

New Scientist

WEEKLY 19 March 2022

**UKRAINE WAR
DISINFORMATION**

The fight against
online propaganda

SAVE OUR BUNNIES

Why it's time to stop thinking
about rabbits as pests

LIFE ON MARS?

Rover finds tantalising
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RIPPLES FROM THE BIG BANG

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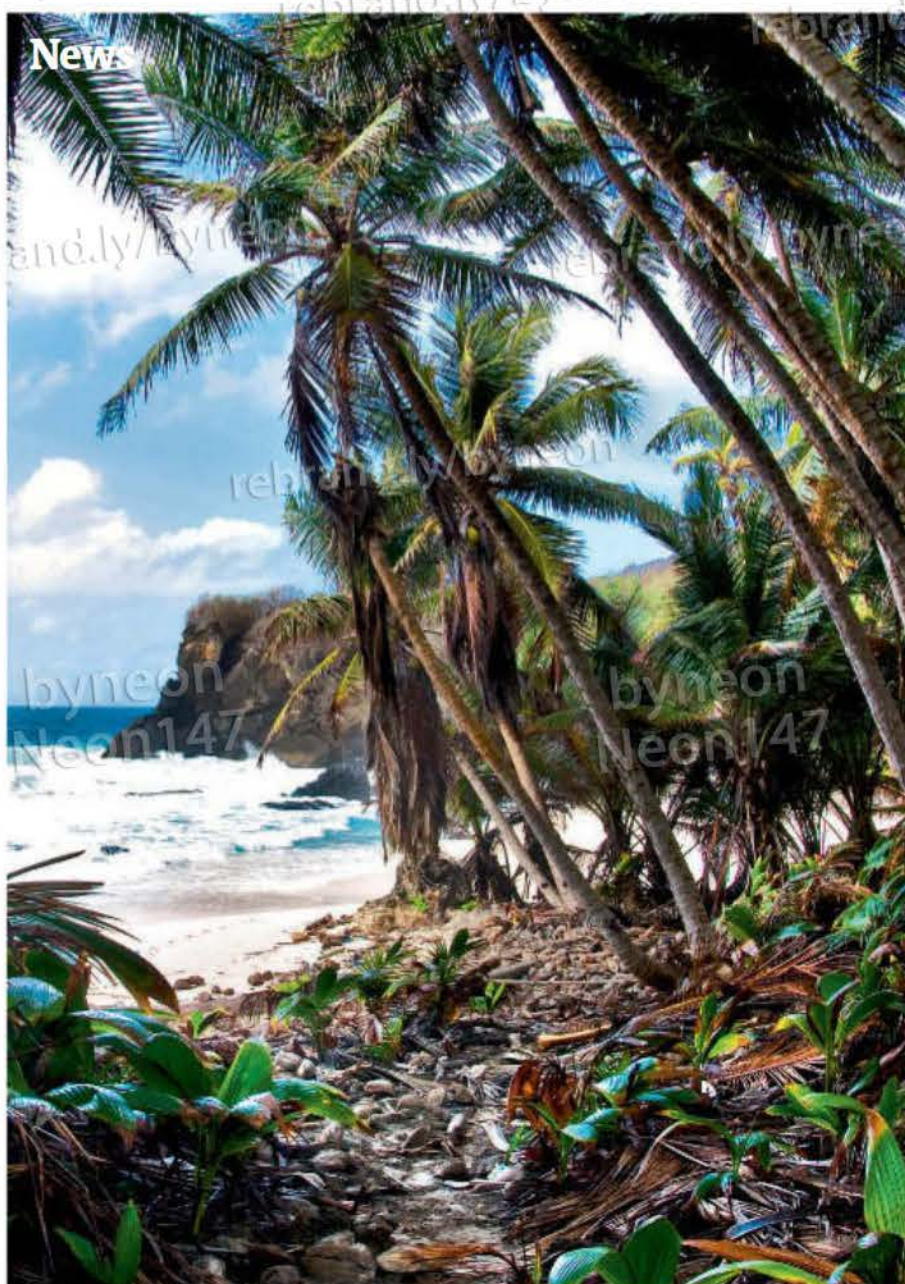
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Why do we love?

Anthropologist Anna Machin explains the why, how, who and what of human love. Using the latest evidence from neuroscience, genetics and more, she explains how love evolved as a form of biological bribery and how we now know that it is a crucial determining factor in how long and healthy our lives are. Join us for this virtual talk on 5 May at 6pm BST.

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Weekly

This week, the team discuss whether Russia's war in Ukraine will speed up the pivot to green energy. Plus we hear about a virgin birth that has taken place in a mouse through the power of CRISPR gene editing. They also cover fears that the Amazon may soon pass a tipping point that would turn the whole system into savannah, and the latest news from two rovers on Mars.

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Astronomer Royal Martin Rees reflects on his life in science



Going underground See the smashing science of CERN

Video

Martin Rees interview

In a career spanning more than half a century, Astronomer Royal Martin Rees has contributed to some of our most intriguing theories about the universe. *New Scientist's* executive editor Richard Webb sat down with him at his home in Cambridge, UK, to look back at his scientific life and discuss everything from black holes to billionaires.

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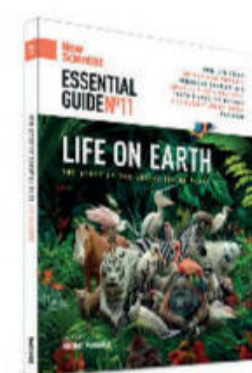
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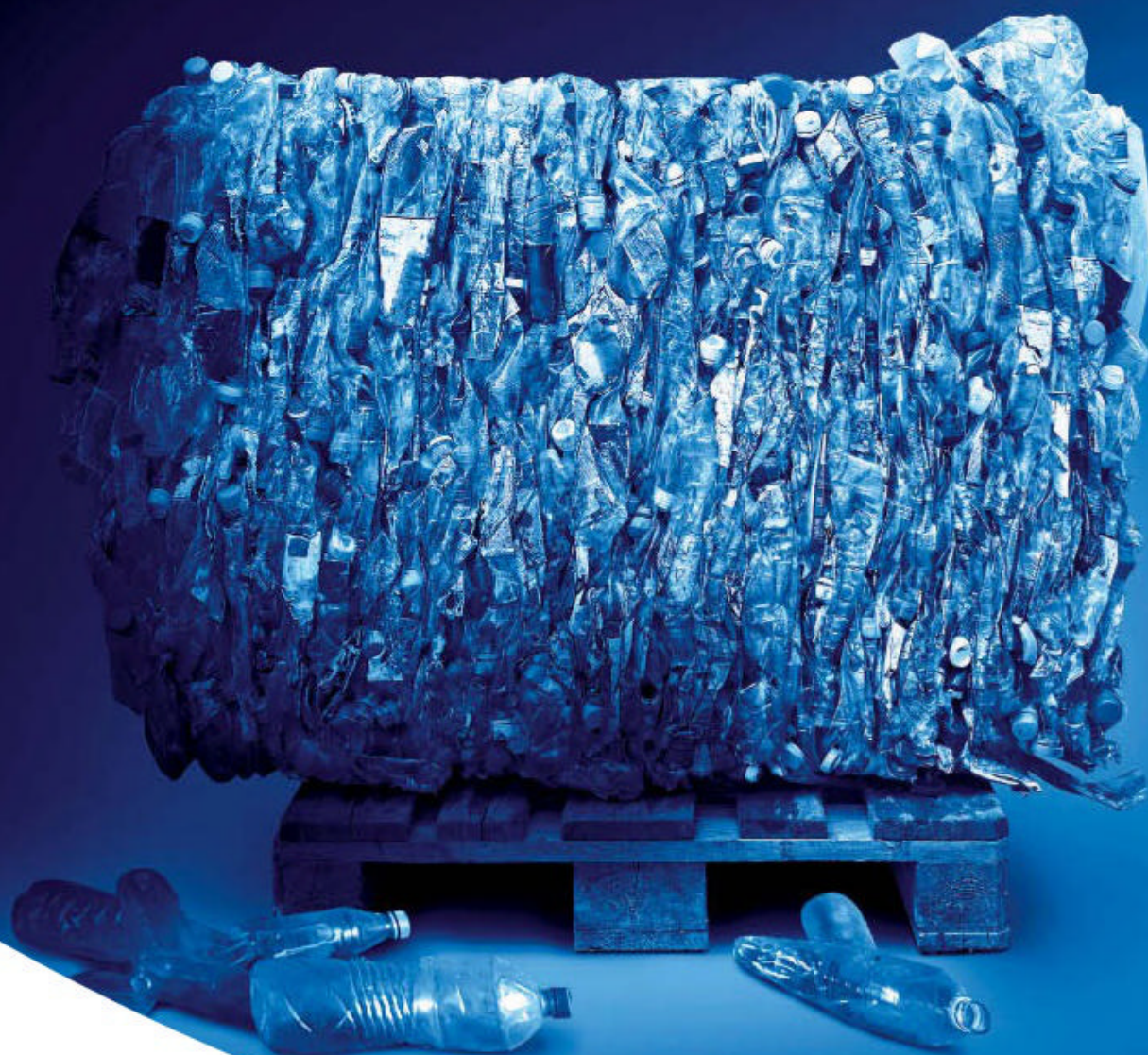
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Phoney war

The internet is a key battleground between truth and lies about the Ukraine invasion

THE ever-growing threats of cyberwarfare and online disinformation are now in the spotlight amid Russia's invasion of Ukraine. With the NATO military alliance reluctant to establish a no-fly zone over Ukraine, or engage in any other actions that could ignite a much wider conflict, the internet has inevitably become a key battleground.

But that isn't to say there haven't been surprises. On page 8, one expert expresses shock at the volume of online fake news about the war. Clearly, the invasion isn't the first war associated with this issue – researchers and think tanks have also monitored online propaganda in other recent conflicts, including in Syria and Libya – but it is characterised by a much larger wave of false information.

Another surprise has been the apparent

lack of an all-out cyberwar on Ukraine by Russia. As detailed on page 9, we are yet to see the kinds of crippling digital infrastructure attacks that had been predicted. In part, this is likely to be because, after years of such attacks, Ukraine has learned to defend itself.

"The invasion of Ukraine is characterised by a much larger wave of false information"

However, Russia may also now be hemmed in by the fact that the fate of its attempt to occupy Ukraine is tied up with the functioning of the country. Taking down communication lines or the power grid would make operations harder for Russian forces.

For similar reasons, a significant

radiation leak from one of Ukraine's captured nuclear power plants is unlikely (see page 7). Any leak caused by bombing or safety lapses would probably be carried by wind into Russia itself, making this an undesirable outcome for Russian forces.

Cyberwarfare and nuclear issues have been the subject of *New Scientist* reporting for decades. As this issue went to press, there was concern that two other threats we have followed closely over the years – biological and chemical weapons – might be deployed. In spreading disinformation that the US has been developing biological armaments in Ukraine, the fear is that Russia is setting the stage to use biological and chemical weapons. This troubling development is a reminder that, even in the age of the internet, war is still life or death for those in the firing line. ■

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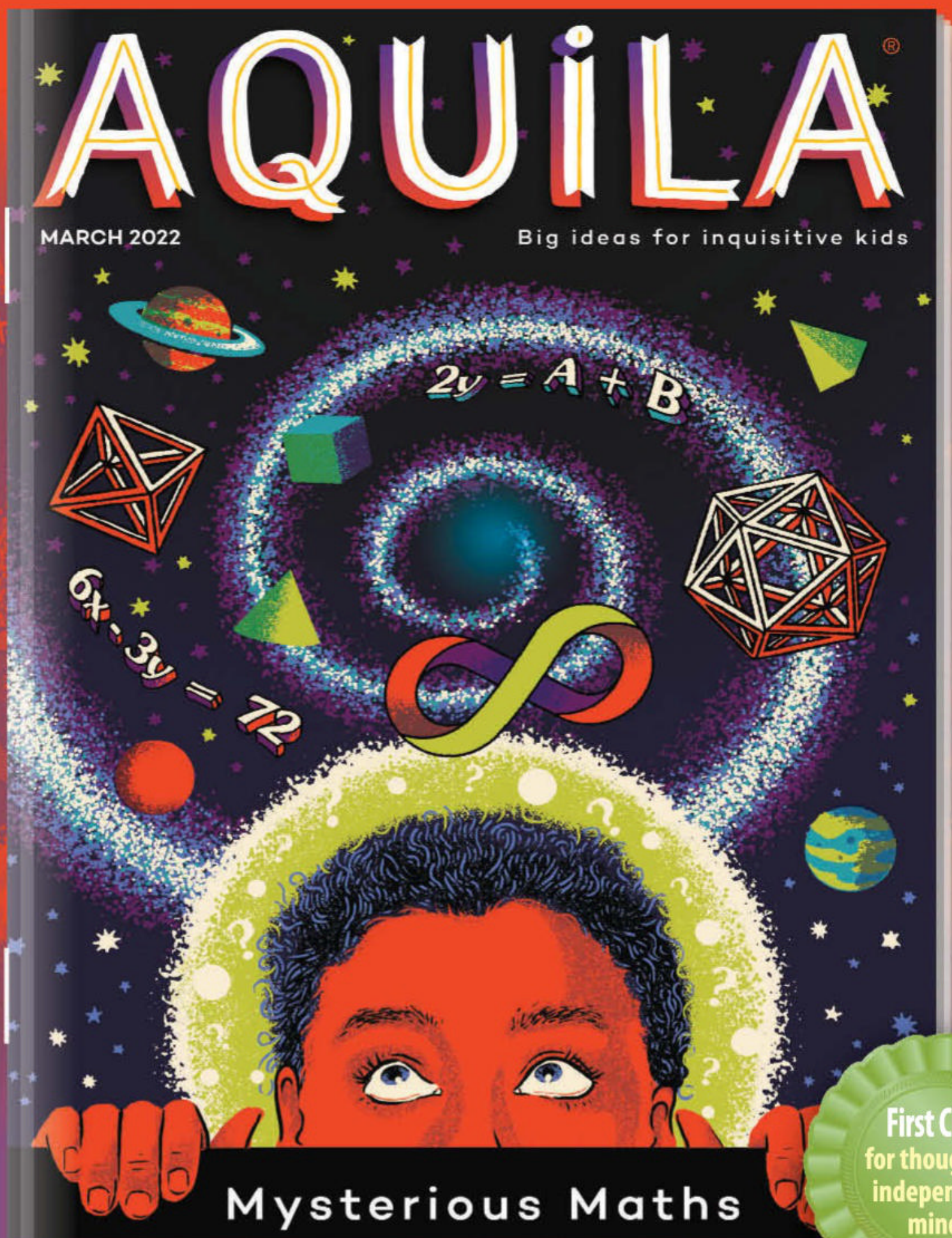
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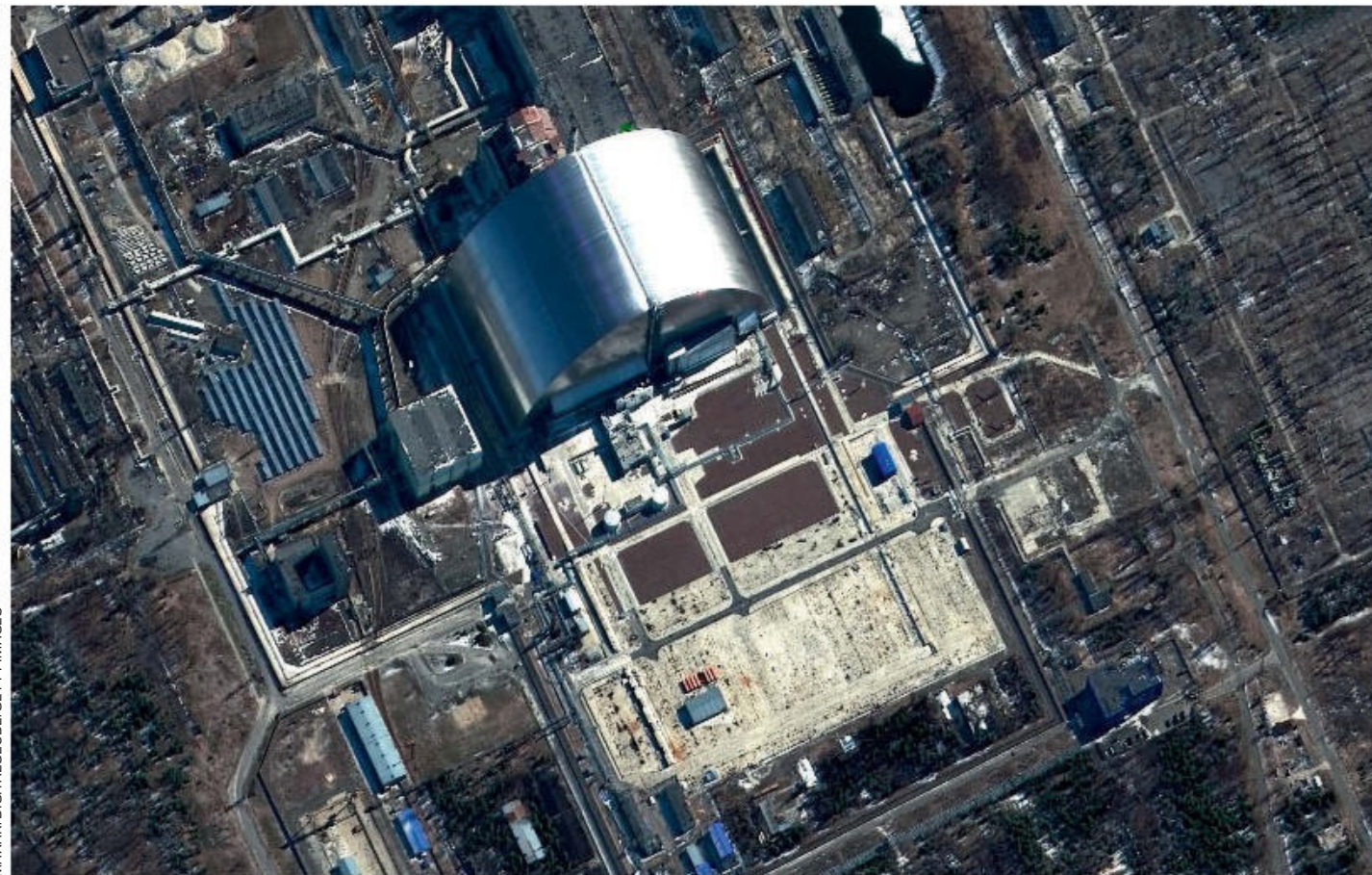
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Satellite photo of the Chernobyl site taken on 10 March

Nuclear safety

Ukraine's nuclear peril

Russian forces have threatened safety at nuclear power plants, but a serious incident is considered unlikely, says **Matthew Sparkes**

THREE weeks into Russia's invasion of Ukraine, concerns are growing about the safety of several nuclear sites across the country.

But the risk of a serious incident is thought to be low despite Russian troops having disrupted normal safety procedures. Simon Middleburgh at Bangor University in the UK says the circumstances are serious and Russia's actions in regard to nuclear sites in Ukraine have been "completely reckless", but that a significant radiation release is unlikely.

Ukraine is home to Chernobyl, the site of the infamous 1986 nuclear disaster, as well as four operational nuclear plants and a small reactor used for research.

