interpretations of the moral goodness at our core don't always tally with our own. Whether you believe that Mark Pierpont's gay self was his true self or not might depend on your own existing moral perspective, but ultimately Pierpont made up his own mind. He renounced his life of proselytising against homosexuality and decided he was gay after all. As Shakespeare had it, to thine own self be true. ■

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All gain, no pain

Some lucky critters beef up without lifting a paw, finds Richard Lovett



AS MORE than 40,000 runners prowl the start line of the London marathon this weekend, many of them will be wondering what they have got themselves into. Even without a heavy novelty costume, and no matter how well they have stuck to their training regime, running non-stop for 26.2 miles (42 kilometres) is going to hurt.

Now consider the barnacle goose. Before setting off on a 3000-kilometre migration, it undertakes the training equivalent of sitting on the sofa guzzling fish and chips.

What about the months of gradually building up fitness, followed by a steady taper before the big day? That's not really the barnacle goose's style. Instead, says Lewis Halsey, an environmental physiologist at the University of Roehampton, London, "they just basically sit on the water and eat a lot".

Scientists are only now beginning to investigate how this can be. Until recently, nobody had really asked whether exercise is as tightly connected to fitness in the rest of the animal kingdom as it is for us. In the past year or two, though, a handful of researchers have been inspired to do so by seemingly lazy creatures that manage feats of endurance that make marathons pale by comparison.

The question is tied up in a broader assumption: that, because of the exercise they

get finding food and escaping predators, wild animals live at the peak of physical fitness. Halsey, who recently wrote an article for the *Journal of Animal Ecology* with the provocative title "Do animals exercise to keep fit?", points out that this may not necessarily be the case.

Take, for a moment, a domestic equivalent, the house cat. Most cats spend much of the day lounging around, apparently doing nothing. But over short distances, even the laziest could put Usain Bolt to shame. And all that time spent napping seems to have no effect on their natural agility should a dog suddenly appear in the garden. Similarly, black and brown bears manage to come out of several months of hibernation with their muscle mass intact – without having to lift so much as a paw.

Barnacle geese go one better. In the process of sitting around, they don't just maintain their fitness. They also develop stronger hearts, bigger flight muscles and – somehow – get fit enough to fly for thousands of miles in a migration lasting just two days.

So, if exercise isn't necessarily the key to physical prowess, then what is? One clue comes from a broader view of the meaning of physical fitness. Biologically speaking, all it means is that the body has undergone changes that make it stronger and more efficient. ➤

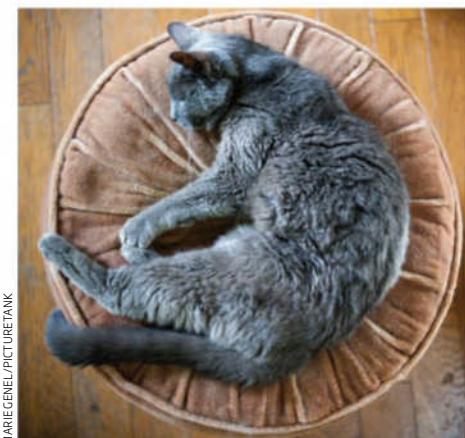
"Over short distances, even the laziest cat could put Usain Bolt to shame"



In humans, these changes are induced by exercise. In animals such as bears and migratory birds, they appear to be triggered by seasonal changes that alert their bodies to a coming challenge. For bears, that cue might be falling temperatures or a lack of available food. Whatever the exact tip-off, it seems to prompt the release of muscle-protecting compounds in their blood. In experiments in which rat muscle was bathed in the blood of hibernating bears, muscle loss was reduced by 40 per cent compared with muscle put in blood from bears that were not hibernating.

Barnacle geese, Halsey suggests, may be responding to an environmental change such as temperature, which helps their bodies somehow "know" that a big physical challenge is looming and to beef up accordingly.

In other bird species, that cue is a seasonal change in the amount of daylight. Chris Guglielmo, a physiological ecologist at the University of Western Ontario in Canada, has found that subjecting migratory yellow-rumped warblers to changing hours of daylight stimulates hundreds of changes in the genes that are activated in their muscles. "We don't need to take little songbirds and train them up to do a 6 or 10-hour flight," he says. If they are subjected to the right daylight cycle, "we can take them out of the



MARIEGENEL/PICTURETANK

Lazy cats can still spring into action if the mood takes them

cage and put them in the wind tunnel, and they fly for 10 hours".

Unlike migratory birds, however, humans have no biological shortcut to getting fit every April, however much the modern marathoner might wish we did. And we have no muscle-protecting substances in our blood that we can switch on to prevent losing our hard-earned strength while lounging on the sofa. Instead,

pressures in our evolutionary history made our bodies tie fitness to exercise.

Our ancestors' lives were unpredictable. They had to do a lot of running to catch food and escape danger, but they also needed to keep muscle mass to a minimum because food was limited. Seen through this lens, losing condition is an adaptation in itself. Muscle is biologically expensive. Each kilogram contributes about 10 to 15 kilocalories a day to our resting metabolism – which doesn't sound like much until you realise that muscles account for about 40 per cent of the average person's body mass. "Most of us are spending 20 per cent of our basic energy budget taking care of muscle mass," says Daniel Lieberman, an evolutionary biologist and marathon runner from Harvard University.

So our physiology evolved to let our weight and fitness fluctuate depending on how much food was available. This makes us evolutionarily different from most other animals, says Lieberman. In general, animals merely need to be capable of short bouts of intense activity, whether it's the cheetah chasing prey or the gazelle escaping. Cats are fast, but they don't need to run very far. Perhaps a few mad dashes around the house are all it takes to keep a domestic one fit enough for feline purposes. Humans, on the



other hand, needed to adapt to run slower, but for longer, says Lieberman.

He argues that long ago on the African savannah, natural selection made us into “supremely adapted” endurance athletes, capable of running prey into the ground and ranging over long distances with unusual efficiency. But only, it appears, if we train. Otherwise we quickly degenerate into couch potatoes.

As for speed, even those animals that do cover impressive distances don't have to be the fastest they can possibly be. Barnacle geese needn't set world records when crossing the North Atlantic; they just need to be able to do it. And, says exercise physiologist Ross Tucker at the University of the Free State in Bloemfontein, South Africa, humans may be the only animal that actually cares about reaching peak performance. Other than racehorses and greyhounds, both of which we have bred to race, animals aren't directly competing against one another. “I don't know that all animals are all the same, performance-wise... and we don't know whether training would enhance their ability,” he says.

So, what can the human fitness fanatic learn from nature's lazy fit animals? It is tempting to hope that science will come up with a marathon preparation pill that might make



DAVID TIPPLING/2020VISION/NATUREPL

No training required: barnacle geese get fit by stuffing themselves

our bodies transform like a goose's, but, the health and ethical aspects of doping aside, that seems unlikely in the near future. In the meantime, perhaps we should look to a humbler kind of creature for motivation.

As anyone who has ever had a pet hamster knows, rodents love to run. In fact, brain chemistry experiments show that they appear to derive pleasure from it, says Vincent

Careau, an evolutionary biologist at the University of Ottawa, Canada. “Mice are wired to like it through the dopamine system,” he says. “It gives them a runner's high.”

In fact, a 2014 Dutch experiment found that it isn't just domesticated rodents that react this way. If you put an exercise wheel outdoors, the study found, even wild mice will exercise on it, once they figure it out.