The situation at Chernobyl has been tense since the first day of the invasion when Russian troops seized the site. Scientific monitors detected a local increase in

radiation levels, which was put down to Russian tanks disturbing contaminated dust. Since then, many radiation sensors around the plant have been offline and communications between plant workers and regulators have been sporadic at best.

Scientists who had been working at the site were unable to access their laboratories because Russian troops controlled the plant. One of these scientists, who asked to remain anonymous, told *New Scientist* on 14 March that those staff remaining on the site were doing their best to maintain safety.

The International Atomic Energy Agency (IAEA) has complained that workers have been held in poor conditions without the chance to be replaced by new shifts. A power cut at Chernobyl on 9 March meant

it was impossible to actively cool ponds containing nuclear waste.

Electrical lines were repaired and power was due to be restored, but the IAEA said on 15 March that the lines had again been damaged by the Russian military. It also warned in a statement on 13 March that staff were no longer carrying out

"If they don't get a handle on things then I could conceivably see a minor leak from Chernobyl"

repair and maintenance of safety equipment due to their "physical and psychological fatigue".

IAEA director general Rafael Mariano Grossi called on Russia to allow an international team access to ensure safety. So far Russian president Vladimir Putin hasn't accepted the request.

Ukraine also has four

operational nuclear power plants. These are of a newer design than Chernobyl, known as VVER, that is safer and easier to operate.

As *New Scientist* went to press, the Zaporizhzhia nuclear power plant, in the south of Ukraine, is the only one under Russian control, although forces are closing in on others. The IAEA reports that the Russian state nuclear company Rosatom now has 11 of its staff on site. On 12 March, the Ukrainian nuclear regulator informed the IAEA that it believed Russia was planning to take full and permanent control of the plant, which was later denied by Russia.

Middleburgh says it is irresponsible for Russian forces to interfere in the operation of these plants. "It's like throwing a friend your car keys and just expecting them to know where all the buttons are," he says. "As soon as you start disrupting their safe working practices and the ability for them to get raw materials and tools, that's when incidents start happening. Not necessarily radiological incidents, but people are going to start hurting themselves. Bad health and safety practices start creeping in."

While the VVER reactors have sophisticated safety systems that will be a crucial crutch during any period of upheaval, Middleburgh says the less predictable Chernobyl site is an outlier. "If they don't get a handle on things, then I could conceivably see a minor leak from Chernobyl. I don't think it would be major, but I can see things going south," he says.

Russia is strongly motivated to avoid disaster. Prevailing winds make it likely that any nuclear incident in Ukraine would carry the vast majority of the fallout east, towards Russia.

The IAEA and Ukraine's nuclear regulator didn't respond to a request for an interview. ■

Technology

How to fight disinformation

Researchers and fact checkers are debunking a huge amount of online propaganda and fake news about the Russian invasion of Ukraine, reports **Chris Stokel-Walker**

THE fog of war makes it difficult enough to know what is going on in Ukraine, but deliberate disinformation being shared by the Russian government and pro-Russia social media users is tinting our view of events.

“Tidal waves of disinformation accompany crisis,” says Joan Donovan at Harvard University. For example, the Russian Embassy in the UK claimed in social media posts on 10 March, without providing credible evidence, that a pregnant woman injured in the bombing of a maternity hospital in the Ukrainian city of Mariupol was an actor. Twitter and Facebook removed the posts for being disinformative.

TikTok has also struggled with disinformation, from a falsified video of a paratrooper parachuting into Ukraine in the early days of the invasion to Russian influencers all giving the same pro-Russia speech in videos.

Spot it at the source

“I’m a little shocked how much disinformation there is,” says Lukas Andriukaitis at the Atlantic Council, a US think tank. “It’s basically a fire hose of fake news.” The Atlantic Council has tracked disinformation for years through conflicts, including Syria, Libya, the Russian invasion of Crimea and the ongoing war in the Donbas region of Ukraine, but has never seen as much disinformation being spread wittingly and unwittingly as today.

However, non-governmental organisations, researchers, social media platforms and journalists are calling out disinformation about the Russian invasion of Ukraine as it spreads across the internet. They do so using a combination of high-tech tools, intuition and plenty of practice.



A protest in Dublin, Ireland, against the war in Ukraine

There are two basic strategies pursued by organisations that aim to seek out and debunk disinformation, says Al Baker at Logically, an AI-powered fact-checking organisation in the UK. “You can either try to find disinformation narratives which are emerging or disinformation narratives gaining traction on social media networks you would not normally expect them to have that sort of traction,” he says. The fake news is either spotted at the source or as it is beginning to gain ground in the mainstream.

Finding disinformation as it is created involves trawling through the murkier parts of the digital world. “There are elements of the internet where all people do is share things that are obviously false,” says Baker, pointing to groups on messaging app Telegram that are affiliated with QAnon, a conspiracy movement that has been described as a cult. “You don’t want to spend your time combing through those channels and debunking every single thing.”

Instead, a more targeted

approach is sensible, tackling disinformation if it breaks out of those niche communities into the mainstream. Social media analytics tools such as BuzzSumo, Meltwater and CrowdTangle – which is owned by Meta, the owner of Facebook and Instagram – can track the spread of posts as they are shared by an increasing number of people.

“If we see something suspicious, then we can take a deeper look,” says Andriukaitis. At the Digital

“I’m a little shocked at how much disinformation there is. It’s basically a fire hose of fake news”

Forensic Research Lab, part of the Atlantic Council, he and his colleagues scrape data from social media and create maps of potential disinformation spreaders – people known to share inauthentic content.

Inadvertent dissemination of incorrect information is as big a challenge as state-sponsored attempts to muddy the waters, he says. “So many people are

trying to do the right thing, but take information that hasn’t been verified and mislabel it, or share things that happened a while ago,” he says.

Debunking some claims can be difficult. “Generally, it’s not easy to prove that something is false,” says Baker. Some of the easiest things to disprove are photos or videos that it is claimed show one thing, but are falsified or repurposed. Take, for instance, footage that claims to show an ongoing attack, but is actually from a previous war or is even a clip from a video game.

Finding the original version that predates the claim can quash a rumour before it gains ground. That is often done by image-matching technology, by geolocating footage using image metadata or from details in the image. If a road sign in some footage is in Arabic, but the claim is that it is from Kyiv in Ukraine, it is probably from another time and place.

Truth may be harder to discern in other videos. “Twitter is flooded with amateur video footage,” says Baker. “One of the compounding factors is this is a war zone and there’s very little in the way of reliable, on-the-ground information you can verify independently or trust because it comes from reputable news organisations.”

Despite the challenges involved in debunking fake news, it is essential work. “My research team firmly believes we have a right to truth and the public has a right to the truth,” says Donovan. “If we give up that right – because social media as a technology is so chaotic and exploitable – then it’s only going to get worse.” ■

Why hasn't Russia waged an all-out cyberwar against Ukraine?

Matthew Sparkes

AS RUSSIAN forces built up near the Ukraine border at the start of this year, tensions grew over whether an invasion would occur. At the same time, there were numerous digital incursions over the border, as cyberattacks affected key Ukrainian infrastructure.

In the middle of January, the so-called WhisperGate attack took down around 70 Ukrainian government websites, and on 15 February a cyberattack briefly disrupted two Ukrainian state-owned banks. The UK's National Cyber Security Centre said days later that it already had evidence that meant it was "almost certain" the Main Intelligence Directorate, the Russian military's foreign intelligence agency, was involved.

Malware attacks targeting Ukrainian institutions and infrastructure were also launched on 23 February, the day before the Russian invasion. These carried on through the first two days of hostilities, according to digital security firm ESET. While these attacks were disruptive, they came nowhere near the worst-case scenario expected by some: that an all-out cyberwar would coincide with a military invasion.

"After two weeks of atrocities in the shape of physical war, the cyber threat is yet to create the impact to businesses and people around the world once predicted," says Jake Moore at ESET.

Ukraine has experienced regular cyberattacks since 2014, with targets including electronic voting machines and the country's power grid. Tim Stevens at King's College London says this may have honed Ukraine's defensive skills, but it may also not be to Russia's

advantage to launch devastating attacks on a country in which it has thousands of troops. "We have enough eyes on Russian actors to have a pretty fair idea of what is, and what is not, happening. Broadly speaking, we expected cyberwarfare to play a bigger part in this war," he says. "But let's not forget, it's been playing a very big part for the past seven, eight years in Ukraine, which you could view as the first phase of a war. It's just that when the main, conventional phase of military operations started, it seems to have been pushed to one side."

Russia may be wary of bringing down internet connections, phone networks and power grids that its own military will also be relying on, says Stevens.

Ukraine has also had outside help to stop cyberattacks, and this may have shored-up defences and limited the effectiveness of any attempts. Two days before the invasion, the Lithuanian defence ministry announced that it was leading a team of international cyber specialists to help bolster Ukraine's defences, and the US and UK have also sent experts to Ukraine to assist. A host of security companies, as well as tech giants



BEATA ZAWRZEL/NURPHOTO VIA GETTY IMAGES

Security alert on a mobile website for the Ukrainian bank Oschadbank

70

Ukrainian government websites hit by WhisperGate attack

2

Ukrainian state-owned banks disrupted by cyberattacks

500+

Hackers in a volunteer group targeting Russian institutions

Microsoft and Google, also gave free tools and licences to Ukrainian organisations, which are being used to spot and stop attacks.

"Maybe Ukrainian cyber defences are a lot better than we'd expected," says Stevens. "Your allies can help you to improve your cyber defences, and maybe they're just quite good at repelling some of those attacks. When push comes to shove, it may be that the Russians have tried stuff, but we've either not seen them or they've been repulsed."

The technical security and intelligence service of Ukraine claimed in a tweet that attempted distributed denial-of-service (DDoS) attacks designed to bring down government websites had been continuous throughout the war, but had been largely unsuccessful. "The only thing the occupants managed to do was to substitute the front pages at the sites of some local authorities," it said. "We will endure! On the battlefields and in the cyberspace!"

Ukrainian citizens are also engaged in cyberwarfare with Russia. One Ukrainian computer programmer, now working outside the country, told *New Scientist* that when war broke out, he quickly formed a hacktivist group to attack Russia.

The hacker, who asked not to be named, now runs a volunteer group of more than 500 members who target Russian institutions in DDoS attacks. "There are other groups, of course; mine is small but active and effective," he says. "People do it for free, from morning till late evening."

The international activist hacker group Anonymous also claims to be seeing success in attacking Russia, including interrupting broadcast television to display anti-war messages. ■



ARIS MESSINIS/AFP VIA GETTY IMAGES

People leaving the city of Irpin, Ukraine, on 10 March

How to ease global food shock

The US and Europe could compensate for the loss of Ukraine's grain exports by scrapping biofuel mandates, reports **Michael Le Page**

THE war in Ukraine has already caused food prices to shoot up as global markets anticipate a loss of wheat and maize exports from one of the world's largest producers of these crops. But Europe and the US could more than compensate for the loss of Ukraine's exports by diverting crops destined to be made into biofuels into food production instead. This would bring food prices down and help prevent a major global food shock.

On 9 March, Ukraine banned most food exports to try to ensure that its people don't go hungry as Russian forces invade.

Food prices were already at the highest levels for 40 years, says Martin Qaim at the University of Bonn in Germany. This is for many reasons, including poor harvests because of extreme weather driven by global warming.

Quickly increasing the global supply of food crops is difficult. But a large proportion of food crops isn't eaten but converted to biofuels. Globally, 10 per cent of all grain is turned into biofuel, says Qaim.

Blended fuel

In the US, a third of the maize grown is converted into ethanol and blended into petrol. Around 90 million tonnes is used for ethanol, nearly double the 50 million tonnes exported by Ukraine and Russia, says Qaim.

In the European Union, 12 million tonnes of grain, including wheat and maize, is turned into ethanol, says Qaim, around 7 per cent of the bloc's production.

The EU also produces large quantities of biodiesel. It turns 3.5 million tonnes of palm oil alone into biodiesel, says Qaim. "That's almost the amount of sunflower oil coming out of Ukraine and Russia."

Governments have the power to



ANTON PETRUS/GETTY IMAGES

Ukraine is one of the world's biggest producers of wheat

change this, says Ariel Brunner at Birdlife International. "Because the biofuel market is entirely driven by subsidies, you can unplug it literally with the stroke of a pen," he says.

If the US and Europe were to decrease their use of ethanol made from grain by 50 per cent, they would effectively replace all of Ukraine's exports of grain, Tim Searchinger at Princeton University has calculated in response to a question from *New Scientist*.

"This is one of the few really quick things we can do," says Brunner. "We are literally burning a hell of a lot of food."

One country has already done just this. On 11 March, the Czech Republic ended its mandate requiring ethanol to be blended with petrol. It did this to reduce the costs of fuel rather than food, but Brunner is calling for other countries to follow suit.

"It absolutely would make a difference. It would begin to

relieve prices immediately," says Jason Hill at the University of Minnesota in St Paul. "It would also send a signal that can be acted on immediately by farmers. Northern hemisphere farmers are deciding now what to plant."

The US Environmental Protection Agency has the power to waive the requirement to blend ethanol into fuels, says Hill. "The EPA could very quickly send a signal that ethanol is not needed."

Temporarily halting biofuel mandates wouldn't be popular with farmers. The powerful

10%
The share of the world's grain that is used to produce biofuel

agrobusiness lobby in the US is currently demanding the opposite, that biofuel production is increased in response to the rising oil price, says Hill.

However, only 6 per cent of fuel sold at petrol pumps in the US is ethanol, he says, so changing this either way isn't going to have a big effect on global oil prices. By contrast, it could have

a major effect on food prices.

Higher food prices hit those with the lowest incomes the hardest, and can contribute to political unrest such as the 2011 Arab Spring. "Hunger may go up significantly," says Qaim.

"It's profoundly immoral to try to solve a shortage of energy by creating a shortage of food," says Brunner.

In general, fuel price rises affect those who can afford to drive cars and fly, whereas people with low incomes spend most of their money on food, he says. "You are taking food off the table of people in the slums of Cairo to subsidise rich people driving SUVs."

"It's a question of what you care about most," says Searchinger. Some proponents of bioenergy have argued that it provides a buffer that could be removed during food shortages, he says, and now is the time to use it.

"Even that signal of increased availability is going to have a disproportionately beneficial effect on prices," says Hill. "You are going to reduce the potential for catastrophically large market responses."

Many researchers have long been calling for a permanent end to biofuel mandates, because study after study has shown they don't reduce greenhouse gas emissions by much if at all and in fact often increase them.

Charities such as Oxfam have campaigned against biofuels, saying that by increasing demand for food crops, they have caused global food prices to rise, pushing more people into poverty. Higher demand has also led to more land clearance and habitat loss, the main factor driving the decrease in biodiversity.

"There's growing recognition of the negative repercussions of using food for fuel," says Hill. ■



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Ageing

Clue to the rejuvenating effects of young blood

Michael Le Page

YOUNG blood's revitalising properties could be largely due to packages of RNA and proteins that bud off from some cells and travel via the blood to other cells. When researchers injected these cell buds from young mice into old ones, it reversed several signs of ageing, including boosting hair growth and muscle strength and improving coordination and endurance.

"What we saw was that the physical performance of the animals was better," says Consuelo Borrás at the University of Valencia in Spain.

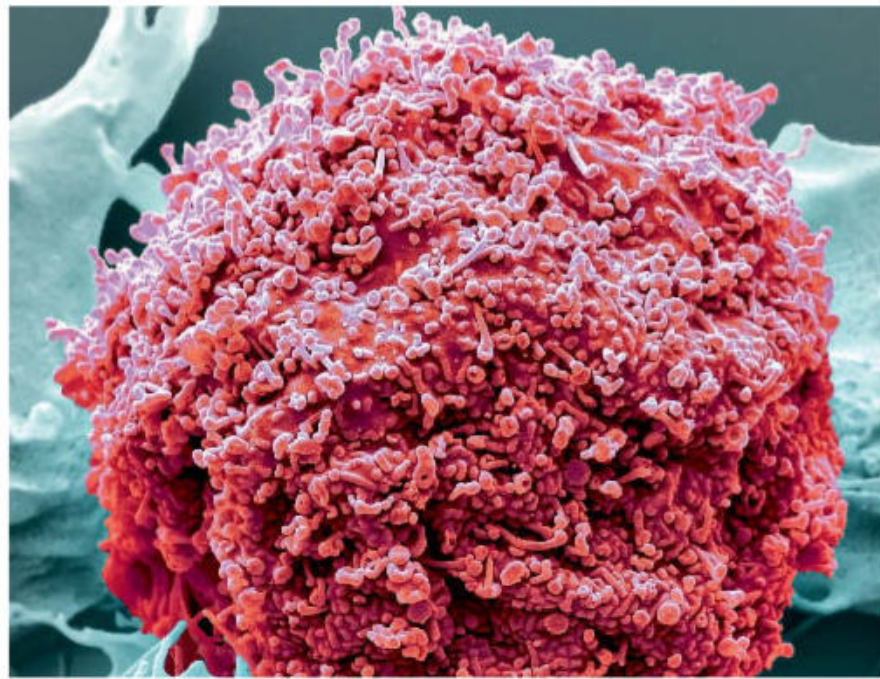
Several animal studies over the past decade have shown that transfusions of young blood can have rejuvenating effects, and there are signs this might work in people, too. Borrás thinks that the particular make-up of extracellular vesicles – tiny bags of chemicals released by cells in the bodies of animals – in young blood is largely responsible.

"After injections containing vesicles from young mice, old mice could exercise for longer"

"I don't know if all the effect is due to the extracellular vesicles, but I'm sure that extracellular vesicles are important," she says.

"Yes, I think that is possible," says Tony Wyss-Coray at Stanford University in California, whose team first demonstrated the effect of young blood in 2012 in experiments that involved linking the blood supplies of young and old mice.

Some extracellular vesicles form when the membrane of a cell pinches in and tiny parts of the cell bud off. They can travel through the blood and fuse with distant cells, releasing



STEVE GSCHEISSNER/SCIENCE PHOTO LIBRARY

their contents. The proteins and RNA that extracellular vesicles carry can switch genes on or off, and thus alter the behaviour of the cells.

Recent studies have suggested that extracellular vesicles are involved in ageing in both good and bad ways. While those from stem cells can boost healing, the contents of extracellular vesicles change as cells age. Those from senescent cells – older cells that can no longer replicate – may accelerate ageing.

Borrás and her colleagues first obtained fat stem cells from young mice, then derived extracellular vesicles from these stem cells. They injected old mice with two doses, spaced a week apart, of either extracellular vesicles or a saline solution.

A month later, the motor coordination and grip strength of the mice had improved, and they could exercise for longer. Those mice given only saline injections showed no improvements. Neither did mice injected with extracellular vesicles from old mice in a separate test.

A cell releasing large numbers of extracellular vesicles

The team also plucked the fur from a small patch of skin just before the first injection. After two weeks, it had completely regrown in the mice given extracellular vesicles from young mice, but only partially in those given saline solution ([bioRxiv, doi.org/hkqm](https://doi.org/10.1101/2022.03.01.478121)).

However, two months after the injections, the effects had faded. Borrás and her colleagues are now giving mice monthly doses to see if this extends lifespan.

Because of the safety issues involved in injecting extracellular vesicles into the blood, the team is planning a human trial that will instead involve applying them to the skin, to see if they can help heal pressure sores in older people.

The researchers are also trying to pinpoint the specific components in these vesicles that are responsible for the beneficial effects. There are likely to be several elements at least. ■

Health

Even a low level of light at night may disrupt blood sugar

Clare Wilson

KEEPING the TV or a bedside light on overnight could slightly disturb your sleep – enough to disrupt the way bodies normally keep blood sugar levels within a healthy range.

Previous studies have found that people who sleep with a light on in their bedrooms are more likely to be overweight or have type 2 diabetes. But such research can't say if it is the light that causes the poor health.

Now, a study by Phyllis Zee at the Northwestern University Feinberg School of Medicine in Chicago and her colleagues supports the idea that the connection is causal.

Her team asked 20 volunteers to spend two nights in a sleep lab. On the first night, all participants slept in a dark room.

On the second, half slept with a lighting level of 100 lux, equivalent to keeping a TV or bedside light on or having a bright street light shining through thin curtains.

On both mornings, Zee's team investigated the volunteers' blood sugar control using two common tests involving insulin, the main hormone involved in regulating glucose levels. One measure combined glucose and insulin levels after waking up, and the other involved giving people a dose of glucose and measuring their insulin response.

People who slept in the dimly lit room on their second night had slightly worse blood sugar control next morning than after their first night, when the room was nearly dark, while those who had spent two nights under dark conditions had little difference in their blood sugar control ([PNAS, doi.org/hk29](https://doi.org/10.1073/pnas.2111111118)).

However, people should wait to see if the results are repeated in a larger trial before considering changing their sleeping habits, says Jim Horne, who until recently ran a sleep lab at Loughborough University in the UK. ■

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Astrobiology

Organic mineral bonanza on Mars

NASA's Curiosity rover has found more potential signs of ancient life

Alex Wilkins

MORE signs of the organic molecules that could have helped sustain life have come to light on Mars. The molecules were well-preserved in the clay minerals of Gale crater, a 155-kilometre-wide suspected former lake.

These sulphur-bearing organics were found in the Glen Torridon region of the crater, which the Curiosity rover explored from 2019 to 2021. Kristen Bennett at the US Geological Survey Astrogeology Science Center in Arizona and her colleagues presented the findings at the Lunar and Planetary Science Conference in Texas on 9 March.

"We identified the most clay minerals in a sample thus far observed in the mission and we observed the most organics," says Bennett. "It really showed that [Gale crater] was this habitable ancient environment with high organic preservation potential."

Curiosity collected and analysed 10 samples from Glen Torridon by drilling into the Martian rock and then heating the extracted material to determine its

chemistry using an on-board sample-analysis machine.

While organic molecules have been found in Gale crater before, the Glen Torridon region presented the greatest abundance. They also included several molecules that can be found on Earth associated with biological processes.

Scientists are now trying to identify the point of origin

NASA's Curiosity rover landed on Mars in August 2012

of these molecules. While they could indicate biological processes – for instance, they can be produced by heating coal or through the activity of bacteria that metabolise energy from sulphur – it is more likely that they are the product of non-biological processes such as impacting meteorites or volcanic activity.

"It's going to take years before we can actually constrain, and maybe we never will, where this organic matter is coming from," says Maëva Millan at Versailles Saint-Quentin-en-Yvelines

University, France, who is part of the team analysing these sulphur-bearing compounds.

There are several ingredients that go into a life-supporting environment in addition to sulphur organics, such as the presence of water with a neutral pH and temperatures similar to those found on Earth's surface. Many of these important preconditions for life as we know it have been found over the course of Curiosity's time in Gale crater. But the clay minerals are of particular significance, because they can both preserve evidence of organic matter and serve as evidence itself of previously habitable conditions.

"Clay minerals are an important marker for planetary scientists, because they require water to form," says Bennett.

"If the original goal of the Curiosity rover was to identify habitable environments, and water is a key indicator of a habitable environment, it follows that clay minerals that are water indicators are a good way to go about that," she says. ■



NASA/JPL-CALTECH/MSS

Physics

The slow speed of sound on Mars has been measured

NASA's Perseverance rover has used its microphones to give us our first ever measurement of the speed of sound on Mars.

Baptiste Chide at Los Alamos National Laboratory in New Mexico and his colleagues recorded sounds from Mars's Jezero crater last year, such as the rover's laser striking rocks, which generates a shock wave. They also captured the frequency shift of the Ingenuity

helicopter's blades as it moved through Mars's atmosphere after launching from Perseverance.

The laser and microphone aboard Perseverance were precisely synchronised, allowing the team to use these recordings to calculate the speed of sound on Mars. It is about 240 metres per second, slower than the 340 metres per second at which sound travels on Earth.

The sound of speed on Mars also varied over small distances, which the researchers used to infer characteristics about the planet's atmosphere, such as temperature over small scales, which hadn't

been previously measured.

"We have a response time with acoustic measurements that is way faster than what we can achieve with standard and classical air temperature sensors," says Chide.

The work, which was presented at the Lunar and Planetary Science Conference in Texas on 8 March, also revealed that sound travels in an unusual way in the Martian atmosphere, which is primarily

"You would receive the low and high frequencies separately, leading to a kind of distortion"

low-pressure carbon dioxide. Higher frequency sounds arrive before the lower ones due to the way CO₂ molecules vibrate at low and high frequencies.

"You would receive all the low frequencies of my voice a few milliseconds after the high frequencies... so it would lead to a kind of distortion of sounds that would be quite difficult to understand," says Chide.

The rover recorded more than 5 hours of sound, which people are still analysing to learn how the atmosphere and temperature change with Martian seasons. ■ **AW**

Astrophysics

Moon's emergence from planet crash reconstructed

Alex Wilkins

COMPUTER simulations that trace how our moon formed in high resolution may explain the mystery of why it is so chemically similar to Earth.

The conventional story for the moon's origin is that a primordial planet named Theia smashed into Earth and spewed molten rock into space. This debris, primarily made up of Theia, then coalesced into the moon over a period of tens of millions of years.

While this scenario accounts for the moon's observed angular momentum, it fails to explain the near-identical profile of its isotopes to those found on Earth. Isotopes are atoms of the same element that differ by the amount of neutrons they contain, and the ratio of different isotopes in a sample can be used to trace its origin.

Jacob Kegerreis at Durham University in the UK and his colleagues ran more than 400 high-resolution simulations of what might have happened when the early Earth was struck, using different initial conditions like impact angle and speed.

Many of the simulations showed a satellite forming within hours of the impact – much more quickly than suggested by previous research. They produced a moon with a similar angular momentum and isotopic make-up to Earth, which means that the moon contains more of Earth and less of Theia than other models supposed. The findings were presented at the Lunar and Planetary Science Conference in Texas on 10 March.

"It's interesting that simulations in this work lead to more mixing between the impactor and proto-Earth than previous work suggested," says Miki Nakajima at the University of Rochester in New York. "This would help explain the isotopic similarities between Earth and the moon." ■

Astronomy

Double-shadowed craters could hold ice on the moon

Jonathan O'Callaghan



JORGE MAÑES RUBIO/ESA/ACT/DITISHOE

SOME of the moon's craters may contain "double-shadowed" regions that are so dark they would be among the coldest places in the solar system.

The small tilt of the moon – just 1.5 degrees – as it orbits with Earth around the sun means that it has hundreds of craters where direct sunlight never reaches. We know that inside these craters, located near the moon's poles, temperatures can drop below -170°C, making them prime locations for water ice to collect and optimum locations for future human missions, as astronauts could use the ice as a source of water for their missions.

Even though the insides of these craters don't receive direct sunlight, they can be heated by sunlight reflecting off their rims, which can melt some of their more exotic ices, such as carbon dioxide ice.

Now, Patrick O'Brien and Shane Byrne at the University of Arizona in Tucson think they have found even darker craters that are shielded from this reflected sunlight. These double-shadowed regions would be rare, a fraction of a per cent of the total area of craters that don't receive direct

sunlight, with temperatures dropping to -250°C.

"Their main source of light is starlight," says O'Brien, who presented the work at the Lunar and Planetary Science Conference in Texas on 7 March. "They could be the coldest places in the solar system."

Evidence for these frigid craters comes from NASA's Lunar Reconnaissance Orbiter,

-250°C

Temperature in lunar craters that see no reflected light

which uses a laser to study the moon's surface. Billions of pulses have been fired at the moon for more than a decade, says O'Brien, allowing detailed measurements of the lunar surface to be made. The team used this information to search for and examine these double-shadowed craters.

"They've been predicted, but we're the first to actually look for them on the moon," he says.

For a double-shadowed crater to exist, it must be sufficiently deep and set at an angle that wouldn't allow sunlight to be reflected in. In total, the researchers found hundreds

Shackleton crater sits at the moon's south pole

of suitable craters that could host double-shadowed regions, ranging in size from 100 to 600 metres across, but the team says there could be many more smaller ones, with diameters of just tens of centimetres.

Margaret Landis at the University of Colorado Boulder, who wasn't involved in the research, says these colder regions could help us work out where water ice or other exotic ices on the moon and other bodies came from.

Temperatures of -170°C "are great to preserve water ice, but too warm for other ices like carbon dioxide, or organic species that might be a fingerprint of a comet impact", she says. Such impacts could have been a source of Earth's water.

"It has massive implications for the amount of water that Earth got from non-Earth sources," says Landis.

An upcoming NASA lunar rover may be able to drive into some of these regions. Called VIPER, it is scheduled to arrive at the moon's south pole in November 2023 and will drive for up to 10 hours at a time into three regions that never receive direct sunlight. It will use a drill and headlights to look for ice, and it may also discover some of these double-shadowed craters.

"One of our objectives is to locate and observe multi-shadowed craters," says Anthony Colaprete at NASA's Ames Research Center, the VIPER mission's lead scientist. "It's going to be pretty awesome." ■

Iceland targets herd immunity

The country's new covid-19 strategy aims for "widespread societal resistance" to the virus, but most experts think this cannot be achieved, reports **Clare Wilson**

LIKE some other countries, Iceland has scrapped its remaining covid-19 restrictions. Unlike other nations, however, its health ministry coupled this move with a startling announcement: the country will start aiming for herd immunity.

"Widespread societal resistance to covid-19 is the main route out of the epidemic," the government said in a statement on 23 February. "To achieve this, as many people as possible need to be infected with the virus as the vaccines are not enough, even though they provide good protection against serious illness."

Until now, Iceland has adopted a "zero covid" strategy, which has contributed to it having one of

"We just don't know enough about the long-term impact of infection. You're asking for trouble"

the world's lowest covid-19 death rates. The country has recorded just 79 covid-19 deaths since the start of the pandemic in a population of 366,000.

On 25 February, Iceland lifted all its remaining restrictions, allowing an unlimited number of people to gather indoors and fully opening its border. Since then, official government statistics show that daily case numbers of covid-19 have fallen from 4862 to 2656 on 11 March.

The phrase herd immunity is controversial in itself. It has no set definition, but is often associated with allowing the SARS-CoV-2 coronavirus to spread while vulnerable people shield. When the virus has infected most of the population, the hope is that

outbreaks would fizzle out.

Almost all experts agree this definition of herd immunity cannot be achieved. In January 2021, hospitals in the Brazilian Amazon collapsed under the strain of covid-19, despite the region having had a high infection rate in its first wave. Later that year, it emerged that nearly everyone in Iran had caught the disease at least once, but herd immunity wasn't achieved.

Immunity wanes after a person overcomes SARS-CoV-2 or is vaccinated against it. The virus has also mutated into new variants, which somewhat evade past immunity.

Nevertheless, a past infection may reduce the risk of becoming seriously ill with a different variant. This is the population-level immunity that Iceland hopes to harness, says Gudrun Aspelund at the country's Directorate of Health. Individuals aren't advised to deliberately get infected and are encouraged to test and isolate, she says.

The lifting of restrictions was partially driven by growing confidence in omicron's reduced severity compared with previous variants, says Aspelund. In addition, 80 per cent of the



HALLDOR KOLBEIN/AFP VIA GETTY IMAGES

Scientists at a covid-19 sequencing lab in Reykjavik

population have had two vaccine doses, helping to keep the number of deaths low.

However, while younger people are at reduced risk of coronavirus complications, they can still develop long covid, says Christina Pagel at University College London. "We just don't know enough about the long-term impact," she says. "You're asking for trouble."

But the government felt it had little choice, says Aspelund. As well as being milder, omicron is more transmissible than previous variants, so extreme

measures would be required to stop its spread. "We are talking about severe restrictions on gatherings, on working from home, limiting society for a long time," says Aspelund. Trying to achieve zero covid-19 cases is no longer possible, she says. "Not here, for sure."

After omicron

The threat of another variant emerging is a worry for public health experts. "We don't know what comes after omicron," says Francois Balloux at University College London.

If the next variant is more virulent and people retain some of their immunity, then previously overcoming omicron would be an advantage, says Balloux. Recent studies suggest the best protection comes from being fully vaccinated and having had an infection, dubbed hybrid immunity.

Yet no one knows if omicron immunity will protect against a future variant. "There's no guarantee it's going to provide similar protection in a few months' time to whatever the next variant happens to be," says Neil Mabbott at the University of Edinburgh, UK.

Ultimately, Iceland's lifting of restrictions is similar to that in other European countries, says Balloux. In early January, England reported more than 147,000 daily cases. After falling considerably, cases started rising at the end of February, corresponding with restrictions ending on 24 February.

Aspelund is clear that the government doesn't want to encourage infections. "We are not telling people to go and have a covid party, but how we look at it here is that it is inevitable that people are going to get it," she says. ■



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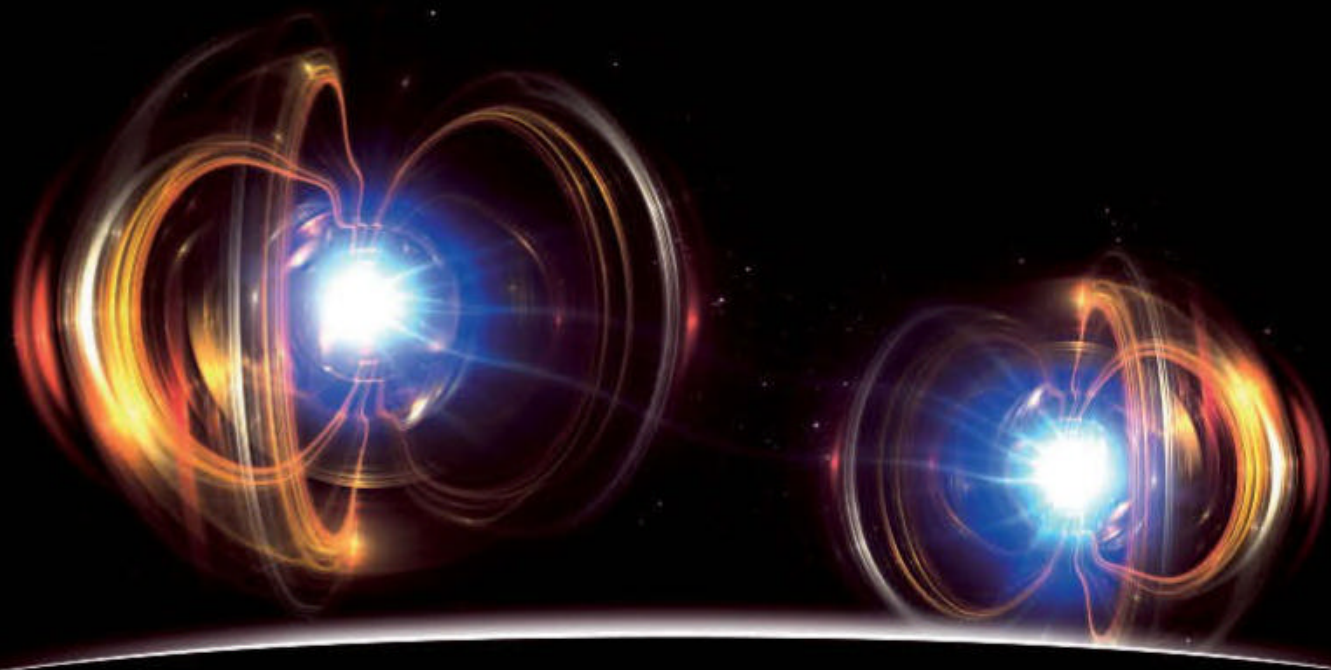
Customers sit outside a restaurant in Reykjavik in July 2020

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Microbiology

Pink lake mystery solved

DNA sequencing identifies microbes that colour Australian landmark

Alice Klein

THE reason for the bubblegum pink colour of a remote lake in Western Australia has long been a mystery, but new research suggests it is caused by a mix of colourful microbes.

Lake Hillier on Middle Island in Australia is about eight times saltier than the ocean. Scott Tighe at the University of Vermont in Burlington and his colleagues analysed water and sediment samples using metagenomics to sequences all the DNA in the environmental samples.

They found that the lake contains almost 500 types of extremophiles – organisms that thrive in extreme environments – including bacteria, archaea, algae and viruses (bioRxiv, doi.org/hkmh). Many of them produce purple, red and orange pigments known as carotenoids, which may provide some protection against extreme saltiness and provide the water's colour, says Tighe. ■



TOURISM WESTERN AUSTRALIA



Technology

Crash-avoiding drones can fly in mines

PROTOTYPE drones that are capable of navigating dangerous and unpredictable environments could prove to be valuable for search-and-rescue teams.

RMF-Owl, a drone created by Paolo De Petris at the Norwegian University of Science and Technology and his colleagues, made its debut while winning a competition hosted by the US Defense Advanced Research Projects Agency. This involved navigating around a mine and performing rescue-related tasks.

The drone, which dodges collisions by using laser mapping and onboard algorithms, can also work with other flying and walking robots as part of a team.

“If the robot crashes in the middle of a passage, which is really [narrow], then all the other robots that come afterwards will be blocked and cannot proceed in their navigation, so we wanted to avoid that,” says De Petris.

The flying drone weighs about 1.5 kilograms and has a resilient carbon-foam frame in case its collision-avoidance system fails. However, no such failure occurred during its tests (arxiv.org/abs/2202.11055).

“It’s an impressive capability,” says Raphael Zufferey at the Swiss Federal Institute of Technology in Lausanne. “They travel quite a long distance inside of a mine without having any collisions



The RMF-Owl uses laser mapping and algorithms to dodge collisions

and by generating their own map and moving within their map.”

Ricardo de Azambuja at Montreal Polytechnic in Canada and his colleagues, meanwhile, have taken a different approach to avoiding drone crashes.

Inspired by the flexible exoskeletons of insects, they designed the CogniFly, a small, autonomous drone weighing around 250 grams that can survive repeated high-impact collisions (arxiv.org/abs/2103.04423).

“We were doing experiments and mostly we were crashing [the drone] against the floor, so we needed something to absorb the crash landings,” says Azambuja.

The team has designed a shell that absorbs landing impacts like a cricket’s legs, with the drone being built from 3D-printed parts and having flexible joints. It could be used in cave exploration. ■

Alex Wilkins

Animal behaviour

Common toads surprise biologists by climbing trees

Michael Le Page

THE common toad doesn't look like a good climber, yet citizen surveys suggest that the amphibians often climb trees to hide in hollows.

"The people who do surveying for bats were like, 'Oh yeah, we do find toads from time to time'. But



The European common toad (*Bufo bufo*)

nobody working with toads knows this," says Silviu Petrovan at the University of Cambridge.