This summer, Careau plans to follow up on this by putting training wheels out in the wild, tagging as many mice as possible and clocking their running miles to see if there is any effect on their survival rates. It makes sense that there might be, because mice spend their entire lives trying to avoid predators, whether they are hawks, foxes, snakes or weasels. It may turn out that, just like us, the exercise they get in the course of normal life isn't enough for the running they may have to do, so they need to work out in their spare time. For humans, being fit is an evolutionary luxury. But for mice, being fit is the difference between survival and being cat food. So, if you are a marathoner looking for a good result, forget the geese, cats and bears. Instead, think like a mouse, and ride the dopamine high. ■

Richard Lovett is a science writer and running coach based in Portland, Oregon



Rocks of ages

Meteorites tell of our solar system's turbulent past. But finding them is no easy matter, says Sophia Chen

A MAN with a Stetson perched on his head reclines in his chair, an assortment of rocks displayed in front of him. A second man in a fedora browses the collection, pausing over one specimen. The size of a chocolate bar, the silvery rock is inlaid with a mosaic of grainy grey shapes.

"What are you asking for that one?" asks the fedora.

"Oh, somewhere around five thousand," replies the Stetson.

It's a routine exchange at the annual Tucson Gem, Mineral & Fossil Showcase in Arizona, a marketplace for international collectors of petrified wood, dinosaur bones, gold and more. Except there's something special about this rock: it came from space.

The man in the Stetson, Marvin Killgore, hunts and trades meteorites. It's not an easy living. Rocks from space fall anywhere, any time, and many look unremarkable to the untrained eye. Killgore honed his skills in more than 40 countries over 27 years. Catch him at an idle moment, and his eyes are trained on the ground. "I'm always prospecting," he says. "I found a meteorite in the parking lot here last year."

Collectors aren't the only ones interested in his wares. Meteorites are objects of great scientific interest – they are time capsules from the solar system's birth, encoding clues about how our cosmic neighbourhood came to be, and maybe about why life blossomed in at least one part of it. To piece together the full picture, we need more of them. Killgore and his ilk's trained eyes won't be enough. It's time for some cleverer ways of finding space rocks.

SHUTTERSTOCK

Across town from the gem show, some of Killgore's prize specimens are on display at the University of Arizona. The collection of space shrapnel there comes in a bewildering array of varieties: silvery iron-nickel asteroid cores, a grey-pink lunar rock, an olive-faced boulder the size of a newborn calf.

But such flashy rocks are rare. About 85 per cent of meteorites, space rocks that actually reach Earth's surface, are of a type called ordinary chondrites. Often homely grey lumps that won't earn you much cash, these are scientific treasure troves. Each is packed with spheres called chondrules, ranging in size from pepper flakes to marbles. They formed when molten rock droplets cooled 4.6 billion

"Often just homely grey lumps, meteorites are scientific treasure troves"

years ago, long before any planets existed in the solar system. "With a chondrite, you have the oldest rock you'll ever hold in your hand," says planetary scientist Dolores Hill, who leads tours of the exhibition.

Meteorites like this could help us figure out some of our cosmic backyard's deepest mysteries, such as why the planets exist in a neat arrangement of four rocky worlds followed by four gas giants. In the burgeoning number of other planetary systems we now know of, it's far more common to see a mixed line-up with gas giants that have migrated inwards to mingle with their rocky cousins. Why are we so different? One proposal is that Jupiter may have barrelled inwards before retreating to its current position.

Another theory says there was no water on the young Earth, in which case it was probably delivered later on by collisions with other bodies like asteroids or comets. Jupiter's gravity might have helped slingshot these bodies towards Earth – depending on where it was.

Chondrites and other meteorites mainly come from the asteroid belt, a repository of material from the solar system's early days

Rarest rocks

Even though there are lots of space rocks out there, they're rare on Earth

1.9m

ASTEROIDS IN THE ASTEROID BELT

larger than 1 kilometre across

13,095

NEAR EARTH OBJECTS

that are more than 30 metres across

51,000

SPACE ROCKS

weighing more than 1 kilogram hit Earth's atmosphere every year

4590

METEORITES

weighing more than 1 kilogram reach the ground every year

30,000

METEORITES

have been found by searching at random

1149

METEORITES

have been found by seeing a meteor fall

that sits between the orbits of Mars and Jupiter. Examining the chemical composition of any fragments that come our way can tell us where they ultimately came from. We could then run computer simulations exploring how the gas giants might have moved around in the early solar system, and how this could have kicked asteroids from where they were born into the orbits they ended up in.

In particular, the farther out the asteroid material was when it formed from the cloud of dust and gas surrounding the early sun, the more laden it would have been with deuterium, a heavy isotope of hydrogen that has a neutron in its atomic nucleus. So analyse the ratio of hydrogen to deuterium in meteorites and you can tell roughly where their parent rock was born.

A neat idea – but there are a few stumbling blocks. First, there's what keeps people like Killgore in business: the sheer rarity of meteorite finds on Earth. Second, there's the fact we have a biased sample, consisting only of the sorts of rocks that cross Earth's orbit. Finally, although analysing isotopes can point to where a rock originally formed, it doesn't reveal its most recent orbit, limiting the accuracy of any simulations.

Dante Lauretta of the University of Arizona is pursuing one obvious solution: get space rocks of known providence by grabbing them where they lie. He leads NASA's OSIRIS-REx mission, which plans to take samples from a 500-metre-diameter asteroid called Bennu in 2022.

But such missions are expensive, so we need better ways to bulk up the harvest of space shrapnel. One well-worn method is to head to Antarctica. Meteorites that fall on the continent's high interior get buried in the ice and carried towards the coast as the ice slowly slips towards the sea. But then they meet the rising underlying terrain of the Transantarctic

Mountains, where they can be forced upwards to the surface. For the past 40 years, the US government has sponsored hunts along the base of the mountain range as part of the Antarctic Search for Meteorites programme. Researchers combing the ice on snowmobiles have now found more than 21,000 objects, including meteorites from Mars and the moon.

Conel Alexander of the Carnegie Institution of Washington and his colleagues have found another source to harvest in Antarctica: space dust. This is a mixture of material, some of it shed from comets, some of it that has just never coalesced into larger rocks and has been hanging around in space since the early days of the solar system.

There's no hope of distinguishing this dust from the grains made on Earth – at least not in most places. "The air at the South Pole is so clean that there's very little terrestrial dust," Alexander says. "Most of the dust, hopefully, is from outer space." To sample it, the team recently installed a 6-metre-high "vacuum cleaner" with an inlet tube that sticks out like a trunk. Alexander expects that much of the dust has had a very different life from your average meteorite. His preliminary analysis suggest that some of it is very old, and along with the chondrules possibly represents the first solids formed in the solar system.

More samples from different sources help ease the first and second problems of meteorite hunting, but there is still the crucial third problem of pinpointing where the material came from. "All we can do," says Hill, "is analyse the specimens, group them together, and say that maybe these were formed in the same region or from the same object."

Getting around this last problem means knowing not just where a meteorite fell,

Australia's Nullabor plain isn't a hospitable place to search



SOURCES: NASA, METEORITICAL BULLETIN DATABASE, METEORITES AND THE EARLY SOLAR SYSTEM II, EDITED BY DANTE LAURETTA AND HARRY Y. MCSWEEN (UNIVERSITY OF ARIZONA PRESS)

Space rocks are easy to spot against the Antarctic ice



ANSWER/NASA

but how it fell, in the hope of reconstructing its trajectory and so its origin. But most meteorites are like Killgore's parking lot rock: a lucky find without context. Killgore sometimes locates meteorites in a more systematic way by tracing how they disrupted weather radar. But much of the search is by walking and looking, often using a metal detector or a walking stick with a magnet stuck on the end.