The finding emerged from a dormouse monitoring scheme run by the People's Trust for Endangered Species (PTES) in the UK. The nesting boxes are typically placed at least a metre above the ground on tree trunks, so small animals can only get into them by climbing the trees. In 2016, a volunteer monitoring the nesting boxes found a toad in one and asked why it was there.

Petrovan and his team couldn't find any published reports of toads climbing trees, so they asked other volunteers with the PTES dormouse scheme if they had seen any amphibians. Sure enough, some had kept records of finding toads, even though they hadn't been asked to (bioRxiv, doi.org/hkqg).

Petrovan also looked at the animals found in tree hollows as recorded by another UK initiative, the Bat Tree Habitat Key project. Altogether, his team has now found around 50 reports of amphibians in trees, almost all of them common toads (*Bufo bufo*).

Why toads climb trees isn't clear, but it may help them avoid predators and parasites, says Petrovan. ■

Technology

A simple maths trick makes training AI more efficient

Matthew Sparkes

ARTIFICIAL intelligence is growing ever more capable at increasingly complex tasks, but it is intensive to develop. A more efficient technique could save up to half the time, energy and computing power needed to train an AI model.

Deep learning models are typically composed of a huge grid of artificial neurons linked by "weights" – computer code that takes an input and passes on a changed output – that represent synapses linking real neurons. By tinkering with these weights over thousands or millions of trials, it is possible to gradually train a model to carry out a task, such as identifying a person from a picture of their face or digitising text from an image of handwriting.

This training usually relies on an iterative process of passing data in, assessing the quality of the output and then calculating a gradient that informs how the weights should be altered to improve performance. This involves passing data from one side of the neural network to the other, via every link in the chain of artificial neurons, and then

working back to the beginning to calculate the gradient.

Atılım Güneş Baydin at the University of Oxford and his colleagues have now taken this two-stage process, known as back-propagation, and reduced it to just one, where an approximation of the gradient close enough to be effective is calculated during the first pass, making the second redundant. In theory, it could slash the time needed to train AI models in

50%

Potential savings in time, energy and computing power to train AI

half. The team ran numerous tests with back-propagation and their new approach, each for the same number of iterations, and found that the performance of the AI was comparable (arxiv.org/abs/2202.08587).

Andrew Corbett at the University of Exeter, UK, says that calculating the gradient in the forward pass is "a simple mathematical trick" but has the potential to solve one of the largest problems facing

AI researchers: the increasingly high demands of computation.

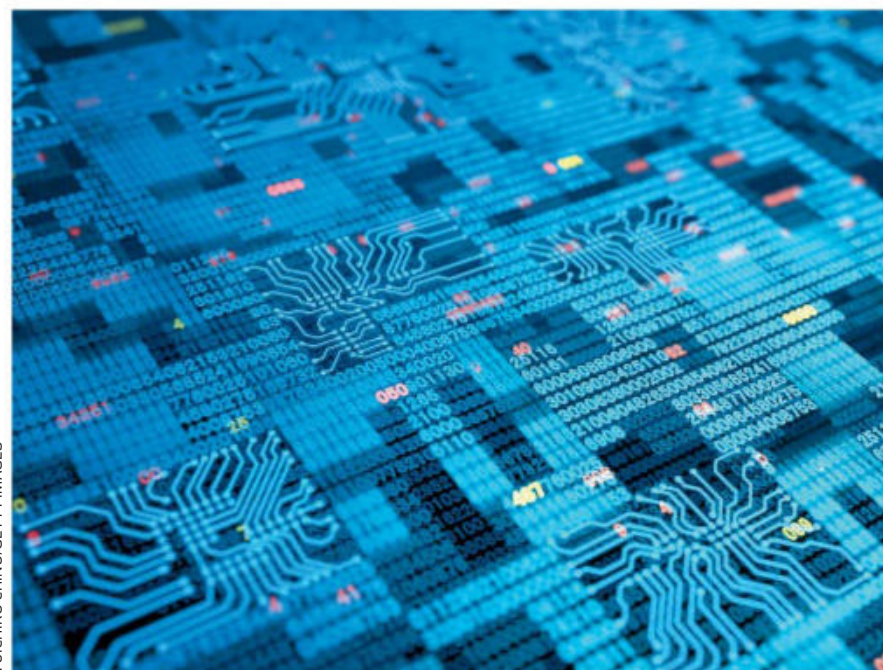
"It's a very, very important thing to solve, because it's the bottleneck of machine learning algorithms," says Corbett.

Cutting-edge AI research relies on vast models with hundreds of billions of parameters. Training these can occupy huge supercomputers for weeks or months at a time. One of the largest neural networks currently operating, the Megatron-Turing Natural Language Generation model, has 530 billion parameters and was trained on Nvidia's Selene supercomputer, which has 560 powerful servers and 4480 high-end graphics cards, each costing thousands of pounds when bought commercially. Despite the huge power of that machine, it took more than a month to train the model.

Güneş Baydin says the best-case scenario is that this new approach slashes the time taken to train AI models in half, but that is far from guaranteed. He says time will tell what results other researchers see when it is tested across a range of models.

"You can run one iteration of optimisation faster with our algorithm, but it doesn't automatically mean you can get the same result twice as fast, because there are other things involved," he says. "It might do a worse job than the back-propagation algorithm in some cases, and it might need more iterations to achieve the same quality of training. And if that happens, maybe it can end up like losing all your competition advantage." ■

Back-propagation is an intensive technique used to train AI models



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Extinct species will stay extinct

An effort to reconstruct the genome of the Christmas Island rat suggests we will never be able to resurrect lost animals just as they were, finds **Michael Le Page**

IT IS impossible to bring extinct animals back to life in their original form, according to a study of the extinct Christmas Island rat. Even though researchers were able to recover a very high-quality genome from preserved specimens, they couldn't recreate many key genes, meaning any resurrected animal would differ in some crucial ways.

"You may be missing what's most important for the extinct form," says Thomas Gilbert at the University of Copenhagen in Denmark. "If you think you are going to create a mammoth that's exactly like the mammoth that went extinct, well, you are not really."

A few research groups are trying to resurrect extinct animals by sequencing the DNA in preserved samples, then editing the genome of a close living relative to make it like that of the extinct species.

These teams include Colossal, a biosciences company that wants to create a woolly mammoth, and the TIGRR lab at the University of Melbourne, Australia, which aims to bring back the thylacine, or Tasmanian tiger. Last week, Colossal announced that it has raised US\$75 million in funding, which it will spend on further developing the technologies needed for de-extinction.

"The most important pieces of the jigsaw puzzle are the parts that can't be put back together"

The fundamental problem is that old DNA breaks up into lots of tiny pieces that are impossible to completely reassemble, says Gilbert.

The Christmas Island rat (*Rattus macleari*) – also known as Maclear's rat – was once found on Christmas Island in



Christmas Island and the extinct Christmas Island rat

the Indian Ocean, before it went extinct in the early 20th century.

The researchers were able to reassemble most of the pieces of its DNA by using the genome of the related Norway brown rat (*Rattus norvegicus*) as a guide, but they couldn't assemble all of them. "Every bit of DNA that we could recover, we got," says Gilbert. "There's a 5 per cent fraction we can't make sense of."

Crucially, it is the parts of the extinct animal's genome that differ most from the living relatives that are the hardest to match and reassemble. This 5 per cent includes the genes that have been evolving the fastest, which are the ones that make closely related species different to each other.

In other words, the most important pieces of the jigsaw puzzle are the parts that can't be put back together, because those areas of the guide picture have been lost.

With the Christmas Island rat, the team was able to recreate near-complete versions of around half of its genes. These include genes related to its hair and ears, suggesting that it would be possible to create an animal with the long black hair and round ears characteristic of this species.

However, many other genes, including those involved in the rat's immune system and its sense of smell, could only be partially reconstructed (*Current Biology*, doi.org/hkpf).

The Christmas Island rat is thought to have been wiped out by a disease carried by the Norway rat, so it might actually be an advantage for a resurrected animal to have Norway rat immune genes. However, smell plays a key role in behaviours such as finding food, avoiding predators and choosing mates, says Gilbert, so a recreated Christmas Island rat might behave differently to the original species.

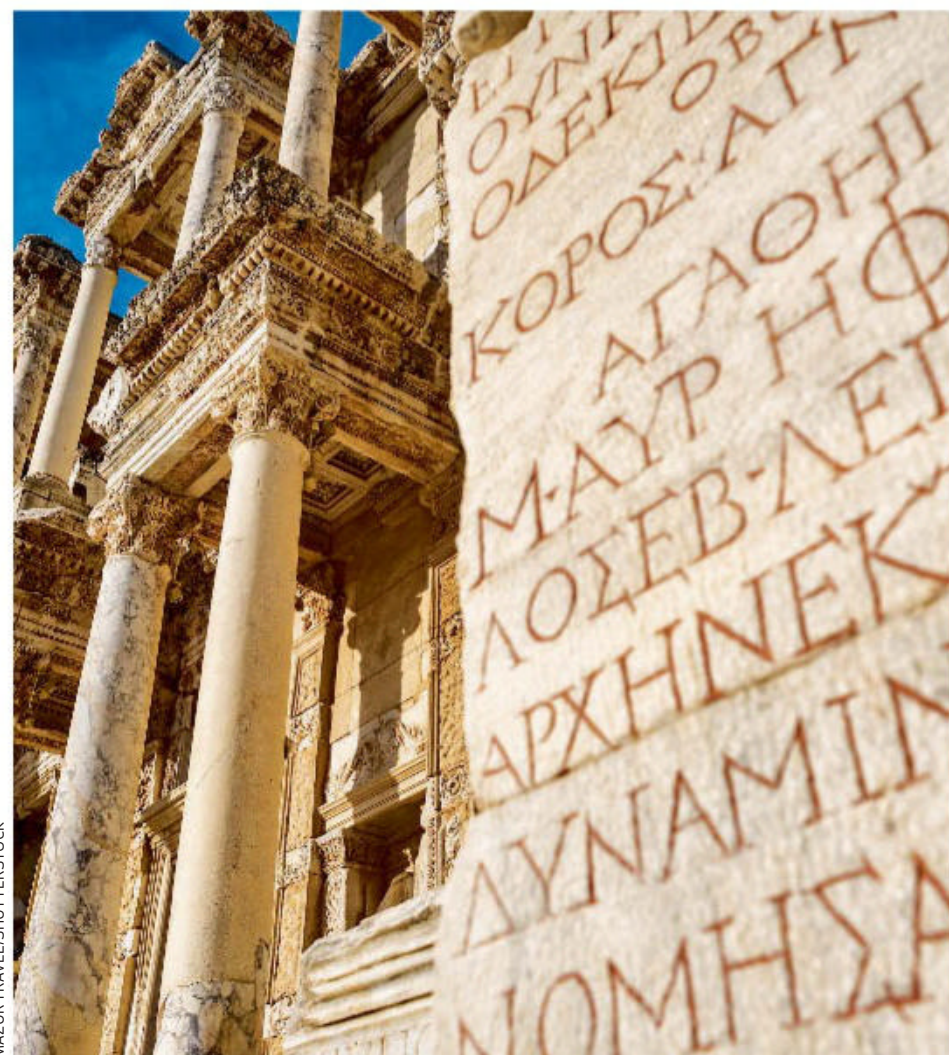
Gilbert has no plans to try to resurrect the Christmas Island rat. The team studied it only as a way of exploring what is possible. But he isn't opposed to de-extinction. It is feasible to create animals that can perform the same role in ecosystems as extinct ones, he says. "If you're happy with the end product, awesome."

"This paper nicely shows that the more evolutionary distance there is between the extinct species [and living relatives], the more of the genome won't be correctly assembled," says Beth Shapiro at the University of California, Santa Cruz.

"Does this mean that we will never, ever be able to reconstruct a genome using gene editing that is 100 per cent identical to a specific extinct organism? Yes," she says. "But that is not surprising, and nor does it mean that Colossal will never be able to create an Arctic-adapted elephant that some might call a mammoth or that the TIGRR lab won't be able to create a marsupial that has physical and behavioural traits that reflect the evolution of the Tasmanian tiger."

"The goal of de-extinction has always been to create functional equivalents," says Ben Novak at Revive & Restore, a US conservation non-profit organisation whose initiatives include efforts to resurrect the passenger pigeon and the heath hen. "De-extinction is about restoring nature, not individual species."

If resurrected animals turn out to have key traits missing, it might still be possible to restore those traits by taking genes from other living or extinct relatives, says Novak. "Ultimately, the paper changes nothing about how de-extinction works in practice or how the world's four projects are proceeding." ■



MAZUR TRAVEL/SHUTTERSTOCK

Artificial intelligence

AI can help historians restore ancient Greek texts

AN ARTIFICIAL intelligence algorithm developed as part of a collaboration between historians and UK-based AI firm DeepMind can help restore ancient Greek texts with 72 per cent accuracy.

Ancient inscriptions can often be damaged or moved from their original location. When recovering them, historians have three main goals: restoring the text, and working out exactly when and where it was written. Thea Sommerschild at Ca' Foscari University of Venice in Italy and her colleagues worked with researchers at DeepMind to train an AI, called Ithaca, to carry out all three tasks.

To train Ithaca, the team used around 60,000 ancient Greek texts from across the Mediterranean that are already well-studied. The team masked some of the characters in

the texts and then compared Ithaca's predictions for this "missing" text with the actual inscriptions.

Next, the team used a data set of nearly 8000 well-studied inscriptions to test Ithaca's performance. On its own, Ithaca could restore texts with 62 per cent accuracy; in comparison, historians alone restored text with around 25 per cent accuracy. However, when historians took Ithaca's top 20 most likely reconstructions for a given text and used them to inform their own work, they could restore the text with 72 per cent accuracy.

Ithaca could also predict where in the Mediterranean a text was written 71 per cent of the time and could date them to within 30 years of their date of creation, as established by historians (*Nature*, doi.org/hkpg). **Carissa Wong**

Medicine

Electric field aids kidneys kept on ice

ELECTRICITY can help keep biological tissues functioning while stored on ice, a finding that could help boost the number of successful kidney transplants.

The approach seems effective in mice given transplants and in human kidneys stored for 24 hours – although it hasn't yet been tried on organs put inside people.

Kidney transplants can be life-saving, but some kidneys don't function well after the surgery because they are damaged from lack of oxygen during transport.

Low oxygen stops kidney cells making enough of a compound called adenosine triphosphate (ATP), which normally powers a molecular pump on their surface that keeps sodium levels low and potassium levels high inside cells. The shutdown causes the cells to swell and damages many of their enzymes and other biochemicals.

But the molecular pumps are sensitive to electrical fields. Ruisheng Liu at the University of South Florida in Tampa and his team have found that putting electrodes on the surface of a kidney and applying an oscillating field can restart the cells' pumps.

To test the approach, the team gave 10 mice a kidney transplant after storing the organs in cold saline before implantation. Seven mice were given kidneys that had received the electrical treatment, and these mice had a more than 50 per cent better kidney function than the three mice that received untreated kidneys.

The team also tested the approach in five pairs of human kidneys that had been donated but couldn't be used. One of each pair had four electrodes placed on it while they were all stored on ice for 24 hours. Afterwards, the cells of the treated kidneys had less damage than the untreated ones (*Science Translational Medicine*, doi.org/hkpx). **Clare Wilson**

Technology

'Breathing' pillow helps reduce anxiety

A HUGGABLE pillow that mimics breathing reduced anxiety as effectively as guided meditation in people who were about to take a mathematics test.

Interactive tactile devices, such as Paro the cuddly seal robot, have previously been linked to reduced anxiety, potentially providing near-immediate relief without medication. To better understand the potential of these devices,



DR. ALICE HAYNES

Alice Haynes, now at Saarland University in Saarbrücken, Germany, and her colleagues developed a prototype pillow that expands and deflates like human lungs (pictured).

To test it, the team asked a group of 129 volunteers to complete a questionnaire that measured their anxiety level before and after they were told they would need to complete a maths test.

Next, 45 of the volunteers hugged the prototype pillow across their chest and torso for just over 8 minutes, while 40 of the participants listened to a guided meditation and the remaining 44 sat and did nothing, acting as the experiment's control group. The volunteers' anxiety was then measured again.

Hugging the pillow was found to reduce pre-test anxiety by the same amount as guided meditation, while the control group's anxiety increased ahead of the test (*PLoS One*, doi.org/hkpp). **Carissa Wong**

Really brief



Trees protect each other in high winds

Tightly packed cedar trees growing in Japan withstood the strong winds of a typhoon that toppled loosely packed cedars. This may be because crowded trees dissipate energy by colliding with nearby trees. The finding may help forest managers (*Science Advances*, doi.org/gpn4cg).

Vaping need not lead to smoking

The number of young people in England who vape has risen to about 5 per cent over the past 11 years. But the number of smokers in this age group has fallen from 30 to 25 per cent, which suggests vaping isn't acting as a "gateway" that encourages young people to try smoking (*Addiction*, doi.org/hkmp).

Static electricity to clean solar panels

Solar panels in the desert can be kept clean using static electricity. Even in low humidity, dust adsorbs some water and becomes a conductor. By applying electric fields around the solar panel, the dust can be made to fall off the panel's surface (*Science Advances*, doi.org/gpnvs4).

Biology

Your organs may age at different rates

SOME organs and body systems can age faster than others. Tracking the biological age of different parts of the body could help doctors predict the onset of disease more accurately.

We already knew that the condition of cells in the body can give someone a biological age that is older or younger than their age measured in years. In other words, cell condition – which varies depending on genetic

and lifestyle factors – determines the pace of the ageing process.

Now, work by Brian Kennedy at the National University of Singapore and his colleagues supports the idea that the various organs and systems in the body can age at different rates within the same individual.

The researchers collected stool and blood samples from about 480 people aged between 20 and 45 and measured a total of 403 biological features in each person. They used these biomarkers to assess the biological age of the individual's kidneys, liver, gut

microbiome, cardiovascular system, immune system, metabolic system and sex hormone system.

They found that the biological age of a person's cardiovascular system correlated the most with their age in years, while that of the gut microbiome showed the weakest link.

The team also found that the biological age of the liver could be used to predict who had non-alcoholic fatty liver disease – a risk factor for type 2 diabetes – and the condition's severity (*Cell Reports*, doi.org/gpm26t). **Carissa Wong**

Health



BOEHRINGER INGELHEIM INTERNATIONAL GMBH/TT/SPL

Recurring UTIs may be prevented with an antiseptic

AN ANTISEPTIC drug that inhibits the growth of bacteria in urine (pictured) may be as effective as antibiotics in preventing recurring urinary tract infections (UTIs).

UK guidelines recommend a daily low-dose antibiotic to prevent recurrent UTIs. However, long-term use of these drugs raises the risk of antibiotic resistance. The antiseptic methenamine hippurate has shown promise for UTI prevention, but the evidence is inconclusive.

To learn more, Chris Harding at the Newcastle upon Tyne Hospitals NHS Foundation Trust in the UK and his colleagues studied 205 women who had, on average, six UTIs a year.

Every day for 12 months, 102 of the participants took an antibiotic, while the remaining 103 were given a methenamine hippurate pill. Over the year, those in the antibiotic group had 0.89 UTI episodes on average, compared with 1.38 episodes among those taking the antiseptic (*The BMJ*, doi.org/hkpk).