Ten years ago Phil Bland of Curtin University in Perth, Australia, started experimenting with a smarter way. He and his colleagues created the Desert Fireball Network, made up of 50 cameras spread across the desert of southern and western Australia. Each captures night-long exposures of the sky, including the luminous path of any meteors. A fireball's size reveals how large the rock is and whether it will burn up in the atmosphere. Bland's team measures its trajectory on multiple cameras and calculates where the meteorite landed. Then they drive into the desert.

Their first hunt began on the night of 20 July 2007 with a bright white fireball that had ripped through Earth's atmosphere at 13 kilometres per second. After months of work, the team traced the fall to a spot in the Nullarbor plain.

The following year, Bland and seven others set out in a truck and three cars carrying water supplies for two weeks of camping. "It wasn't great searching country," Bland says. But combing through clusters of short, hardy shrubs, and marking the area they covered on GPS devices, they found a meteorite on their first day, within 100 metres of their prediction. Bland later found another chunk, making 324 grams of rock by the end

EXOASTERIODS

What can we hope to know about asteroids in other solar systems? Nothing, you might say: surely they are far too tiny and distant.

Jay Farihi at University College London would disagree. He has been watching "exoasteroids" fall into stars called white dwarfs. They produce flashes of light that are particularly clear because white dwarfs shine so purely. "They act like a white sheet of paper," says Farihi.

Against that background he can detect the signatures of chemical elements. These reveal that the exoasteroids come in a variety of types. Some are largely iron, others a mixture of elements – just like the asteroids in our solar system.

That is a surprise: we thought the rich mix of asteroids in our cosmic neighbourhood was down to a very peculiar set of circumstances, in which the radioactive decay of the rare isotope aluminium-26 melted some early space rocks. Heavy iron sank to their cores, leaving a rocky outer crust, and collisions then broke those rocks apart.

We didn't expect aluminium-26 to be prevalent everywhere, so the fact that rocks have apparently melted and split in other solar systems is prompting a rethink.

"That appeals to a lot of scientists," says Farihi. "It's like, great: we're not special. Good."

of the trip. They christened their find the Bunburra Rockhole meteorite, after a nearby cave. "It was a very nice way to start," says Bland.

Since then they have recovered three more meteorites, convincingly better than similar camera networks in North America and Europe that cover areas rich in vegetation where the rocks are trickier to spot. "Most of them have only delivered one meteorite each over 10 years," Bland says.

His team now has a different problem: having estimated the locations of 15 further meteorites, they're struggling to recruit enough people who know what a meteorite looks like and are willing to sleep in the middle of nowhere for weeks to bring them in.

Crucially, trajectory mapping from the camera networks can point to where a meteorite came from. "You can get the entire orbital history of this rock," Bland says. That is the first step to a more detailed chemical map of the entire asteroid belt, and perhaps some answers as to what happened in the early solar system.

The Bunburra rock itself demonstrates some of this promise. It turns out to be a type called a eucrite, which lacks the internal chondrules of a chondrite. But it's an unusual

"Meteorite hunters often use just a walking stick with a magnet stuck on the end"

sort, originating not from the asteroid belt, but from an orbit almost entirely contained within Earth's.

All this, along with what we're learning about other planetary systems (see "Exoasteroids", left), is revealing ever more secrets buried in space rocks. But nothing will replace old-fashioned prospecting, says Lauretta, largely because camera networks like Bland's cover only a small fraction of land. Places like the Sahara and Atacama deserts will continue to be the territory of collectors like Killgore.

Back at the meteorite booth in Tucson, the man in the fedora decides not to buy the rock. Killgore says that no longer bothers him much. Since he started sharing his samples with scientists, he has come to appreciate his wares for the information they contain. It's just one more reason to keep collecting these postcards from the solar system. ■

Sophia Chen is a science writer based in Tucson, Arizona

Parkinson's true passion

His article on the “shaking palsy” 200 years ago immortalised his name, but in his day James Parkinson was famous for a very different reason, says **Cherry Lewis**

JAMES PARKINSON was many things: apothecary, surgeon, scientist, political radical, closet heretic. Today, most people know his name solely through the disease that immortalised it. A shame, because medicine was just one of Parkinson’s passions: he was described in his lifetime as “not merely the best but almost the only fossilist of his day”. And fossils, back then, were troublemakers. As a result, Parkinson struggled to reconcile the widely accepted biblical story of creation with the conflicting story being revealed to him by fossils. Decades before Darwin rocked the scientific world with his theory of evolution, the conflict gave Parkinson a headache.

Not literally, thankfully, because you didn’t want to be unwell in 18th-century London. Parkinson was born in 1755 – a time when epidemics festered in dirty, overcrowded tenements, one in two children died in infancy, bleeding was considered a cure-all, and medications containing mercury and other toxic substances did more harm than good. To top it all, there were no anaesthetics if you were unfortunate enough to need surgery.

It was against this backdrop that the young Parkinson was apprenticed to his father for seven years, learning the art and mystery of an apothecary. His ambition, though, was to become a surgeon, so when his father died in 1784, leaving him to manage the practice single-handedly, Parkinson attended evening classes given by the legendary surgeon John Hunter. Above the operating theatre where Hunter taught was a museum housing his spectacular natural history collection. There, a carefully ordered series of skulls, “from the most imperfect of the animal, to the most perfect of the human species”, testified that Hunter was thinking about evolutionary

progression more than half a century before Darwin. But when Parkinson visited, it was another display that inspired him: Hunter’s collection of 3000 fossils. From that moment, Parkinson began collecting fossils himself, a passion that would come to dominate his life.

He began by looking for them in the gravel pits around London, but soon moved on to bidding for fossils at auctions, and buying and swapping them with dealers and collectors. Geology was an embryonic science and little had been written on fossils, so as Parkinson’s collection grew he found it hard to identify and classify many of his specimens. For example, while many fossil seashells were almost identical to their modern-day counterparts,

“The extinction argument implied such a flaw in God’s plan as to border on heresy”

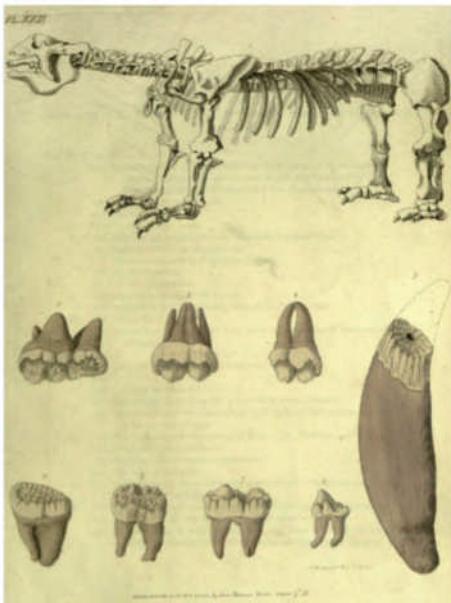
other fossils like that of *Megatherium* – an elephant-sized ground sloth (top right) – had no modern analogues. More worryingly, some local fossils resembled exotic species today found only in the tropics. When was it, Parkinson asked, that elephants and hyenas had “lived together in [Britain], were shaded by forests of palms, and took shelter in caverns along with bears as large as our horses?” Such discoveries were creating one conundrum after another, so Parkinson decided to write an account of these wondrous objects himself.

The first volume of *Organic Remains of a Former World* was published in 1804. The second and third followed in 1808 and 1811. Over those years, the collector transmogrified into a scientist, now diligently examining and analysing every fragment for the information



it could provide. Were the ubiquitous fossilised crinoids (above), for example, plants or animals? It was Parkinson who revealed that their fronds were tentacles and not roots. Each description was accompanied by exquisite illustrations, mostly drawn by him and hand coloured by his daughter Emma.

But there was a complication. In Parkinson’s day, religion lay at the heart of most people’s



Fossilised crinoids (left), and a *Megatherium* and bear teeth (above)

however repugnant to popular opinion or prejudice".

Much hinged on whether it could be proved that humans existed before Noah's flood, confirming the biblical account of creation. Evidence for the flood was seemingly demonstrated by fossils found on the tops of some mountains, and much of northern Europe being covered in sediments that had evidently been transported hundreds of miles. How else could these have moved such distances? Today we know these sediments are the result of ice ages, which were then not known about. Since animal fossils were found in these sediments then surely, Parkinson argued, fossilised humans and "their various utensils and articles of furniture must necessarily have been frequently discovered" too. But there was scant evidence of humans in Britain's fossil record, so Parkinson boldly declared, "We are without a proof of the existence of any human beings at the time of the deluge." He even went as far as accusing theologian William Buckland, the University of Oxford's first reader of geology, of "misdirecting the exertions of science" because Buckland would not agree. In an angry letter, he explained to Buckland that the biblical account of the flood should be attributed to Moses's "uninformed judgement, embracing the adopted tradition of that day".

When it came to the question of extinction, Parkinson realised that "many genera and

species... which existed before the flood, are now entirely lost". But extinction implied such a flaw in God's architecture of the universe that to argue that it occurred bordered on heresy. Nevertheless, wrote Parkinson, "the facts are indubitable [despite the] impropriety of such modes of reasoning". Furthermore, how did new species arrive on the planet? Parkinson must have been aware of the ongoing debate around the transmutation of one species into another, but he doesn't discuss it in his books.

In any case, *Organic Remains* became incredibly popular and made Parkinson internationally famous, with many fossils being named in his honour. Fossils, he insisted, told us about the formation of Earth in a way nothing else could, and history has proved him correct.

Fickle history

But history is fickle, and so Parkinson is better known today for something else entirely. Next month, it will be 200 years since Parkinson, then in his early 60s, published "An essay on the shaking palsy". The result of years spent observing patients, it was the first time the disease was recognised as a distinct medical condition. The essay described in remarkable detail the varied symptoms still used to diagnose Parkinson's disease today. Mortified at being unable to offer a cure for it, he only hoped that physicians of the future would "point out the means of relieving a tedious and most distressing malady". While the essay was favourably reviewed in the medical press, it was not recognised at the time as the classic it turned out to be: it was 55 years before the disease was first named in his memory.

In 1823, a year before his death, Parkinson was awarded the Royal College of Surgeons' first Gold Medal. The college had established the award for "distinguished labours, researches and discoveries" in 1802. It took them 21 years to find anyone of sufficient calibre to be its first recipient. However, the college didn't award it for Parkinson's many medical publications, but for his "splendid Work on Organic Remains".

So while Parkinson would no doubt have been proud to know that a disease now bears his name, surely it is his outstanding contribution to palaeontology – "my favourite science", as he called it – for which he would rather we remembered him today. ■

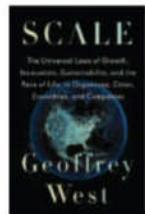
understanding of the world: Earth was 6000 years old and had been created in six days, and God had once sent a great flood to kill all humans except Noah and his family. Parkinson was nervous about offending the religious sensibilities of his audience, as Darwin would be decades later. But despite his trepidations, he determined to face this challenge and "conceal no conclusion,

Cherry Lewis is an honorary research fellow at the University of Bristol's school of earth sciences, UK, and author of *The Enlightened Mr. Parkinson* (Icon)

The power of us

Runaway demand is fuelling a nightmare only transformative tech can fix. Is there another way out, asks **Fred Pearce**

Scale: The universal laws of growth, innovation, sustainability, and the pace of life in organisms, cities, economies, and companies
by Geoffrey West,
Penguin Random House/Orion



AFTER overdosing on chaos, science's big thinkers seem determined to put the genie back in the bottle. Now they are finding unexpected order everywhere, from the cosmos to cellular biology to the whiz-bang complexity of human society. How much it helps us negotiate the miasma of cause and effect in the real world is moot, but Geoffrey West makes a heroic effort to do just that in *Scale*.

A British-born particle physicist, West came to public attention a couple of decades ago when he introduced power laws to biology. He showed how, despite hundreds of millions of years of evolution that ought to have maximised complexity, all life seemed spookily similar. The "most complex and diverse phenomenon in the universe" obeyed a series of simple rules predictable from network theory.

Draw a graph plotting the metabolic rate of any animal against its body mass, and everything from a mouse to an elephant falls neatly on a straight line. The bigger the body, the slower the metabolism. Even odder, whatever their weight and however long their typical lifespan, every mammal can

expect to expire after the same number of heartbeats (about 1.5 billion, if you're counting).

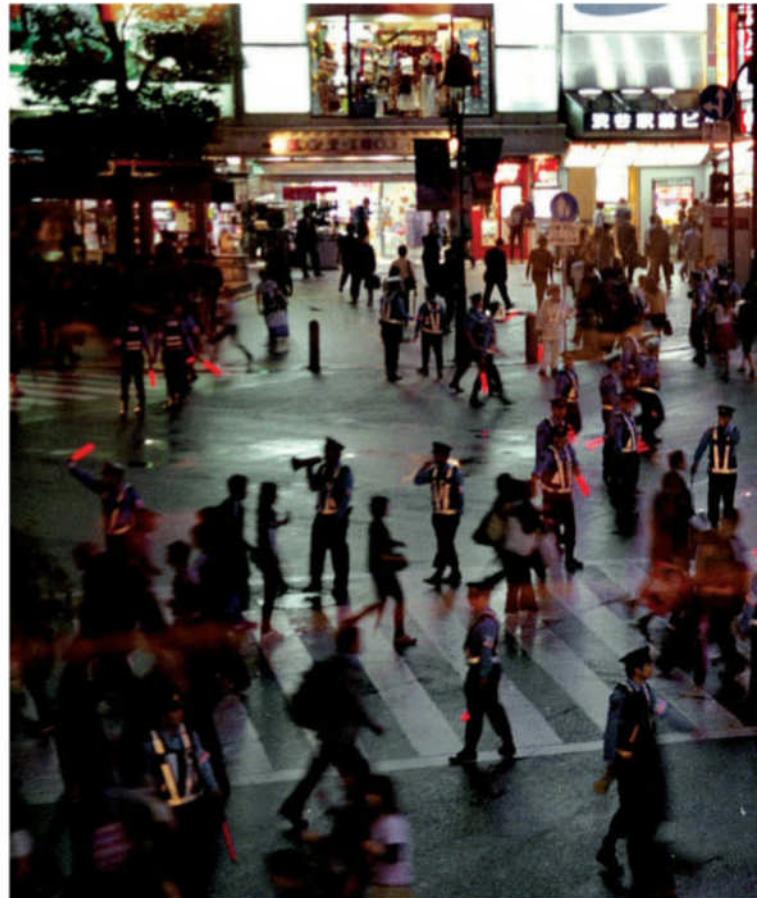
Clever. So what next? Cities, obviously: the hearts and minds of our modern industrial world, they are even more complex than life forms.

West hit the headlines again when he argued that cities, too, operate according to predictable power laws. They are very like organisms, except they don't die. They don't even

"West argues that cities, too, operate according to power laws. They are like organisms, but don't die"

mature; they keep on growing – like a cancer, in fact.