"If we want to reduce the use of antibiotics to combat antimicrobial resistance, then trials like this provide clinicians and patients a credible non-antibiotic option for prevention," says Harding.

However, the long-term safety of methenamine hippurate is unclear. **Jason Arunn Murugesu**

Palaeontology

Fossil gharial solves crocodile mystery


A NEWLY identified crocodile-like animal that lived in China 3000 years ago helps make sense of the evolution of crocodiles and their relatives.

Chinese researchers discovered the animal's bones in the 1960s and 1970s, but they were misidentified as a living species, says Masaya Iijima at Clemson University in South Carolina. Iijima and his colleagues have now studied four of the specimens and determined it was a gharial, part of the crocodilian group that also includes crocodiles and alligators. The team named it *Hanyusuchus sinensis* (*Proceedings of the Royal Society B*, doi.org/hkpr).

The Chinese gharial clarifies a mystery about crocodilians. Genetic evidence shows that alligators split from the others first, and crocodiles and gharials separated from each other later. That is odd because crocodiles and alligators more closely resemble each other than gharials. But the Chinese gharial is intermediate in body shape between gharials and the other two groups.

"There was a huge gap between the gharial and the rest of the crocodilians," says Iijima. "Our specimens fit in the gap."

Michael Marshall



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Comment

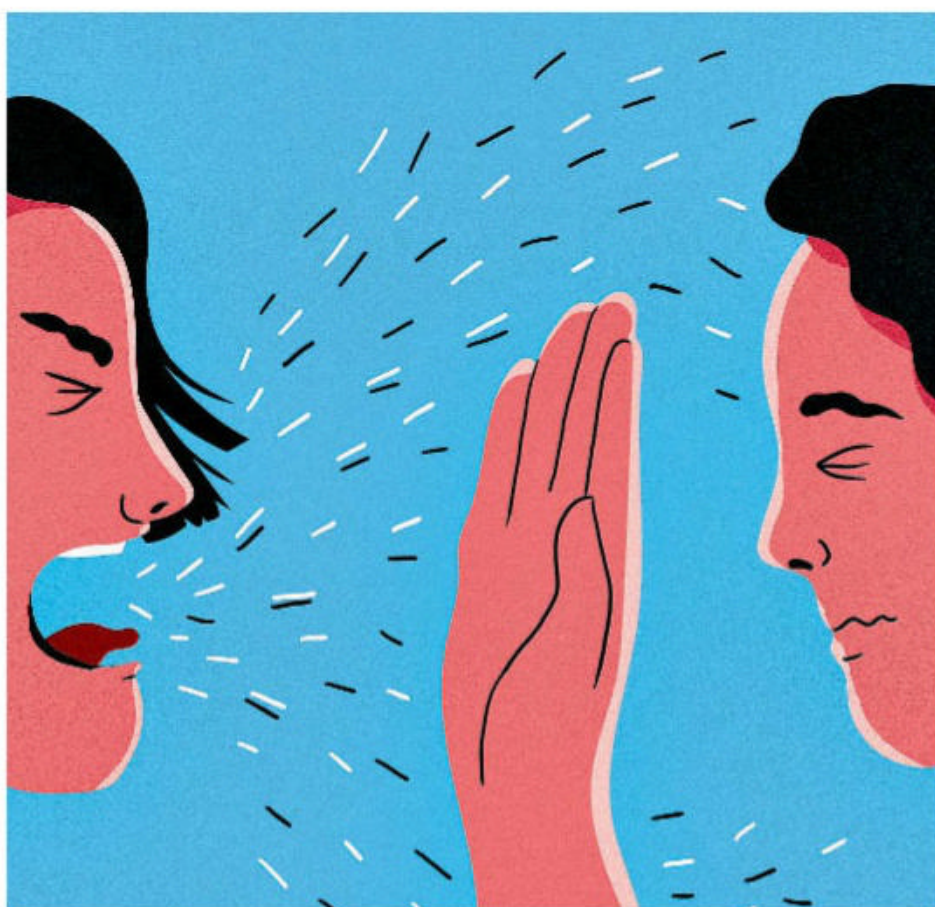
What's in a sneeze?

As covid-19 restrictions end, there is a moral duty to adjust our attitudes towards the spread of disease, says **Jonathan Goodman**

A FEW weeks ago, my partner and I went out for dinner at a local restaurant. Shortly after we arrived, a couple sat down at the table next to us, and it quickly became apparent that they were both sick. One sneezed and coughed more or less continuously over the following hour; the other kept sniffing, and – in what felt like a personal assault on my sensibilities – dropped a used tissue on the floor.

Personal hygiene is linked with a wide array of reactions. Most people are now taught at school that you should cover your nose and mouth when you sneeze – preferably with your elbow, according to the US Centers for Disease Control and Prevention. There is, however, enormous variation in whether people actually follow this guidance. Research carried out in 2009 in New Zealand showed that, during an influenza outbreak, more than a quarter of people didn't cover their mouth or nose at all when coughing or sneezing.

In contrast, there is little variation in how people react when encountering a used nappy abandoned in a public place. The bacteria that travel in human waste and the airborne particles released by coughing and sneezing – as we all know only too well from covid-19 – are both linked to disease transmission. Yet only with the nappy do we tend to be disgusted. With the coughs and sneezes, there are



socially prescribed rules, which many of us don't follow.

Now, as some countries across the world lighten or eliminate covid-19 restrictions, it falls on the public to consciously redefine the social norms around the transmission of infectious diseases. Coughing and sneezing in public can kill, just as exposing people to human waste can. We should, therefore, react with similar disapprobation.

Throughout history, human behaviour has adapted in response to disease. We learned how to avoid cholera, for example, when John Snow discovered its waterborne mechanism of

transmission in 1854. Over time, and as social groups grew larger and more complex, humans have changed how they live, accordingly. Rather than instinct guiding us, we learned from our elders, in a process known as cultural transmission, how to prevent the spread of dangerous infectious diseases.

This pattern of adopting and passing on social conventions has been hugely beneficial for us. It seems strange, then, that when faced with diseases that are extremely infectious and potentially deadly, such as covid-19, many of us cough and splutter in public – despite the fact

that this perpetuates the spread of infections. This makes each of us indirectly responsible for the deaths of hundreds of thousands of people a year worldwide.

One explanation may be that we have lived with respiratory viruses, including those that cause the common cold, for so long that we don't typically regard them as a major threat. Any perceived wisdom against socialising during the cold season, then, might be ignored by people who regard contact with others as more important than the risk they might pass on an infection.

Now that many of the mask and isolation regulations linked to covid-19 are being shelved, we should rethink this outlook. With the continual risk that a new variant of covid-19 will arise, we need to take personal responsibility and distance ourselves when sick, avoiding mixing both at work and socially. Allowing the coronavirus to circulate freely raises the risk that it will develop mutations, allowing it to escape vaccines.

Coughing and sneezing in public should be reviled. Without effective laws, it falls to individuals to protect the health of those around us. ■



Jonathan Goodman is at the Leverhulme Centre for Human Evolutionary Studies, University of Cambridge, UK

Field notes from space-time

Who is space for? Billionaires fuelling a new space race are having a big say in what happens to the night sky. But space belongs to everyone, writes **Chanda Prescod-Weinstein**



Chanda Prescod-Weinstein is an assistant professor of physics and astronomy, and a core faculty member in women's studies at the University of New Hampshire. Her research in theoretical physics focuses on cosmology, neutron stars and particles beyond the standard model

Chanda's week

What I'm reading

I have been rereading one of my favourite novels, Kiese Laymon's Long Division.

What I'm watching

Wow, do I have opinions about the new season of Love Is Blind!

What I'm working on

I'm helping to lead a national particle physics planning process here in the US.

This column appears monthly. Up next week: Graham Lawton

WHEN I was a kid, only a few governments could afford to send people into space. By and large, this continues to be true. Though much has been made of the billionaire space race, what often goes unsaid is that the likes of SpaceX and Blue Origin relied on enormous investment from the US government, through NASA, to advance the experiments that would allow them to launch civilian astronauts.

Such public-private partnerships aren't entirely new. Corporate actors have always played a role in US spacefaring efforts: military contractors like Lockheed Martin and Northrop Grumman have long had a seat at NASA's table, providing launch rockets and spacecraft development. One thing that has changed, however, is the people involved. These days, NASA is working alongside companies with fewer ties to the defence industry, companies that also happen to be strongly identified with billionaires – especially Richard Branson, Elon Musk and Jeff Bezos.

This has triggered a new personality-driven space race and, with it, a re-evaluation of the power dynamics. Increasingly, the public conversation seems to assume that government organisations like NASA are no longer leaders in space. Instead, NASA has been relegated to client (for getting astronauts to the International Space Station), funding source and launch management support. My own understanding is that this transformation in attitudes isn't an accident, but rather began intentionally under the George W. Bush administration in particular. The goal? The commercialisation of space, the next capitalist frontier.

I am under no illusions about why NASA came into existence. I know it is a product of the cold war between the US government and the government of the Soviet Union. I make a point of saying this was a conflict between two governments because everyday people were caught in the middle, with little say over the power plays of their leaders. In different ways, people on both sides of the Iron Curtain weathered a terrifying time, filled with extraordinary amounts of propaganda and a militarised space race that each nation's leadership articulated as proof of political supremacy.

"I'm concerned that human expansion into space will exacerbate colonial logics and growing inequalities"

Part of the propaganda I grew up with was that the US was a real democracy. The United States is, in theory, a democracy where the people can have a say in what NASA does. I say in theory because, to quote Langston Hughes, "America never was America to me." As a settler colonial nation that built its wealth through dispossession and slavery and followed those acts up with a long and ongoing campaign to deny many citizens the right to vote, the idea that the US is a democracy can seem a bit laughable.

But an interesting idea arises out of the false narrative that the US is a true democracy: a space agency for the people, by the people. This week, I have been thinking about this possibility a lot because I have recently been at a two-day workshop that brought interested parties together to discuss the future

of the space economy. I think that most of the attendees came in concerned about the opportunities space provides for economic growth – plans are already afoot to mine the moon and asteroids, for example.

There were a few sceptics like me who were concerned that accelerating human expansion into space will exacerbate colonial logics and already growing economic inequalities. What right do we have to exploit other planets the way we have exploited Earth?

In two days of conversation, I was the only person I heard bring up the importance of labour rights advocates having a say in how it all pans out. There was little acknowledgement of billionaires' dependence on public finance, on the taxes paid by workers across the US that helped to launch their commercial space-flight ventures.

One person told me that a particular billionaire, some of whose workers are currently suing because of alleged workplace racism, was entitled to everything he had because he had earned it. I said my concern wasn't with merit – I mean fine, give him an award – but rather how we can create the conditions where everyone has what they need.

You might think that has nothing to do with space. But I think space is part of what we need. Every human community has a long-standing relationship with the night sky. It is part of who we are. The problem is that, right now, very few of us have a say in what happens to the night sky, how humans get to space or what we do there. That has to change. Instead of giving space up to billionaires, maybe we should all be working to make good on the idea of a space agency that supports humans living in good relations with each other. ■

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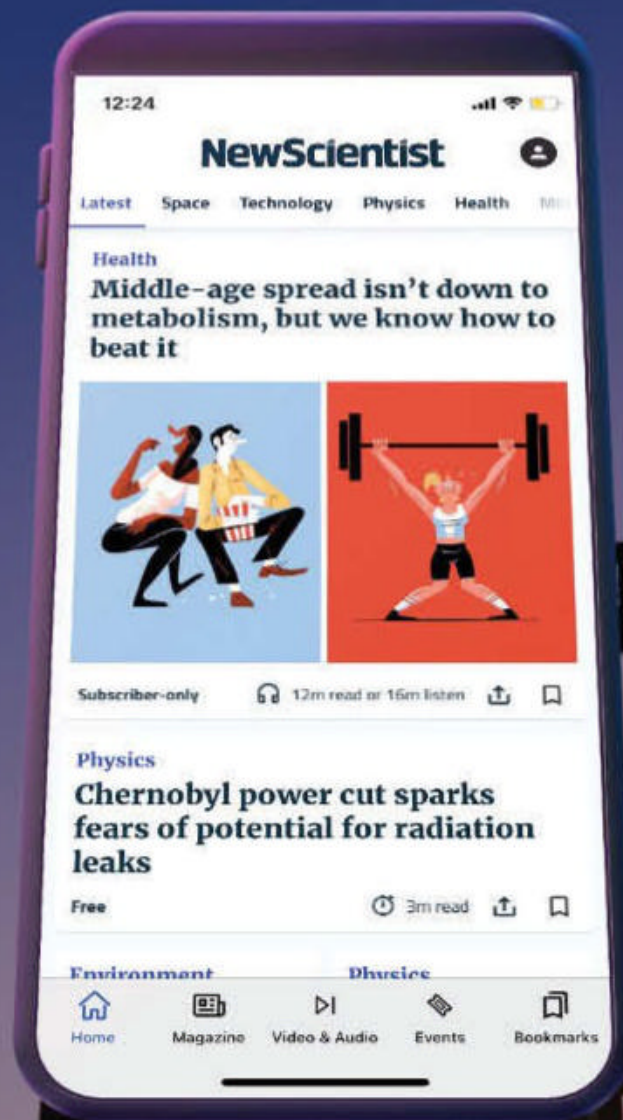


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In the pink



Photographer
Claudio Contreras Koob

THESE dazzling photos showcase one of the world's most distinctive birds: the flamingo. Taken by biologist and photographer Claudio Contreras Koob, the images are a selection from his new photography book, *Flamingo*, which captures the lives of colonies in the Yucatán peninsula in Mexico.

An aerial view of Yucatán's flamingos is shown in the near-left image. The Ría Lagartos delta, located at the northern edge of the peninsula, and the Celestun estuary, which is a few hundred kilometres to the west, provide wetlands that are an ideal habitat for these wading birds. Shallow waters make these estuaries excellent for nesting and feeding. The region sustains some of the world's largest populations of flamingos.

In the top far-left photo, a flamingo chick peeks out from the bright pink-orange plumage of its parent, while the images below it show a lone adult and one of the peninsula's crowded nesting sites. Flamingo mud nests must be continuously maintained to ensure rising water doesn't wash away any eggs. ■

Gege Li

Editor's pick

Surely there is more to baby boomer misery

5 March, p 21

From Pam Lunn,

Kenilworth, Warwickshire, UK

You report research that concludes baby boomers are the “unhappiest generation” because of “greater competition” in a large cohort.

This raises the question: can cohort size really be the only cause? What about the intergenerational and epigenetic changes from two world wars? These would relate to the effects of stress and social, economic and nutritional shifts.

A large proportion of the baby boom generation had grandparents affected by the first world war. The parents of the boomers were born to, and raised by, those people; then they themselves were affected by the second world war. These parents then gave birth to and raised the boomers. Can all of this be ignored?

Could a slight change avoid reliance on Russian fuels?

5 March, p 9

From Zoe Farren,

Windermere, Cumbria, UK

Further to coverage of energy issues related to the Russian invasion of Ukraine. Less than 10 per cent of the oil and gas used in the UK seems to be imported from Russia, and the figures are smaller in the US.

Is it too simplistic to suggest that if everyone in these countries cut use of oil and gas by a minor degree, there would be no need to import from Russia, no need to court questionable regimes for supplies, and no need to revive the case for fracking in the UK?

Advice from a Pollyanna on keeping up spirits

22 January, p 38

From Bonita Ely, Sydney, Australia

Following up on David Robson's article “The pursuit of happiness”,

as a Pollyanna with a relentlessly sunny disposition, I am never lonely or depressed.

I offer the following lessons to add to Laurie Santos's free online course that Robson mentions: enjoy your own company; use your imagination, be creative, be a maker; enjoy the creativity of others – writing, music, films, art, plays and so on.

Solar doesn't need to cover fields with panels

Letters, 5 March

From Georgina Skipper,

Weymouth, Dorset, UK

In reference to the circular economy, Geoff Russell paraphrases that “for every complex problem there is an answer that is clear, simple and wrong”. He says this applies to mass solar power, in part due to its land requirements.

This ignores a clear and simple application of solar panels – on the 50 per cent of pitched roofs in countries such as the UK that face south-east to south-west. There is already a system to feed surplus solar electricity into the grid in productive periods, and with better batteries, more houses can become self-sufficient. There is no need for vast solar panel arrays.

The many unsung health benefits of owning cats

5 March, p 23

From Ametrine Lavender,

Hebden Bridge, West Yorkshire, UK

In your article “Dogs trump cats in helping people stay fit as they age”, the conclusion appears to be that walking a dog regularly has benefits in reducing future ill health, but that having cats has no ongoing health benefits.

I suggest the researchers are

defining health and disability too narrowly, and particularly missing out the role of cats for people who have ongoing mental health issues or are neurodivergent. Many such adults, especially if single, are aware they can't manage the day to day needs of a dog, but having a cat can provide a furry friend.

I often tell people that “my cats are the people I come home to”. There seems to be evidence that cat ownership by people with poor mental health has a beneficial effect on their lives because of their commitment to and relationship with their cat.

It would be interesting to see some research into the benefits of feline companionship for single adults, and particularly those with already existing conditions, whether physical, neurological, or psychological.

It might be wise to temper long covid cure hopes

26 February, p 38

From Stephanie Woodcock,

Carnon Downs, Cornwall, UK

It may turn out to be premature to think that many treatments will become available for long covid a year after the immunological toolkit has been applied to studying the condition.

If current research doesn't yield the hoped-for answers, then paths forward become elusive. People with similar conditions, such as myalgic encephalomyelitis (ME), also called chronic fatigue syndrome, have come to know this only too well.

We should consider the idea that a latent infection, carried undetected and capable of evading and confusing the immune system, is involved in long covid. Were this to be the case, then any additional serious health

challenge, such as the coronavirus, might cause the immune system to become overwhelmed. At that point, any latent infection would have a chance to manifest.

I'm ready to catch the slugs, but what then?

5 March, p 48

From Jane Pearn,

Selkirk, Scottish Borders, UK

After reading your interview with “slug hunter” Rory Mc Donnell, I'm all set to trot outside with bread dough to catch the little blighters. But if it works as well as it did for Mc Donnell, I'm picturing heaving balls of live and happily feasting slugs and snails.

He talks about “terminating” more than 18,000 snails. My question is: how? Instruction part two needed, please.

A good book is as good as self-transcendence

5 March, p 44

From Anne Goodall,

Churchdown, Gloucestershire, UK

Regarding your look at the benefits of self-transcendence. Simply losing yourself in a good book can be a benefit in this world of constant outside stimuli.

From Peter Brooker,

London, UK

Is it the case that transcendental experiences could counteract the depression and anxiety generated in most people by the reports of daily horrors in Ukraine?

London cabbies seem to be able to gain new brain cells

26 February, p 16

From Charles McDowall, Bristol, UK

The idea that adults can't grow new brain cells clashes with some empirical evidence. In particular, reports of trainee London taxi drivers developing enlarged geographical capability with a corresponding rise in brain size when learning “the knowledge”, a taxing test of navigating the city. ■



Want to get in touch?

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Flying into disaster

When we fasten our seatbelts, we put our trust in aviation companies to keep us safe. But what if they are more interested in profit, asks **Elle Hunt**



Film
Downfall: The Case Against Boeing
 Rory Kennedy
 Netflix

AS STORM Eunice buffeted much of the UK last month, a surprising focal point emerged: the live webcam stream of arrivals at London Heathrow Airport. At one point, 200,000 viewers tuned in to watch passenger planes struggle against the wind to land safely.