And while in the natural world, it is small creatures that live in the fast lane, metabolically speaking, in cities the opposite is true. Urban metabolic rates, as it were, increase with size, taking humanity with them (*Homo urbanus*... maybe that makes us



the cancer). The bigger a city gets, the more its inhabitants get up to: busier bees in a bigger hive. Per capita, they generate more GDP, commit more crimes, patent more innovations and spread more disease. People even walk faster in big cities. Big is bountiful, beastly and above all rapid.

West grew up in rural Somerset,

the son of a dress-maker and a professional gambler. Excelling in mathematics, he made his way eventually to the Los Alamos National Laboratory, New Mexico. His startling discoveries followed a mid-career move to the nearby Santa Fe Institute, an interdisciplinary think tank in a very small city whose intellectual productivity rather belies West's urban power law.

The first part of this book is a brilliant exposition of those intellectual forays into biology and urban metabolisms. The second part digs in deeper, by asking what all this surprising order amid complexity means for humanity and the planet in the Anthropocene. Do West's scale laws doom us, or might there be a path to a "sustainable future"?

Here, I think, he begins to come unstuck by putting his own power-law spin on some rather



CHRIS STEELE-PERIN/MAGNUM PHOTOS



GEORGI PINKHASOV/MAGNUM PHOTOS

old-fashioned neo-Malthusian catastrophism – the stark prediction of mass starvation as the world's propensity to over-breed outpaces food production.

In the late 18th century, the Victorian country vicar Robert Malthus had defined our demographic predicament by saying that human numbers rise exponentially (2, 4, 8, 16...) over generations, while the resources available to feed us can only rise arithmetically (2, 3, 4, 5...), however hard we try. "The power of population," Malthus concluded, "is infinitely greater than the power in the Earth to produce subsistence for man."

It is worse than that, says West. Our post-industrial urban world zooms ahead not exponentially, but "super-exponentially". The metabolism of a human body requires an input in food calories at a rate equivalent to about

Our cities (top) and economies (left) might not be so unsustainable

90 watts, whereas the lifestyle of the average American requires a staggering 11,000 watts.

Delivering this largesse while sustaining a world population approaching 10 times that in Malthus's day has only been possible because of something Malthus never factored in: technological advance. Whether steam power or the green revolution in agriculture or digital information technology, it has transformed Earth's capacity to sustain us. So far, so lucky.

But because we are pushing the bounds of the planet's resources with faster-than-exponential growth, we have to come up with new transformative technologies ever more quickly, says West. "Not only does the pace of life inevitably quicken, but we must innovate at

a faster and faster rate." We are not, he says, just on a treadmill; we have to keep jumping off one treadmill on to an even faster one. This can't go on.

I headed breathlessly for the final pages – reading ever faster, as seemed appropriate – to see how he would resolve the cliffhanger. The final chapter offers the "vision of a grand unified theory of sustainability". It asks the right question: "Can we return to an analog of a more 'ecological' phase from which we evolved... a no-growth, stable configuration?" In other words, can cities, as the great centres of "exponential innovation", deliver the eco-sustainability changes that are our only way out? Can cities become not the problem but the solution?

What is a shame is that he only asks this question on the last page of the last chapter. And answer there is none. Instead, this otherwise eye-opening book peters out in a way very unlike the world he envisages. Let me suggest one denouement. I think the missing element is already with us, hiding in plain sight: demography.

West lists population growth as central to his "successive accelerating cycles", and takes as a given the future exponential growth that Malthus warned about. But this is wrong. For the population "bomb" was a temporary phase caused by the arrival of transformative medical technologies that, for the first

"We are not just on a treadmill; we have to keep jumping off one treadmill on to an even faster one"

time in human history, allowed most kids to grow up and have kids of their own. World population doubled in a generation, then doubled again.

But that exponential phase has passed. People are not following Malthus's lemming-like demographic model. Instead they are reducing family sizes to reflect

the new survival rates. The world fertility rate has halved in half a century to 2.4 children per woman. That is approaching stable replacement levels. We have already reached "peak child", and peak population will follow.

Even consumption may have its limits. Many Western economies have reached "peak stuff". We no longer consume more and more basic resources each year. We pollute less, too. Yet nowhere does West acknowledge these decidedly non-exponential megatrends. Why? Because, despite his book's prescient title, I suspect that he is not looking at them on the right scale. He is using a microscope to peer at the 20th century when what he needs is a pair of binoculars to scan the historical horizons.

Stable salvation

In the past, our species has seen long periods of fairly stable population followed by bursts of growth when technologies – whether tool-making, agriculture or industrialisation – transformed the planet's capacity to support us. This suggests an ability to manage our numbers in ways beyond Malthus's imagining, or, it appears, West's. We seem to be returning again to demographic stability today. Could that be our salvation?

Perhaps West is right to argue that industrialisation and urbanisation have changed everything, putting us on a super-exponential trajectory that we cannot hope to escape this side of apocalypse.

Or perhaps the defusing of the population bomb and our changing sensibilities about the idea of unending economic growth will alter societies in ways that transcend his power laws. I'd love to know what he thinks. It would have made a fascinating final chapter. ■

Fred Pearce is a consultant for *New Scientist*

Native justice

Finders need not always be keepers, finds **Bob Holmes**

Plundered Skulls and Stolen Spirits: Inside the fight to reclaim Native America's culture by Chip Colwell, University of Chicago Press

 IN 1971, a highway construction crew in the US state of Iowa accidentally dug up a cemetery. The remains of 26 white people were laid back to rest in another cemetery. The remains of two Native Americans were put into a box for archaeologists to study.

For more than a century, Native American remains and artefacts, including sacred objects, were regarded by archaeologists and anthropologists as research material. But that has changed in the past five decades; many objects have been returned to their tribes.

In *Plundered Skulls and Stolen Spirits* Chip Colwell, an anthropologist and curator at the Denver Museum of Nature & Science in Colorado, ably and sensitively tells the often conflict-ridden story of how and why museums in the US relinquished their hold over this material. Recalling his own involvement, Colwell writes: "My job was to both protect and return the collections I oversaw."

Consider the carved wooden figures called Ahayu:da, usually translated as "War Gods". For the Zuni of New Mexico, these are living beings, created to watch over the tribe. To them, keeping the Ahayu:da on a museum shelf is just as inappropriate

as keeping their children there.

Repatriations of these objects began in 1978: Colwell describes the Zuni leaders' emotionally charged visits to the Ahayu:da imprisoned in his museum, and relates the history of the objects' purchase – or theft – by white dealers and anthropologists. And he follows the Zuni in their years-long struggle to have them returned. (Even in the 2000s, a few were still turning up in dusty corners.) The Ahayu:da now reside in a secure, open-air shrine where they will eventually decay to dust. That's not easy for a curator to accept.

Colwell uses the Ahayu:da and three other examples of repatriations from the Denver collection to explain the complex legal processes that have changed

the way museums approach their collections: a Cheyenne scalp from a 19th-century massacre by the US cavalry; a ceremonial robe, the symbol of clan authority for the Tlingit of the Alaskan coast; and a large collection of human remains that cannot be definitively assigned to any particular tribe.

Behind all these stories is a tension between the rights-based argument for repatriation and the scientific impulse that wants these objects to remain in a museum. Sometimes, as with some Tlingit regalia, the objects were originally sold by clan

"The Zuni's Ahayu:da will eventually decay to dust. That's not easy for a curator to accept"

members faced with a desperate need for cash. On other occasions they were simply appropriated by white conquerors. And sometimes, especially with human remains, the Native American tribes approach repatriation reluctantly, for fear of angering the spirits of the dead.

Colwell finds himself squarely in the middle of each quandary: a practising anthropologist who works alongside Native Americans every day and is sensitive to their cultural dynamics. Colwell's account favours the Native American perspective – a sensible approach for a book aimed at scientifically literate readers who may lean the other way. Readers will come away with a deeper appreciation of Native American cultural imperatives and the complexity of the situation.

Still, the book might have been stronger had it looked more deeply at the scientific side of the coin. What do we gain by studying human remains, especially those that cannot be assigned to a particular Native American group? How often are museum artefacts used in research, as opposed to being merely warehoused?

Both sides have benefited from this prolonged tussle over repatriation. The tribes have regained many of their most precious objects. And the museums have gained a much deeper appreciation of Native American culture and perspective – and, in many cases, can still carry out their research, albeit only with tribal permission. ■

Embarrassment of riches: part of a 19th-century private collection



GEORGE CUNEO'S DISPLAY OF INDIAN CURIOS AT HIS DENVER HOME COURTESY OF NATIVE ART DEPARTMENT, DENVER MUSEUM

Bob Holmes is a consultant for *New Scientist*

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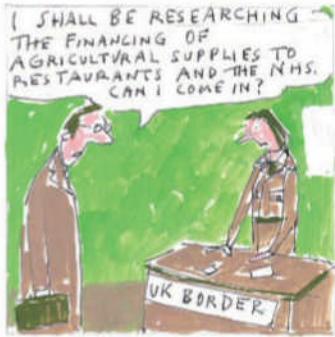
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EDITOR'S PICK

The more likely consequences of Brexit?

From Mike Elliott,
Hull, East Riding of Yorkshire, UK
Chris Leigh of the pro-Brexit Scientists for Britain group forgets to mention that the UK currently pays €1 billion per year into the European Research Area and programmes such as Horizon 2020, but receives €1.6 billion per year because of our leading role in writing

and preparing grant proposals (1 April, p 24). The UK government hasn't offered to underwrite that difference. No wonder universities and other research establishments are worried.

From Frank Hollis,
Steyning, West Sussex, UK

Leigh says he supports Brexit but that scientists and "genuine" students should not be subject to immigration controls that will be part of us leaving the single market. The same argument is used by the National Health Service, the agricultural industry, hoteliers and restaurateurs, the financial sector and others that have come to rely on EU immigrants to keep them running. All believe that theirs is a special case.

This flies in the face of a main plank of the "leave" campaign – that it was the only way immigration could be cut.

But why have we never filled up a brain?

From Carl Zetie,
Waterford, Virginia, US

We don't know the limit on how much an individual brain can know, writes Sean O'Neill, because "we have never filled one up" (1 April, p 39). That statement should set off alarms with evolutionary biologists.

The human brain is a very expensive luxury: it makes childbirth painful and dangerous, ties us to an extended vulnerable childhood and consumes as much as 20 per cent of our total energy expenditure. Evolution wouldn't preserve such a burden without some payback.

So what is all that capacity for if it can't be filled with knowledge? Might the brain have developed for another purpose? It is intriguing to note that the volume

of the human brain appears to have been shrinking for the past 28,000 years. Have we been shedding brain that is no longer needed now its purpose has turned to knowledge?

Of course, given that the article appeared on 1 April, we could also reconsider Aristotle's belief that the original purpose of the brain was to cool the blood...

From Paul Bowden,
Nottingham, UK

I was disappointed that you didn't answer the question of how much one person can know. I have been musing upon this while building a digital knowledge base.

We each know many concepts – such as person, house, atoms – and very many facts that connect them, such as that a person lives in a house and a house is made from atoms. Has anyone tried to estimate how many facts one

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"They also spend a lot of time wondering why humans can't work out how to unlock boxes"

Peanut empathises with chimps, bonobos and orangutans in theory of mind experiments (8 April, p 10)

person could know, perhaps based upon surveys of what percentage of encyclopaedia concepts individuals know?

Asking the right question may lead to wisdom

From Richard Woods,

Lyng, Norfolk, UK

Your fascinating articles on knowledge referred to the prevailing problem of post-truth, fake news and antipathy towards "experts" (1 April, p 5 and p 36). The most frightening current effect is climate change denial.

We can all think of simplistic minds that deny the possibility of climate change because, in their world view, it is an inconvenient possible truth. They promote that position by decrying experts as not knowing facts, only guessing. They accuse anyone promoting the prediction of peddling "fake

news". None of these steps can be easily countered by science since even the best climatologist can say only that "all the evidence we have suggests..."

But there is a question that can be effective and demonstrates that it is indeed knowledge that is the key. What does Donald Trump, for example, want on his tombstone: "The man who saved the world" or "The man who denied his great-grandchildren a future"? The point of knowledge and experts is that taking notice of what they say is wiser than ignoring or denying them.

Good hydrations on our farm and antioxidants

From Caroline Jones,
Karamea, New Zealand

Your article on drinks states that all mammals make milk, "but humans are the only ones to drink

it beyond their early years" (11 March, p 32). Our cats sit and wait for us to finish our breakfast cereal so they can lick the bowl. Our dog goes into the milk shed after the cows have left to lap up the milk flushed from the machines. If an adult cow is in with the feeding calves, someone has to stand by the feeder and chase it away. Some adult cows will drink milk from other cows in the herd. I've even seen a cow drinking from her own udder.

From Tim Burnell,
Ipswich, Suffolk, UK

Your articles on hydration make repeated reference to the benefits of antioxidants. But you have in the past reported these as being debunked (24 August 2013, p 32).

The editor writes:

■ That earlier article was mainly about antioxidant supplements.

It seems pretty settled that these do no good. In food and drink, though, antioxidants have no ill effect and may even be beneficial.

This mammal may have echolocation too

From Michael Zehse,

London, UK

Gwydion Williams asks whether echolocation may once have been found in all animals (Letters, 25 March). There are reports that it's possible for humans to reacquire this skill – especially if they are visually impaired (11 April 2009, p 31).

The truth of the tragedy of the commons

From Peter Harper,

Corsham, Wiltshire, UK

Fred Pearce describes approaches to Garrett Hardin's "tragedy of ➤

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the commons" that can't see the wood for the trees (11 March, p 44). The general pattern of some actors pursuing their own interests to the detriment of the collective interest applies to nearly all environmental problems, including climate change, overfishing, deforestation and biodiversity loss.

These are widely recognised as entailing "market failures" but few, even among economists, believe that solutions lie in privatisation. Jointly agreed and enforced regulation is clearly necessary. A clear analysis of the conflicting interests of the actors is essential to effective policies.

*From Ben Haller,
Ithaca, New York, US*

Pearce describes a view that the lesson of the "tragedy of the commons" is that "the only way to prevent this tragedy was to turn common land into private property... privatising the planet is the key to conservation".

But in his article putting forward the idea, Hardin observed that the economist Adam Smith "contributed to a dominant

tendency of thought that has ever since interfered with positive action based on rational analysis, namely, the tendency to assume that decisions reached individually will, in fact, be the best decisions for an entire society." He notes that many "commons" don't work well as private property: "the air and waters surrounding us cannot readily be fenced, and so the tragedy of the commons as a cesspool must be prevented by different means."

In the end he recommends "mutual coercion, mutually agreed upon by the majority of the people affected" – in other words, the social contract of democratic government.