This mixture of fascination and fear typifies our relationship with flying. It feels risky, but we don't really expect a crash.

Downfall: The Case Against Boeing, directed by Rory Kennedy and new to Netflix after a positive reception at Sundance in January, opens with the usual reassurances about the safety of air travel: tens of thousands of flights pass without incident daily all over the world. Many of these use Boeing planes, a fact that, until recently, was considered to be a good thing. Trust in the company was such that there was a phrase in the aviation industry: "If it ain't Boeing, I ain't going."

Then, in October 2018, all that changed. A Lion Air flight crashed into the sea with 189 people on board, minutes after departing from Jakarta in Indonesia. All passengers and crew were killed. Five months later, an Ethiopian Airlines plane crashed in similar circumstances, and with a similarly tragic outcome. The type of plane in both cases was a 737 Max, a recently released update of the Boeing 737.

These crashes brought to an end the safest period for commercial flying in the history of aviation. It also cast doubt on Boeing's reputation as a model of safety



COURTESY OF NETFLIX

The Boeing 737 Max had a dangerous flaw in its flight control system

and the premier aeroplane manufacturer in the US.

The black box of the Lion Air flight revealed a failure of the "angle-of-attack" sensor that measures the angle of the nose of the plane while in flight. Simulations and testimony from pilots paint a sickening picture of the desperate battle to regain control of the aircraft.

Boeing traced this to a software failure: an erroneous activation of the Maneuvering Characteristics Augmentation System (MCAS), new to the 737 Max. Pilots could have switched it off, had they known it existed. But Boeing hadn't told them it was a feature of the updated 737, let alone trained them on it.

The former *Wall Street Journal* reporter Andy Pasztor, who acts as the audience's guide through the story, says a senior executive at Boeing told him that the airline "didn't want to overwhelm" pilots.

The anger of pilots and unions

at this omission seems justified. Dennis Tajer at the Allied Pilots Association calls it "disrespectful", adding: "You want to know as much about your airplane as possible."

In the fallout, Boeing, having previously enjoyed its position as the pilots' advocate, briefed journalists against Lion Air and the flight's pilot, Bhavye Suneja, saying (to quote Pasztor) that "an American pilot would never

"Simulations paint a sickening picture of the desperate battle to regain control of the aircraft"

have gotten into this kind of a situation". The testimony of Suneja's widow stands in dignified contrast to this. "I knew my husband. I knew how he flew," she says.

After the first crash, while a software fix was in the works, 737 Maxes continued to fly. Then came the Ethiopian Airlines crash. The US Federal Aviation

Administration did nothing, but many countries grounded the 737 Max planes, and put pressure on then US president Donald Trump to take action.

The subsequent government investigation found "repeated and serious failures" by Boeing. In November 2021, the airline admitted total responsibility for the Ethiopian Airlines crash.

Boeing's contribution to the film is limited to a supplied statement in corporate-ese at the end. Combined with the depth of research, this lack of participation makes the film seem like a damning report rather than a one-sided one.

Downfall is a brisk, level-headed account of a company's colossal failing, and the lengths that it will go to preserve reputation and profit margins, even at the expense of safety. But what makes it memorable viewing is the reminder of the trust we need when we take to the skies. ■

Elle Hunt is a freelance writer based in Norfolk, UK

Keeping up appearances

Living an online life can be a dream come true, but it is all too often a nightmare, finds **Chris Stokel-Walker**



Book

Get Rich or Lie Trying: Ambition and deceit in the new influencer economy

Symeon Brown
Atlantic Books

THE influencer economy, fuelled by the ability of social media to instantly reach millions of people, has changed the way we work, rest and play. For some, the rise of this new way to make a living has been a boon – demolishing gatekeepers, minting a new era of celebrities and making millionaires of people who might otherwise be trapped in a dead-end job.

But this has been far from a uniformly good thing for society. As Channel 4 News journalist Symeon Brown uncovers in *Get Rich or Lie Trying*, the seedy side of social media can be as harmful as it is helpful.

Brown's reporting sees him go back to the streets of London where he grew up to hear from school friends who have fallen prey to pyramid schemes dressed up as online cryptocurrency investments. He also heads to Los Angeles, where he meets nipped and tucked influencers seeking the perfect body, often ruining their health in the process.

Get Rich or Lie Trying is a chastening read, clearly showing that the lowlights of online fame are as depressing as its highlights are inspiring. Brown races through the influencer economy and the different industries it touches, from the sweatshops churning out poor-quality clothing to ensure that scrolling teenagers can keep up with the latest red carpet looks

Lights, glamour, followers – and unrealistic expectations about fame, fortune and happiness

on a budget, to the surgeons that perform Brazilian butt lifts, a risky procedure where fat is taken from other parts of the body and injected into the buttocks.

At times, Brown hurtles through first-person stories so fast that there is hardly a chance to blink. Those he highlights as exploiting social media – or being exploited by it – sometimes pass by too quickly for us to remember who they are or why we should care. It feels a bit like the relentless hamster wheel of the algorithms that drive social media platforms, and the whole experience can become a bit discombobulating.

At times, you struggle to see who to feel sorrier for: the young woman cajoled into performing a sex act on camera, or the man who is paid to receive insults online. Sometimes, they blur into a catalogue of horrors that becomes difficult to unpick and reflect on.

The book's stronger sections are those that bring the action closer to home and address some deeper, more systemic issues. A chapter on how social media's unique voice is often driven by authentic Black voices that are then co-opted and copied by richer, white entrepreneurs without qualms

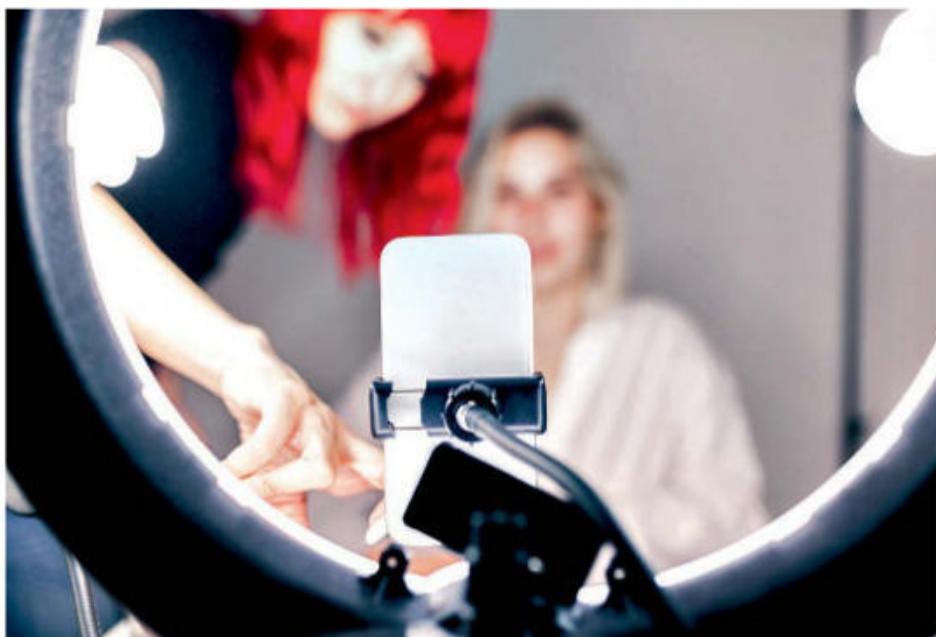
is particularly powerful, and begins to tackle wider problems entrenched in social media.

Elsewhere in the book, the bigger picture is lacking, however. We know, for example, that the drive to achieve physical "perfection" is an issue, and research has made clear both the role that social media platforms play in perpetuating this and the effects of such ideals on mental and physical health. Yet Brown spends surprisingly little time questioning what can be done about the broken bodies and livelihoods left behind in the race to get famous on social media, or even who is to blame.

The book does a much better job of highlighting just how perilous living a life designed to go viral can be – and how quickly the thing that made you famous can become passé. It raises important questions about the value we place on superficial appearances, and how social media all too often encourages us to sacrifice thinking deeply in favour of a neat sound bite.

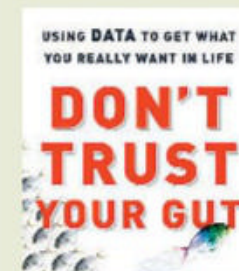
Overall, *Get Rich or Lie Trying* is well worth reading – but, like social media, at times it would do well to go deeper and dwell a little longer. ■

Chris Stokel-Walker is a journalist based in Newcastle, UK



GETTY IMAGES/WESTEND61

Don't miss



Read

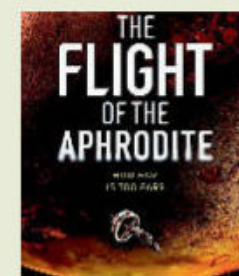
Don't Trust Your Gut

says data scientist Seth Stephens-Davidowitz. You probably know less than you think about how to be healthy and happy. So, it may be time to ignore your instincts and try self-help by data. Out on 9 June.



Visit

Rooted Beings can teach us a lot about how to connect with each other, according to this exhibition on plants and fungi. Work from the botanical archives will be shown alongside new art at London's Wellcome Collection from 24 March.



Read

The Flight of the Aphrodite

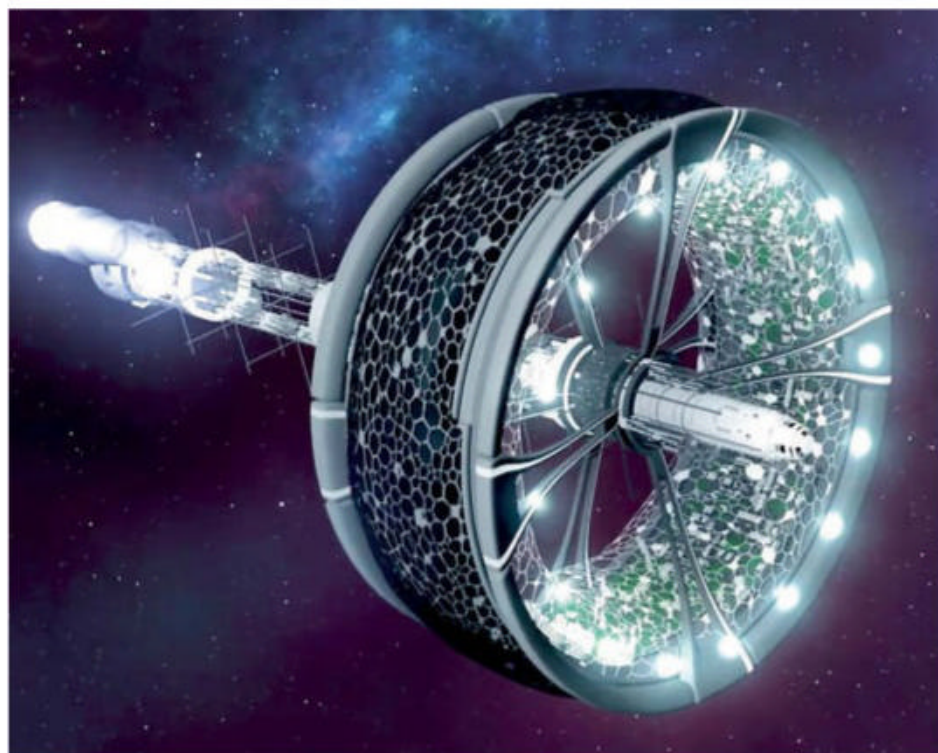
is a thrilling new sci-fiction novel from S.J. Morden about an eventful mission to Jupiter's moons. Ship and crew are already at breaking point and then it seems they have uninvited company.

The film column

Reach for the stars We have made a mess of Earth, but does that mean we should head for space and have another go? There are many reasons not to, and not all of them come down to technical difficulties, finds **Simon Ings**



Simon Ings is a novelist and science writer. Follow him on Instagram at @simon_ings



Interstellar travel will need human ingenuity, and a lot of patience

These issues will only grow with more extreme distances travelled. Interstellar travel will require a ship capable of supporting entire generations of humans. Lapierre's testimony, says Werner Herzog's narration, suggests that any such mission will be plagued with "strife, crime and depravity".

In that case, we might be better off staying put. This, surprisingly, is the advice of a cleric from the Valley of the Dawn community in Planaltina, Brazil, who believe they receive energies from visiting extraterrestrials from the Capella star system. These apparently advise against interstellar travel, which I'm sure NASA would be interested to hear.

Last Exit: Space suffers from its wide-eyed, catch-all approach to the subject; I found the lack of critical analysis frustrating. We are regaled with tales of "the human pioneering spirit", as though humans were destined to explore and become somewhat less than human when not exploring. This is an opinion not established fact. Many human cultures have made a great success of staying put. Set in false opposition to this are an astonishing assortment of dystopian fantasies: space corporations will control our water! Space corporations will control our air!

Astronaut Mike Foale and astronomer Lucianne Walkowicz provide the documentary with small but penetrating moments of reason. Space is an additional field of human endeavour, they point out, not an escape route from a wrecked home planet. "Do we need to seek our destiny among the stars?", asks the documentary early on. Let's hope not. ■



Film

Last Exit: Space

Rudolph Herzog

Discovery+

Simon also recommends...

Film

Apollo 11 (2019)

Todd Douglas Miller

Assembled from archive footage and uncluttered by narration or interviews, this account of the first crewed journey to the moon provides a unique and original view of the moon landings.

Book

The Space Barons

Christian Davenport

Public Affairs

Exclusive interviews and years of research lend ballast to this clear-eyed account of the often overheated and overhyped private space sector.

HOW will people copulate in space? How much antimatter would it take to get to Proxima Centauri b? How much skin would each of us need if we could somehow bioengineer humans to photosynthesise? These are just some of the challenges examined by documentary-maker Rudolph Herzog in *Last Exit: Space*, a peculiar dash through humanity's ambition to colonise space.

A traditional documentary might look for answers via the press offices of the European Space Agency or NASA. Not so Rudolph Herzog, whose father, fellow film-maker Werner Herzog, narrated and executive-produced this film. Instead, the film zooms in on those who are dedicated to solving the conundrums of space travel, one challenge at a time.

The result is a charming, yet unfocused and slightly odd, take on space exploration. In Denmark, we meet volunteers at the non-profit organisation Copenhagen Suborbitals who are crowdfunding to build a full-size rocket to send the world's first amateur astronaut into space.

Meanwhile, in the Negev desert in Israel, citizen scientists from the Austrian Space Forum are putting a not-too-sophisticated-looking Mars spacesuit through its paces.

As well as looking at the technical barriers to moving off-planet, the film ponders whether it is a good idea in the first place. Among the naysayers is space

"The possible future living conditions on Mars are compared to working in an Amazon fulfilment centre"

anthropologist Taylor Genovese, who compares the possible future living conditions on Mars to working in an Amazon fulfilment centre. Judith Lapierre, the sole female crew member of the Sphinx-99 isolation experiment in the late 1990s, describes how this study in close-proximity living ended with her alleging sexual harassment against another crew member. It does beg the question, if we can't get along on Earth, what chance do we have in space?



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Wave after wave

By observing dozens of gravitational waves – and spotting completely new kinds – we are solving some of the universe’s deepest puzzles, reports **Stuart Clark**

IN A darkened room in Sweden, beneath a chandelier and surrounded by dozens of gilt-framed portraits, journalists are listening as a phone connection is established with Rainer Weiss. It is October 2017 and Weiss has just been awarded the Nobel prize in physics for spearheading the detection of gravitational waves, along with Kip Thorne and Barry Barish. The pomp and ceremony was a fitting finale to the quest to detect these elusive waves, which had been predicted by Albert Einstein more than 100 years earlier.

In truth, though, it was as much a beginning as an ending. If the traditional astronomy of telescopes is like seeing the cosmos, then gravitational wave astronomy is akin to hearing it. The discovery of these ripples in space-time had effectively given astronomers a new sense. In that room crowded with reporters, a journalist from Swedish television took the mic and asked Weiss what kind of things we might be able to learn. “Well,” he began, “there’s a huge amount of things to find out.”

Less than five years later, and with scores of gravitational waves now detected, we are starting to see what he meant. These waves are providing us with a rich picture of the universe’s most exotic objects, showing us

fresh details of how stars die and explaining long-standing mysteries about the cosmic population of black holes. What’s more, we seem to be on the cusp of detecting a whole new kind of gravitational wave, one that could tune us in to the frequency of some deeply mysterious objects we think were forged in the aftermath of the big bang.

Giant pebbles

Imagine dropping a pebble into a pond and watching the ripples spread out in concentric circles. A gravitational wave is a bit like this, except instead of a pebble, we have massive, moving objects like black holes, and instead of water, the ripples are in space-time itself and propagate in three dimensions. These waves were one of the last unverified predictions of Einstein’s general theory of relativity. That is why Weiss and many other physicists banded together decades ago to try to snare them.

To do so, they built two gigantic instruments in the US that are collectively known as the Laser Interferometer Gravitational-Wave Observatory, or LIGO. These detectors each fire two precision lasers in different directions from a central starting point at mirrors that are

several kilometres away. The path the beams take is the same length, so any slight difference in when they arrive back at the origin indicates a change in the space they have traversed – a sign of a gravitational wave swooshing through Earth, stretching and squashing space.

Detecting these ripples isn’t easy, given that gravitational waves change space by much less than the width of a subatomic particle. But the LIGO team succeeded. These days, there are another three similar detectors: Virgo in Italy, the Kamioka Gravitational Wave Detector (KAGRA) in Japan and GEO600 in Germany.

The most useful thing about this groundbreaking work is that it gives us a window on black holes, objects that are otherwise tricky to study. Unlike stars or planets, black holes don’t directly give out or reflect light. But they do sometimes crash into each other, creating waves in the fabric of space-time. “Gravitational wave detectors are doing something truly unique,” says astrophysicist Thankful Cromartie at Cornell University in New York. “You’re sensitive to a whole bunch of different kinds of events.”

At first, there was a thrill in just hearing the “chirp” of colliding black holes. But researchers from LIGO, Virgo and KAGRA released



another batch of results in November 2021, which brought the total number of observed waves to 90. With so many gravitational waves now in the bag, we are in a new era, one in which we can answer questions about how the universe works on the grandest scales.

Perhaps more than any other class of celestial object, black holes mark out the history of the cosmos. They come in a variety of sizes and are formed in different ways over the life of the universe. There are stellar black holes, which are born when giant stars die and have masses from several times to tens of times that of the sun. Then there are supermassive black holes, which can be anywhere from a few million to a billion solar masses. These live in the centres of galaxies and are thought to have formed as smaller black holes merged.

Thimbleful of neutrons

Our understanding of how these types of black hole grow and relate to each other is, however, riddled with confusion. One major puzzle is the mass gap between the smallest black holes and the largest neutron stars. Neutron stars are the collapsed cores of dead stars and the second most dense objects in the universe; a thimbleful of neutron star weighs hundreds of millions of tonnes. It is thought that these stars can reach a point of such density that they collapse into a black hole. If this is true, then the lightest black holes should have about the same mass as the heaviest neutron stars.