Tracking what foxes eat in Australia

From Jan Horton, West Launceston, Tasmania, Australia
Guy Cox discusses foxes' tastes in food and whether they are a threat to koalas (Letters, 11 March). An operation in Western Australia, foxbusters.com.au, keeps tabs on stomach contents of dead foxes. In 2015 the list, from 152 foxes, was

"Sheep carrion, spiders, racehorse goanna, canola, wheat, oats, mice, grasshoppers, unidentified bird, rabbits, parrots, wool, beetles, lizard, kangaroo, maggots, blowfly pupae, frog, chook, centipede, hair, sheep feedlot mix, sheep afterbirth, crickets, unidentified insect, earwigs, water beetles, figs, mulberries".

In 2016 it was very similar. But there are no koalas in Western Australia, so we don't yet have a conclusive answer.

Artificial intelligence and natural stupidity

*From Thom Shaw,
Perth, Western Australia*

Progress in artificial intelligence has depended on computational speed and increasing algorithmic complexity. Some classes or type of problem are acknowledged where an AI's inhuman speeds can prosper (for example, by Daniel Dennett, 11 February, p 42).

But the human consequences of real world AI haven't been addressed. Modelling "subjective experience" will mean going from the real world to analogue

measurements to digital models to logical outputs. But as any undergraduate studying computing discovers, problems arise from converting analogue measurements to digital values: there is always a "quantisation" error. And chaos theorists demonstrate how small changes have substantial effects on output from iterative computations. Multiple conversions would lead to multiple stages of quantisation and data compression. And as system complexity increases, system understanding decreases.

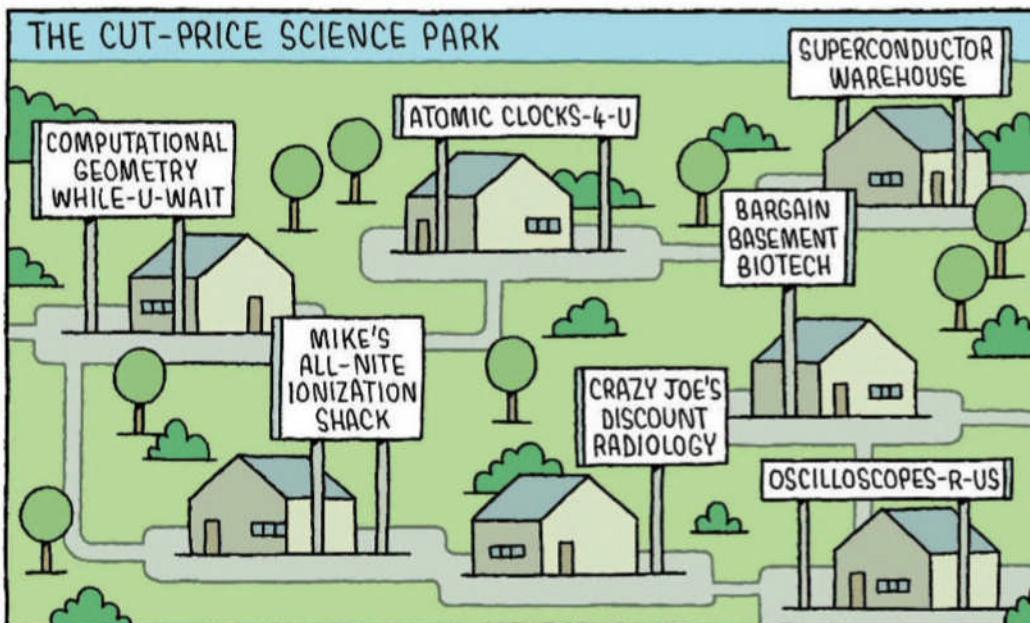
When personal loyalty or self-esteem bonds some people to the AI, what will become of those who distrust it? The real problems will arise in how humans react.

The emotion of life, the universe and everything

*From Joe Dellinger,
Houston, Texas, US*

Like Lisa Barrett I have felt "chiplessness", an emotion felt after overindulging on a bag of chips (11 March, p 40). She is onto something with her call to give names to such emotions of the modern era. Fortunately, there is already a reference guide naming hundreds of them: *The meaning of Liff* by Douglas Adams and John Lloyd. Is it coincidence that you highlight this concept on page 42 of your magazine?

TOM GAULD



For the record

■ Dig for victory: the interval between abandonment of one Channel Tunnel project in 1975 and the opening of the next in 1994 was of course 19 years (Old Scientist, 1 April).

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MAKE

Do try this at home



Trouble brewing? Not with a diligent Dunkbot

This marvellous machine to dip your teabags will have you steeped in praise

"I love a perfect brew," writes Emma Spencer, "but dunking a teabag over and over until it's done is a chore. Can you make teatime less tea-dious?"

I feel your pain, Emma. It takes about 50 dips for a cup of well-balanced green tea, and a mind-numbing 100 for the perfect Earl Grey. Leaving the bag in risks a tarry, bitter mess if you get distracted mid-brew, and a listless teabag doesn't allow the leaves to circulate optimally. Hence the traditional dunking – to improve circulation for better flavour. But could this chore be automated?

After a supply run to my local electronics shop, I got out my Arduino (a programmable microcontroller) and a servomotor. I wrote a loop of code that moved an arm attached to the motor through a certain number of degrees and back – hey presto, a dunker.

But I got bored of recoding the number of dunks each time I switched between jasmine and rooibos. One potentiometer and a bit more code later, and I had a control dial I could use to crank my caffeine up to 11.

But the robot still needed to be plugged into a laptop to function. What's the point of a dunking machine if I can't leave it to work on my tea while I watch Netflix in my bedroom?

After another trip to the shop, I had a 9-volt battery pack and Dunkbot could cut the cord to its mothership. But when I fired it up to reward myself with a cuppa, I realised that without the laptop screen to show the number of dunks planned, I'd lost fine control over my tea.

So I dipped back into the shop again for an LCD display. It was only when I came to attach it that I remembered my dad had borrowed my soldering iron. Pondering this hurdle over a glass of wine, inspiration struck and I cobbled together a replacement with a candle, darning needle and wine cork.

Finally, I could boast my masterpiece was a self-sufficient fixture on the work surface, providing the perfect brew every time with no fuss. Right up until my housemate caught me tying strings to regular teabags when the corner shop ran out of Twinings. **Hannah Joshua** ■

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PAUL McDOWELL



ONLY a few people can still be puzzling over the hotly discussed photo of a dress that was either white and gold, or blue and black, after it took the world by storm two years ago (bit.ly/ns-thedress). Luckily, those that are have published a paper on the matter in the *Journal of Vision*.

Pascal Wallisch, a neuroscientist at New York University, says that both interpretations stem from assumptions the brain makes about the source of light that illuminated the dress. An online survey of 13,000 people found that those who assumed the room was lit by daylight saw a white dress, while others saw a blue dress illuminated by yellow indoor lights. Furthermore, these assumptions correlated with sleeping patterns - with early risers more likely to assume the dress was in daylight, and see it as white.

For the record, the dress was most certainly blue. But an important lesson remains: if you want to see the world in a different light, try getting out more.

PREVIOUSLY, Feedback pondered the ways in which a cruise ship could sail from Southampton to

Iceland in four days while fitting in a quick jaunt to Sydney, Australia, on the way (25 March). "It is not inconceivable that the cruise you mention could take in Sydney," says Terence Hollingworth, "so long as it's Sydney, Nova Scotia."

Feedback adds that if you feel sorry for the copy editor on that travel brochure, spare a thought for Dutch teen Milan Schipper, who, after a booking mishap, last month found himself 17,000 kilometres from his intended destination, facing the snow-capped Canadian hills instead of the balmy Tasman Sea.