But that isn't what we see. Even before LIGO, we had ways of estimating the mass of black holes and neutron stars. These suggested that the heaviest neutron stars got no heavier than about twice the mass of the sun, while the lightest black holes were no lighter than about five solar masses. In 2010, Feryal Özel at the University of Arizona called attention to the paucity of objects of two to five stellar masses, sparking debate about whether we had seriously misunderstood neutron stars. In the first few years after LIGO was switched on, we still didn't see anything definitive in this "mass gap".

But with the data released in November, that has changed (see "Mind the gap", right). There have now been at least two events in which a black hole swallowed some smaller object –

“At first, there was a thrill in just hearing the ‘chirp’ of colliding black holes”

another black hole or a neutron star, we can't be sure which – that weighed in at 2.6 solar masses, squarely within the mass gap. A third sighting from LIGO caught a black hole eating a 2.1-solar-mass neutron star. Meanwhile, Cromartie and her colleagues spotted a neutron star that was 2.19 solar masses using radio telescopes.

Katerina Chatziioannou at the California Institute of Technology, who is part of the LIGO collaboration, says these detections are telling us that the mass gap is an observational bias. LIGO is better at detecting more massive objects. "We're very good at seeing black holes of 30 solar masses, but less good at seeing black holes of five solar masses," she says. Mass-gap objects are out there, it seems, they are just hard to spot. LIGO is currently being upgraded such that it will be more sensitive to lighter objects when it switches back on later this year.

There are also surprises in the latest data when it comes to the most gigantic stellar

Mind the gap

For years, there has been an unexplained gap between the lightest black hole and the heaviest neutron star, (see main story). But key new observations from the Laser Interferometer Gravitational-Wave Observatory (LIGO) are beginning to fill this. We also thought there should be very few black holes more than 45 times as massive as the sun – but LIGO is finding plenty.



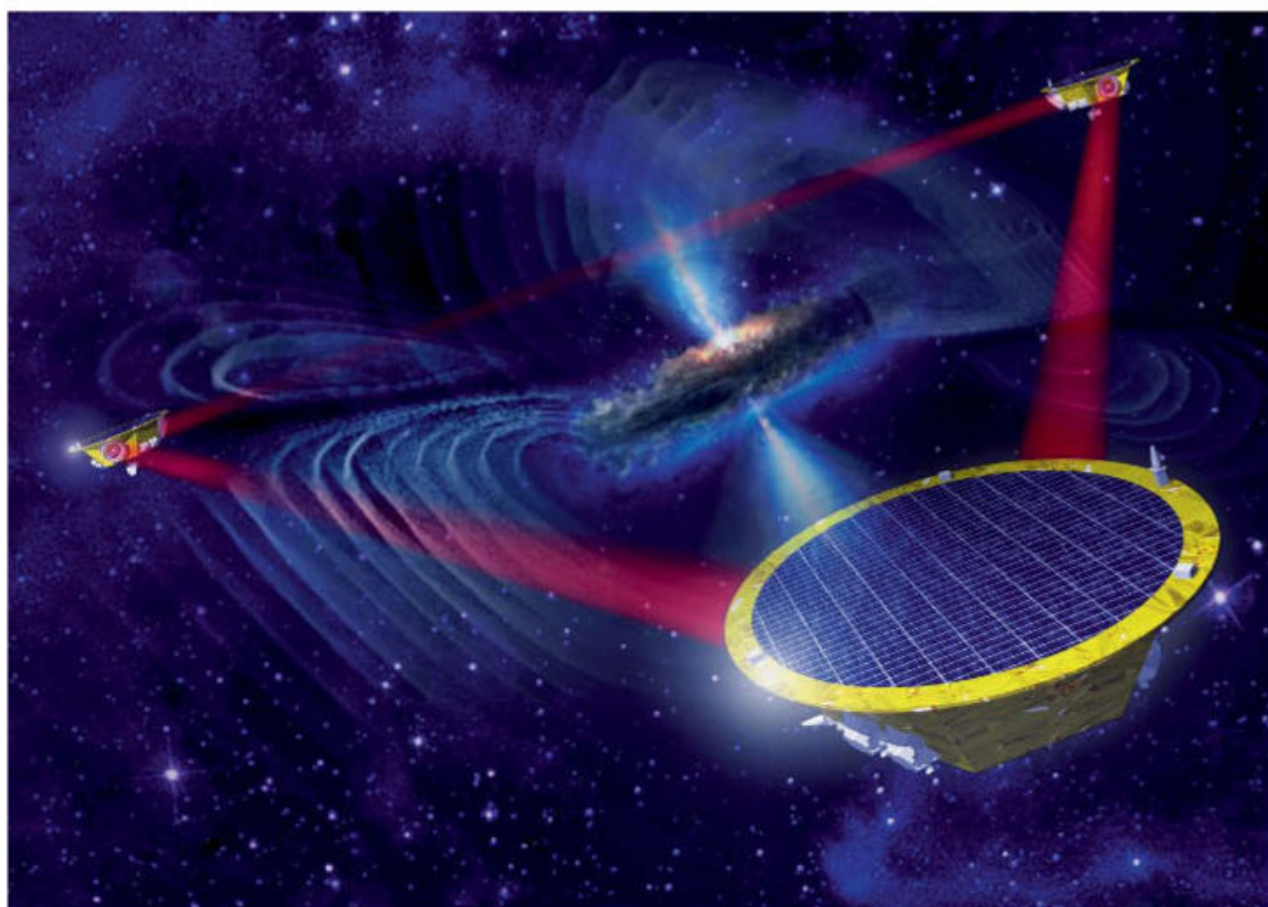
OUT OF THIS WORLD

One reason detecting gravitational waves on Earth is so tricky is that our planet throbs beneath our feet. When you are trying to detect the unimaginably tiny squashing and squeezing of space caused by colliding black holes, the last thing you want is any seismic vibrations in the ground shaking the equipment.

That is why the European Space Agency (ESA) has hatched a plan to get away from those bad vibrations by putting a gravitational wave detector in space. Known as the Laser Interferometer Space Antenna, or LISA, the mission is staggering in ambition. It will work according to the same principles as the Laser Interferometer Gravitational-Wave Observatory on Earth (see main story), but instead of timing the path of laser beams on the ground, LISA will fire lasers from one free-floating craft to two others, each exactly 2.5 million kilometres away.

As the lasers bounce between these spacecraft, they will register the minuscule changes in their relative position caused by passing gravitational waves. While LIGO is designed to snare the waves produced by black holes of about 30 solar masses, LISA should be capable of seeing much longer waves from larger black holes: ones with hundreds of thousands or even millions of solar masses each.

We know the technology works because ESA launched a demonstration mission in 2015 called LISA Pathfinder. It was a great success. Still, we will have to wait a while for LISA to come online – it is scheduled to launch in 2037.



black holes. The heaviest stars yet discovered are more than 200 times the mass of the sun. But when one of these stars dies, we think the explosion is so powerful that nothing is left, not even a black hole. In fact, according to our best understanding of these events, no black hole heavier than about 45 solar masses should be created from a supernova, no matter how massive the star was.

But LIGO is detecting black holes that tip the scales at 60 solar masses and beyond. Even accounting for the bias of the detector towards heavy objects, there are more of these monsters than expected. This might be telling us that we have misunderstood supernovae, or perhaps that black holes grow to such sizes by merging with each other.

Using gravitational waves to study the supermassive black holes – the ones that are millions of times heavier than the sun – could tell us more about cosmic history. Today, one of these behemoths sits at the centre of pretty much every galaxy, providing the gravity gluing its stars together. To get to their present sizes, older, smaller galaxies and their supermassive black holes must have merged. But we have never been able to peer far enough back in time to see this happen.

These colliding supermassive black holes would have given off gravitational waves. But the actual collisions are expected to be rare,

The LISA detector will aim to detect gravitational waves in space

and because the orbital speeds would be low, the waves would have lower frequencies than those observed up until now. A LIGO-style detector would never be sensitive enough to see them – unless it was put in space (see “Out of this world”, left).

But there is another way. Even before they merge, orbiting supermassive black holes give out weak gravitational waves. Individually, these are insignificant, but when combined with those being given out by all other such black hole pairs across the universe, they add up to an incessant, infinitesimal burbling of space-time that criss-crosses the cosmos. It is known as the gravitational wave background.

This background is actually a million or more times “louder” than the LIGO signals, but a full wave undulation lasts for years. Detecting it would mean measuring an oscillation that is still far less than the width of an atom and takes place over the course of years. “The nature of the signal itself is very different,” says Joe Simon at the University of Colorado, Boulder.

Simon and Cromartie are part of the North American Nanohertz Observatory for Gravitational Waves (NANOGrav) project, which aims to measure this signal. ➤



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JEE SEYMOUR IMAGES

NANOGrav uses conventional radio telescopes to monitor fast-spinning neutron stars called pulsars. As they rotate, pulsars send out regular beams of radio waves into space, like a lighthouse, which serve as extremely stable clocks. NANOGrav has been timing signals from dozens of pulsars across the sky for a decade. Any tiny discrepancies in when the flashes arrive here could be a sign of the ripples of the gravitational wave background.

Black hole revelations

About a year ago, the NANOGrav researchers announced an analysis of almost 13 years of data for 45 pulsars. In it, they saw hints of a signal that could be the background. They haven't yet resolved the signal well enough to be sure, but the NANOGrav team has since combined its data with that of two similar pulsar timing arrays in Europe and Australia to form the International Pulsar Timing Array collaboration. This triumvirate announced in January that in the combined data set, the signal stayed put, providing a stronger suggestion that this is no false alarm.

Even if this is the real deal, it won't be possible to deduce anything about individual supermassive black holes. Instead, astronomers would model versions of the

“With so many gravitational waves spotted, we can start answering the big questions”

Radio telescopes, such as the Green Bank Observatory in West Virginia, can observe pulsars

universe in computers, each with different populations of giant black holes and varying merger rates, and see what kind of gravitational background signal should be produced. By comparing the models and the real data, we should be able to deduce a lot about the kinds of black holes out there in the cosmos.

The most exciting prospect would be if the computer models couldn't be made to fit the data. This might mean that we will be forced to invoke another type of black hole entirely to balance the books.

In some interpretations of the big bang, fluctuations in the density of space in the first seconds of the universe could have produced tiny black holes. It is far from certain whether these so-called primordial black holes existed, or if they are still out there. But if they are, they provide an elegant solution to several problems in cosmology. Most appealingly, they could be the secret identity of dark matter, the invisible stuff thought to be guiding the motion of galaxies.

According to Suvodip Mukherjee at the Perimeter Institute in Waterloo, Canada, the gravitational wave background could provide us with the first concrete evidence of primordial black holes. “I find this possibility very fascinating,” says Mukherjee. He and his colleague Joseph Silk at Johns Hopkins University in Maryland recently showed that it should be possible to distinguish regular and primordial black holes in the gravitational wave background.

First, though, we must unambiguously detect the background signal. To that end, the NANOGrav team is analysing another three years of data from almost 60 pulsars. This should tell us for sure whether we are seeing the gravitational wave background. But as our first detection of gravitational waves taught us, that will be only the beginning. “It's not going to end once we say we've detected the gravitational wave background,” says Cromartie. “That's when our science really starts.” ■



Stuart Clark is a consultant for New Scientist. His latest book is *Beneath the Night* (Faber)

Save our bunnies

A mysterious viral disease is putting rabbits in a real hole. Can they get out of it, asks **Graham Lawton**



MR MCGREGOR's only desire was to keep Peter and his pesky playmates off his vegetable patch – and, if he got lucky, to make a pie out of them, according to Beatrix Potter. Meanwhile Elmer Fudd's fervent wish was to put a bullet through his arch-nemesis, Bugs.

Popular culture depicts a certain antagonism between human and rabbit, while often emphasising the bunnies' role as sassy survivors. But having already seen off one huge existential threat in the past century, the viral disease myxomatosis, rabbits now face another horrendous adversary, rabbit haemorrhagic disease virus, or RHDV. At the same time, we have come to realise that rabbits aren't just fast-breeding agricultural pests, but key to many healthy, functioning ecosystems worldwide. "Rabbits are in a lot of trouble," says Pip Mountjoy at UK government agency

Natural England. "They need our help."

The European rabbit, *Oryctolagus cuniculus*, evolved around half a million years ago. It was once widespread across Europe, including the British Isles, before being penned into Iberia by the last ice age. Their global expansion began in the 1st century BC with the Romans, who domesticated rabbits for food and fur and spread them back across their former range.

Some say the Romans reintroduced the rabbit to Britain, others point to the Normans. It was definitely the British who brought them to Australia in 1859 and New Zealand in the 1860s. A small colony established in the US in 1875 to control weeds quickly expanded across North America. The European rabbit is now one of the most widespread species on Earth, living on every continent except Antarctica.

That is partly because rabbits breed like, well, rabbits. Females are reproductively mature at

three to four months and have frequent litters of up to six kits. A breeding pair can produce 40 kits a year, and fertile males roam widely (see "Rabbit rules", page 45). In the 19th and early 20th centuries, developments such as the planting of winter fodder crops for livestock and the slaughter of natural predators also boosted populations, making rabbits a serious agricultural pest in many parts.

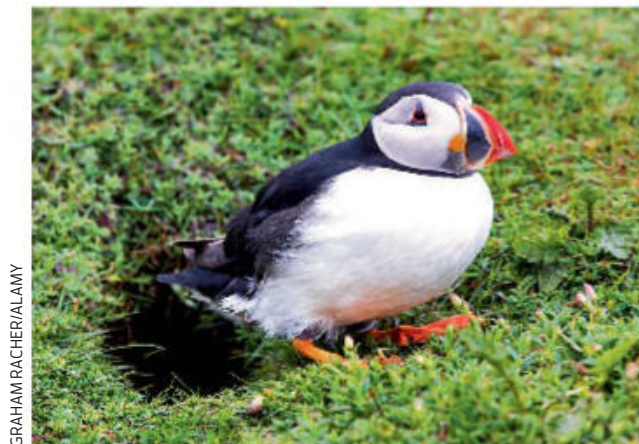
With shotguns, ferrets, traps and poisons proving to be ineffective, and fences simply burrowed under, thoughts turned to a more dastardly method of control: biological warfare. In the 1950s, through a mixture of accident and intention, myxomatosis was unleashed, almost entirely wiping out rabbit populations, first in Australia and then in Europe (see "Myxomageddon", page 44).

Only then did we realise how much we missed them. It turns out that rabbits are



both a keystone species and an ecosystem engineer crucial to maintaining entire sensitive food webs and habitats. On the island of Skokholm off Pembrokeshire, UK, for example, scene of an early myxomatosis trial, rabbit burrows provide nesting sites for puffins and shearwaters. Many airborne and land-based predators rely on rabbits for food, while their relentless grazing and burrowing maintains semi-open “mosaic” habitats rich in wildlife. One example is the Breckland in East Anglia, UK, a Special Area of Conservation that features the country’s only active, constantly moving inland sand dunes and rare wildlife, including the prostrate perennial knawel, a plant found nowhere else in the world.

Following rabbits’ near-elimination in the UK, some farmers rejoiced at increased crop yields. But plant communities became less diverse and rabbit-eaters, such as buzzards, stoats and peregrines, suffered heavy losses. In 1979, the large blue butterfly went locally



GRAHAM RACHER/ALAMY

extinct in the country, its caterpillars starved by a lack of the red ants that once thrived in rabbit-grazed grasslands and fed them. Similar shifts were seen in Australian wildlife, with declines in many bird and marsupial species.

It might seem counter-intuitive that an introduced species can also be a keystone species, says Diana Bell at the University of East Anglia in Norwich, UK, who has been studying

Puffins on the island of Skokholm, UK, benefit from rabbit burrowing

Britain’s rabbits for half a century. But many landscapes in places like the UK are intensively managed, so what is “natural” is debatable. In areas like the Breckland, rabbits have taken over from native herbivores that are no longer present, such as wild boar, says Mountjoy.

The new threat of RHDV was identified in China in 1984. It kills 80 to 90 per cent of its victims like a bunny-boiling Ebola. Victims bleed from the mouth and nose, convulse, fall into a coma and die. The first wave of the disease spread rapidly into Europe. Spain recorded its first case in 1988. Soon more than 60 per cent of Iberia’s wild rabbits succumbed, pushing their natural predators, the Iberian lynx and the Spanish imperial eagle, closer to extinction.

A new wave of a related disease, RHDV2,

Myxomageddon

The devastating lethality of myxomatosis on the European rabbit was first noted in 1896, when bacteriologist Giuseppe Sanarelli at the Uruguayan Institute of Hygiene in Montevideo watched in horror as almost his entire colony of imported experimental rabbits succumbed to an unknown disease. Necropsies revealed the cause of death as tumours in multiple organs, hence the name: a myxoma is a type of connective tissue tumour.

Sanarelli thought mosquitoes were implicated because rabbits kept indoors didn’t catch the disease. After failing to find a bacterial cause, he also surmised it must be viral. He was right: myxomatosis is caused by a poxvirus carried by mosquitoes and other biting insects that normally infects South American cottontail rabbits benignly.

In the early 1930s, the Australian Council for Scientific and Industrial Research (later CSIRO) hit on the idea of using myxomatosis for biological control. In 1934, former employee

Charles Martin, by then in semi-retirement at the University of Cambridge, UK, introduced the virus into two colonies of rabbits in enclosed paddocks, and wiped out the lot. Field trials followed on Skokholm, an island off the coast of Pembrokeshire, UK, that had become overrun with rabbits, as well as in Australia, but they flopped.

In 1950, however, CSIRO released infected rabbits into the Murray valley in south-east Australia. These died without significantly spreading the disease: myxomatosis can be caught though close rabbit-to-rabbit contact, but ill rabbits tend to socially isolate.

Later that year, however, myxomatosis suddenly erupted, spreading fast and with almost total lethality in the rabbit populations it encountered. The turnaround was put down to the Australian summer of 1950 to 1951 being very wet, meaning myxomatosis-carrying mosquitoes bred in areas normally too dry for them. When the outbreak fizzled out in 1951, it was because

almost all of south-eastern Australia’s estimated 100 million rabbits had already kicked the bucket.

It was a similar story with a European outbreak that began when French bacteriologist and landowner Paul-Félix Armand-Delille deliberately and illegally released two rabbits he had infected onto his estate in France in 1952. The disease rapidly spread across western Europe and into the British Isles. There is a widespread belief that the disease was deliberately introduced into the UK, but it appears it wasn’t: according to a 1956 article by a senior official at the country’s Ministry of Agriculture, Fisheries and Food, it was much discussed, but never approved. The first case, recorded in Kent in 1953, probably hopped across the channel naturally. Deliberate spread of myxomatosis was criminalised in the UK in 1954, but this was too late: more than 99 per cent of rabbits that encountered the disease in the UK died, a carnage they are still recovering from (see main story).

struck in 2010 and caused further “massive declines”, says Miguel Delibes-Mateos at the Institute for Advanced Social Studies in Córdoba, Spain. Between 2012 and 2014, the rabbit population in the Doñana National Park in Andalucía, Spain, once a rabbit stronghold, fell by more than 80 per cent. Across Iberia, declines of 60 to 70 per cent have been closely mirrored by falls in lynx and eagles. The UK Breeding Bird Survey, which also records mammals, shows a 64 per cent decline in wild rabbit populations between 1996 and 2018.