GOOD news for the not-so-clean living among us: nutritionist Jenna Barclay creates "healthy solutions for everyday cravings" and knows exactly the kind of craving adults suffer from most. Her Skinny Lemon drink offers "reverse osmosis carbonated water", lemon juice and stevia, allowing you to stay somewhat healthy as you mix it into your "vodka, tequila or gin".

Barclay says she created the mixers because she wanted "something low-calorie that didn't also contain

a bunch of artificial crap that would wreck my skin, body and health".

A good start, but the very pious among us could ditch the mixer altogether and drink their spirits neat for a really detoxed intoxication.

WITH an air of amiable resignation, Feedback must reset our "days without mentioning nominative determinism" chart to zero, to make an exception for a splendid example from Ed Fox.

"I wonder whether you are aware of the designers of the church organ in the parish church at Crediton, Devon," he writes. "In 1915 the newly appointed church organist, Mr Harold Organ, began work on plans for a new instrument." Sadly, Mr Organ was killed in action in 1917 before his plans could be finished, "so work on the organ was completed in memoriam by his successor, Mr Cyril Church."

"Lacking a sense of humour," says Ed, "the parish officials named the finished instrument 'The War Memorial Organ' instead of the much more fitting 'Organ-Church Church Organ'."

OUR mention of the journal *Internal Medicine Review* (not to be confused with the *Internal Medicine Journal*) has Ian Napier wondering whether "there are equivalent 'External Medicine' imprints?". Hmm, how often is there much to say, bar "put everything that's outside back inside, and quick"?

FINDING himself mired in an etymological fix, Brian Smith seeks assistance from Feedback readers. Autological words have or represent the property they describe, "such as short, English or polysyllabic", he says, "whilst heterological words are those which describe something they are not, such as monosyllabic or French". So far, so good.

But what about the word heterological itself? If it does not describe itself, it can be labelled heterological, but that would make it autological, says Brian.

But if autological, this particular word could not be allowed to describe itself, making it heterological. Can any lexicographers – or set theory mathematicians – help?

ALSO having trouble finding the right words is Ian Freney, who says "I wonder if you or your readers have a name for the phenomenon I call a retronym, of which emcee is one example. I've only noticed two others: okay, and kayo in the boxing columns."

Words derived from acronyms are ten a penny - see laser, radar, scuba, and snafu. But we can think of only one more that arises from attempts to sound out the constituent letters: jeep, from the US military's abbreviation for a "general purpose" vehicle. Can you suggest more?

MORE troublesome truncation: "My grandchildren's school recently sent an email to parents inviting them to a lecture on the adolescent brain," says Leo Kelly. The announcement didn't strike the right tone, however, as the resulting subject line read "Unravelling the teenage bra".



FURTHER to reports of the Kent Police Crime Support Unit (25 March), John Stolarski sends word that "over in Northamptonshire, the local authority have a flourishing 'Youth Offending Service'. However, I have yet to witness any council official offending any youths in public."

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.

Sleeping sickness

Being sedentary is one of the causes of deep vein thrombosis. So why don't we get DVTs in our sleep?

■ The DVT risks are different for sleeping in a bed versus sitting or sleeping in a chair; "sedentary" really means the latter.

When we walk around, muscle movement that compresses the veins is largely responsible for returning blood from the legs to the heart. It works – despite the hydrostatic uphill gradient in the body – because our veins have valves that stop blood flowing the wrong way.

We are usually horizontal in bed, so there is no uphill gradient and the small movements we make during sleep are sufficient to budge the blood heartwards. This would seem to be the obvious

"A significant proportion of people with DVTs are admitted from home, some with no risk factors"

reason why we don't get DVTs during our sleep – except it's probably wrong.

Studies on people in hospital, particularly surgical patients, have shown that many have "clinically inapparent" DVTs. That is why anticoagulants are often used routinely to prevent clot formation, since it is hard to predict which DVTs will cause problems.

I'm not aware of any equivalent study of people sleeping at home,

but if one were done it might well reveal that many do have small, clinically inapparent DVTs. Most would resolve uneventfully, but some could progress to become clinical DVTs or could travel to the lungs (causing a pulmonary embolism), or both. Certainly, a significant proportion of patients with DVTs are admitted from home, some with no risk factors as far as we can tell.

The problems of sedentary, chair-related DVTs – particularly ones arising during air travel – are more complex. Impaired return of blood through the veins can be caused by factors such as seats putting pressure on the calf, immobility and dehydration.

*Philip Welsby
Emeritus Consultant
Clinical Teaching Fellow in General
Medicine
University of Edinburgh, UK*

■ The most important cause of DVT is the occlusion, or blockage, of the main popliteal vein behind the knee. This occurs in something like 30 per cent of people when the knee is extended. Our research shows this is much more frequent in the sitting position, so is common in patients resting for long periods, especially if they put their legs up.

In flight, both sleeping with legs outstretched under the seat in front in economy class and sitting with legs extended in flat beds in first class can lead to DVTs. We refer to this as "popliteal vein compression syndrome".

Vascular researcher David

Huber of the Illawarra Health Service in Australia has shown that in the supine position in a standard operating theatre set-up, 40 per cent of patients have total popliteal vein closure.

Conversely, during normal sleep our knees are often flexed and we move frequently, and it is uncommon to sleep in a position that closes the vein.

"The most important cause of DVT is the blockage of the popliteal vein behind the knee"

These findings mean that most information on DVT needs to be reassessed. It's entirely possible that some people will develop small clots through vein obstruction during sleep, and that multiple small clots could affect the lungs, initially without any symptoms. DVTs certainly occur in the few individuals whose popliteal vein becomes blocked while standing.

*David M Grosser
Senior Consultant Vascular
Surgeon
Southern Queensland Specialist
Cardio-Vascular Centre
Gold Coast, Australia*

Driverless dynamics

In the UK's Lake District, tourists tend to drive slowly, leading to congestion on relatively long stretches of road. Would driverless cars make the flow dynamics better or worse? If any of the remaining drivers

were scared of going close to the speed limit, would this negate the use of the driverless element?

(Continued)

■ Earlier answers (4 March 2017) seem to have missed the possibilities that driverless cars offer at junctions, which are major delay points on roads. Driverless cars could communicate wirelessly to adjust speeds and allow cars turning right, for example, to do so with smaller gaps, reducing the queues that build up in these circumstances.

Traffic lights would be similarly unnecessary because vehicles could interleave with millimetres to spare, and adjust speed and priority to suit the conditions. The effect on congestion would be huge, although for a human sitting inside and looking out of such a vehicle it could be something of a terrifying ride of near-misses.

*Ian Davies
Lichfield, Staffordshire, UK*

This week's question

EATER'S DIGEST

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

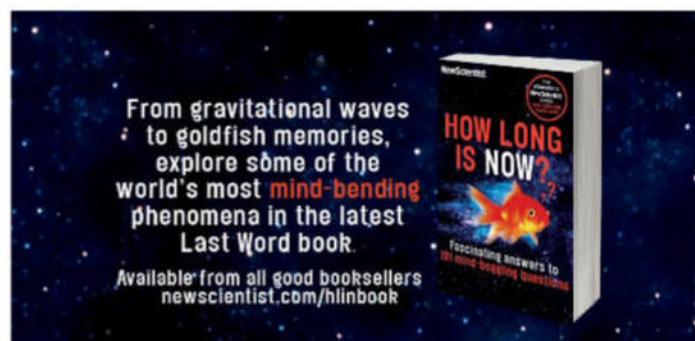
*Ted Woods
Sandton, South Africa*

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By Brigitte Lacombe



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