The origin of the RHDVs remains unknown, says Kevin Dalton at the University of Oviedo, Spain. Like myxomatosis, they might have jumped species, or they could have arisen from recombination events, where two viruses mash up their genomes. But their effects have been enough for the International Union for Conservation of Nature to reclassify the European rabbit from “vulnerable” to “endangered” in Spain. As recently as 1996, it was in the “least concern” category.

Conservation efforts so far have largely failed, in part because many people still consider rabbits a common pest and fair game. “Why would a species that you kill 6 million of a year by hunting need conservation?”, says Carlos Rouco at the University of Córdoba. Around 500,000 rabbits are released each year in Spain and France in an attempt to halt their decline, but more than 90 per cent die from predation, disease and stress.

There are some glimmers of hope. In some areas of Spain, 60 per cent of rabbits now have antibodies to RHDV2. And not all of Iberia’s rabbits are struggling. There are two subspecies – *Oryctolagus cuniculus cuniculus* and *O. c. algirus*, which diverged around 2 million years ago – that each occupy their own halves of the Iberian peninsula, divided by a diagonal line running north-west to south-east. They coexist along the border, but don’t interbreed; Delibes-Mateos has proposed that they should be recognised as separate species. The big declines are in the *O. c. algirus* zone to the south, which is also where the lynx and eagles live. To the north, *O. c. cuniculus* is stable or even increasing. Exactly why isn’t known, says Delibes-Mateos, but finding out could be a route to stabilising populations in the south.

One way to help colonies seems to be to increase their size, perhaps because rabbits then have more exposure to the virus as kits and develop immunity. In Breckland, Bell has found that piles of brush placed strategically

Rabbit grazing maintains rich “mosaic” habitats such as in the Breckland, UK



JIM CLARK/ALAMY

Rabbit rules

Rabbit society is “really complex”, says Diana Bell at the University of East Anglia in the UK. They live in groups of up to 20 individuals, which cooperate to defend their territory, but fight like rabbits in a sack for dominance over it. The prize for being alpha female is control of the group’s breeding rights; for alpha males, it is access to females.

Once weaned, male offspring leave the warren to spread their wild oats. Females stay put in the territory, forming a matriarchal society of mothers, daughters, sisters, grandmothers and aunts led by the dominant female. She rules the warren with a rod of iron, often killing her subordinates’ kits by dragging them into the open to be picked off by predators.

But the top job is often up for grabs: while wild rabbits can live to nine, average life expectancy is only about four years. “In Spain, they have more than 30 predators,” says Carlos Rouco at the University of Córdoba. Corre, conejo, corre!

within 40 metres of an occupied warren provide enough cover for rabbits to expand their earthworks. In a two-year experiment, more than 40 per cent of her brush piles ended up with a warren underneath and more than 90 per cent showed signs of rabbit activity. This simple, low-tech but effective intervention could be used in any rabbit-dependent habitat, she says. Rouco and Delibes-Mateos suggest something similar could make previously unsuccessful restocking efforts more effective.

Other interventions would be more general habitat restoration, although there is little money around for that, and to stop keeping domestic rabbits in close proximity to wild ones. Otherwise, however, it seems we have little choice but to let evolution run its course and hope the virus becomes less deadly. Some point out that the current huge drops in rabbit numbers are measured against the 1950s, when populations were possibly artificially inflated. Overall, it is clear rabbits are in a hole, says Rouco – but then again, they have bounced back before. “I’m 95 per cent confident they won’t go extinct,” he says. Here’s hopping. ■



Graham Lawton is a feature writer for *New Scientist*. His latest book is *Mustn’t Grumble*

Mimicking *touch*



Chemical stimulants helped us piece together how our sense of touch works. Now, they are providing a new way of creating artificial sensations, finds **Victoria Woollaston**

YOU open a door and it hits you – a flare of warmth on your skin. You brace yourself to go inside, battling smoke and heat. Flames flicker around you as you make your way through a burning building. You find what you came for and escape. Outside, it is so cold you start to shiver, while your hands and feet go numb.

But then you remove your headset and it all stops. You just finished an incredibly realistic training exercise. None of those sensations were caused by changes in your surroundings, although they felt real. Instead, chemicals carefully selected to mimic different feelings were pumped onto your skin.

Such stimulants have long been useful for understanding touch, the most complex of all human senses. In the 1990s, studies of capsaicin, an extract of chilli peppers, and menthol, found in peppermint, helped us pin down how our bodies react to hot and cold conditions. Now, Jasmine Lu and her colleagues at the University of Chicago are using this knowledge to create chemically induced sensations, to make virtual environments astonishingly realistic.

In a technology dubbed chemical haptics, they have built a wearable device that, when placed on the skin, can cause the wearer to experience a range of sensations – hot or cold, numb or tingly – on demand. Its uses could include creating intensely realistic virtual worlds for gamers to explore or for training firefighters. But will we ever be able to fully replicate the experience of touching something real, and what might we lose if we can't? Amid growing talk about metaverses, such questions are increasingly important. "How we sense the world around us is critical for pretty much everything in life," says Thomas Perlmann, a biologist at the Karolinska Institute in Stockholm, Sweden.

The word haptics officially means anything related to the sense of touch. Today, it is mostly used as a shorthand for haptic technology, the devices we use in daily life that help replicate a touch feeling using force, vibrations or motion. On your phone, your home button may not be a physical button at all, but made to feel that way using a vibration. Next time your device is switched off, see if you can still press it.

But the applications for haptics go beyond phone buttons. Haptic devices have been used to help people who have had a stroke to regain feeling in their arms and provide realistic feedback to medics practising CPR. In 2019, researchers in Hong Kong used tiny motors to create a virtual skin to "hug" relatives across the world.

The limit with these devices, though, is they only make use of one type of touch – pressure. Our skin can feel so much more than that. "Our sense of touch is mediated by various receptors in our skin," says Lu. "We have thermoreceptors for sensing hot and cold, mechanoreceptors for sensing vibration, pressure and force,

and nociceptors for sensing pain." Why not try to make the most of all of them? This way, says Lu, you could put people into simulations of dangerous situations, like burning buildings, to train them in what to expect without any physical danger.

The idea for chemical haptics began not with touch, but with different senses altogether. Lu's colleague at Chicago, Jas Brooks, was interested in the way chemicals add to the richness of daily life, particularly through smell and taste. Brooks designed a headset that released chemicals like mint and pepper into the nose's trigeminal nerve, a large tract of neural fibres that carries pain, touch and temperature information to the brain. When people wore the headset in a virtual reality environment, pumping menthol into their nose made them feel cooler, and capsaicin made them feel warm. Not only were the users experiencing a smell they associated with a cold feeling, like mint, but the trigeminal nerve was also telling their brains the room was a different temperature.

When Lu joined the lab, she wondered whether there might be a way to bypass the nose and go directly to the skin. "I realised there were a lot of other chemicals that can achieve different sensations on the skin," she says. "Then our team began looking at all other chemically induced sensations that have been studied, expanding beyond just hot and cold." She started reading about work that had been done decades earlier.

A library of touch

In the early 1990s, David Julius at the University of California, San Francisco, wanted to find an alternative type of painkiller to the opioids that were starting to become widespread in the US. But first, he realised, he had to learn more about how we feel pain. He and his team wanted to understand the signalling pathways that underpin our sense of touch.

As a starting point, they created a library containing millions of DNA fragments, each corresponding to genes expressed in the neurons linked with pain, heat and touch. Julius knew capsaicin made skin feel hot and burning. They spent years trying out thousands of fragments to see which ones caused receptors in our cells to respond to capsaicin. ➤

EMOTIONAL TOUCH

Touch a burning hot iron and you will immediately know to pull your hand away. This sense, called discriminative touch, is communicated to the brain using nerves known as A fibres, which provide almost instantaneous information. But there's another group of nerve fibres, called C fibres, that act more slowly, taking around a second to carry a signal from your foot, say, to your brain. These communicate different types of pain, such as throbs and aches, rather than stings or burns.

In the late 1990s, Åke Vallbo at the University of Gothenburg, Sweden, discovered a specific type of C fibre called C-tactile or CT fibre. "It's a lovely nerve," says Francis McGlone at Liverpool John Moores University in the UK. "It responds to exactly the velocity of stroking you would say is nice." The CT fibres only responded to slow, gentle touch – 5 centimetres per second – and they are only found on hairy skin. The type of touch that triggers the CT nerve is called affective touch, because it is used to create social bonds.

Not getting enough of this kind of touch has been linked to depression and anxiety. McGlone and his team published a study in which they stroked rats every day for 10 minutes. One group was stroked at the speed the CT fibres respond to, while the animals in another group were stroked six times faster. Then, they were put through situations that would provoke mild stress. The rats that had been slowly stroked didn't respond to the stress. Whether this works in people is yet to be seen, but McGlone says initial results are promising.

After a long search, in 1997, they finally identified a protein called TRPV1. Receptors for this protein are found in cell membranes, mostly in nociceptive neurons in our skin. These are nerve cells responsible for feeling a certain kind of pain. TRPV1 alerts the brain to both physical and chemical stimuli, such as burning capsaicin and higher temperatures – anything above 43°C. In response to these triggers, TRPV1 opens an ion channel that sends electrical signals to the brain.

Julius and others went on to spend decades examining the intricate web of receptors, other neurons, proteins and ion channels that together give us the complex and varying sense of touch we experience. Ardem Patapoutian at the Scripps Research Institute in San Diego, California, was one of the key researchers, helping to discover the way we feel cold sensations and pressure on the skin (see "Under pressure", opposite). This work was vital in getting us closer to a complete understanding of the sense of touch.

When Lu read about Julius and Patapoutian's work, it made her reconsider the way her lab was using stimuli. "Before, I had just imagined doing it externally – creating heat, providing force feedback, generating vibrations," she says.

Devices worn on the skin can create more realistic virtual worlds

"How we sense the world is critical for pretty much everything in life"

"But now, I was thinking of how to more directly interact with the specific [cellular] channels that regulate the perception of these sensations."

In 2021, Julius and Patapoutian were awarded the Nobel prize in medicine for their work. On the same day, Lu and her team published their paper introducing chemical haptics. "It was actually quite a coincidence," she says. "Their work on detailing the receptors that correspond to these sensations of hot, cold and pain is foundational to our approach."

In their paper, Lu and her team used chemicals ranging from sanshool, a component of spicy Sichuan pepper, to create a tingling feeling, to capsaicin, to mimic warmth. Menthol was used for cold, while a local anaesthetic,



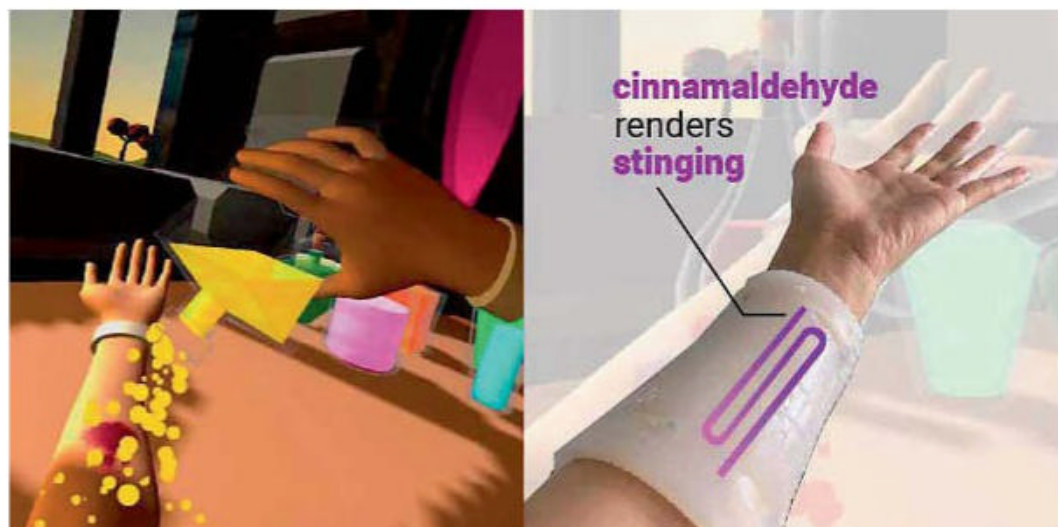
HUMAN COMPUTER INTEGRATION LAB/UCHICAGO

lidocaine, numbed the skin. Each was pumped through a wearable device to the skin.

The results were presented at the User Interface Software and Technology conference in 2021. In a video of a virtual reality scenario, someone wearing the chemical haptic system is seen escaping from a nuclear power plant on the brink of meltdown. With sparks flying, sanshool is pumped into channels on the arm and face to create a feeling of tingling, as if they were hitting the skin. When the person tries to unlock a door using an arm-worn interface, it fails, and lidocaine numbs the area, giving the impression they have lost the use of the limb. As the door to the reactor opens and heat rises, capsaicin flows onto the skin to simulate the warmth coming from a fire, and when they exit the power plant and enter a snowy scene, menthol is released onto their cheeks to mimic the feel of a cold wind.

While this is the cutting edge, the chemical pathways involved in touch have been exploited in various ways before. Medical creams use concentrated levels of minty wintergreen oil to create a thermal reaction on the skin that helps relieve pain. Some skincare products use capsaicin to promote blood circulation, and mouthwashes use menthol to generate a fresh sensation. But such chemicals have never before been used in conjunction with virtual worlds.

Not everyone is excited about this



development. “Honestly, it scares me,” says Francis McGlone, a neuroscientist at Liverpool John Moores University in the UK. He has spent decades studying the social importance of touch to humans (see “Emotional touch”, left) and believes virtual reality will never be able to replicate this. “We know that this digital world is going to take over,” he says, “but we need to find ways to ameliorate the negative consequences of not having physical contact.”

“Touch is a matter of life and death,” says Katerina Fotopoulou at University College London. Compared with other mammals, humans can do very little when we are born. “Our very survival in those early days relies on caregiving from our parents and all of this is

A new haptic system pumps chemicals onto the skin to provide virtual sensations

mediated by touch,” she says. It also lies at the heart of our social development. “Touch has a power unlike that of the other senses,” she says.

Lu is quick to stress that her work with chemical haptics is not, and in her view never will be, a replacement for real touch. “Touch is a really complex sense, which is why using touch to interact with our world in real life is such a wonderful experience,” she says. Instead, she sees it enhancing digital experiences. “I don’t tend to think of VR as a vehicle for escaping our reality, but as a medium that can empower us to do and experience things we can’t normally.”

And while chemical haptics can replicate some sensations, others elude it. “I can’t simulate the softness or texture of my cat’s fur when I pet her,” says Lu. This is why she and her team see the most important applications of VR being experiences and sensations that augment rather than substitute our day-to-day lives.

Chemical haptics was made possible thanks to decades of research using natural stimulants. Next, Lu wants to create new molecules, to see how they react. If all goes well, it could even lead to more discoveries about our most complex sense. “This is the first exploration of generating skin sensations using an interactive device that dispenses chemicals,” she says. “We don’t know how far this can go.” ■



Victoria Woollaston is a freelance journalist based in Buckinghamshire, UK

UNDER PRESSURE

After finding a protein that helps our bodies sense cold (see main story), Ardem Patapoutian at the Scripps Research Institute in California didn’t stop there. To study how we feel pressure, Patapoutian and his colleague Bertrand Coste designed a new experiment. After spending the best part of a year and a half switching off sensory genes one by one, Coste identified two genes that control our body’s sensitivity to pressure. The pair called these *PIEZO1* and *PIEZO2*, from the Greek

word for “pressure”.

They found that when they are silenced, it renders tissues incapable of feeling force and reduces their ability to feel pain. The genes code for proteins that form ion channels that open in response to mechanical pressure on the skin and internal membranes. They help our bodies detect blood pressure, bladder pressure and breathing. But they play a much bigger role too.


Proprioception is the sense of self-movement and bodily location, sometimes

likened to our body’s GPS. People without *PIEZO2* in the nerve cells that supply muscles and tendons tend to lack coordination and can end up in a wheelchair. *PIEZO1* and *PIEZO2* channels regulate important physiological processes, including blood pressure, respiration and bladder control, while *PIEZO2* plays a role in pain-sensing neurons. Researchers are now thinking about targeting force-sensing proteins with medicines to treat, for example, chronic pain.

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The science of cooking

Conquer your spheres

A hallmark of top-tier modernist cuisine, spherification is nevertheless a technique you can try at home, says **Sam Wong**



Sam Wong is assistant news editor and self-appointed chief gourmand at New Scientist. Follow him @samwong1

What you need

250 millilitres of mango juice

5 grams of calcium lactate

5 grams of sodium alginate

1 litre of water

Blender or hand mixer

Hemisphere-shaped

tablespoon measure

IF YOU eat at fancy places, you may have encountered orbs of sauce or puree, held inside a membrane, that burst in your mouth. Making them involves a little chemistry, but it can be done at home.

Now a staple of modernist cuisine, the spherification technique was patented in 1942 by food scientist William Peschardt and later popularised by chef Ferran Adrià at El Bulli restaurant in north-east Spain in the 2000s.

To try it, you need two special ingredients that can be ordered online. One is a salt called sodium alginate, which comes from brown algae. Alginate is formed of polymers made of chains of sugar molecules with negative charges. These polymers can link together to form a gel, but to do that, they need help from ions with a double positive charge. Sodium ions have a single positive charge, so they stick to the negative parts of the alginate, but can't pull two polymers together.

The second ingredient is calcium lactate, another salt, this time containing calcium ions. Their double positive charge means they can attract two alginate polymers at the same time, forming the cross links we need to turn the liquid into a gel.

The original spherification method involves dissolving the sodium alginate in the flavoured liquid, then immersing drops or spoonfuls into a solution of calcium lactate. A gel skin should quickly form on the outside, trapping the liquid in the sphere.

My attempt to do this with



ZHANNA TRETIKOVA/LAMY

mango juice hit a problem: when I mixed in the sodium alginate, it instantly formed a gel. Mangoes contain little calcium, but perhaps another mineral was causing the problem. This method can also fail if the liquid is too acidic.

Luckily, there is an alternative technique: reverse spherification. Here, calcium lactate is mixed with the flavoured liquid, which is dropped into a solution of sodium alginate. This results in a thicker membrane, but it should work with almost any edible liquid.

If you live somewhere with hard water, like London, your tap water could turn to jelly on contact with the alginate, so use bottled water for the alginate bath if you have to.

Sodium alginate dissolves poorly, so create your solution with a blender or hand mixer, then

let it sit so any air bubbles escape.

To make mango spheres, dissolve the calcium lactate in the mango juice. Fill a hemisphere-shaped tablespoon measure and tip it into the alginate bath. Use a spoon to rotate the sphere as the gel sets. After 1 minute, take it out of the alginate bath with a strainer and put it into a water bath.

You can also use a pipette, syringe or squeeze bottle to make small drops that form caviar-like spheres, but this is trickier because the spheres tend to stick together.

The membrane is permeable, so if you want to make the spheres in advance, store them in mango juice so the flavour doesn't escape. ■

The science of cooking appears every four weeks

Next week

Stargazing at home

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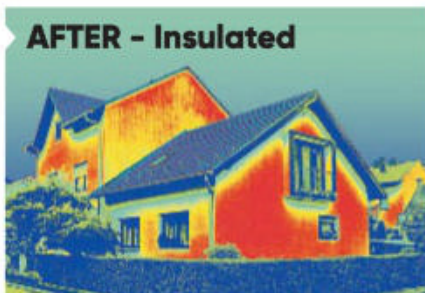


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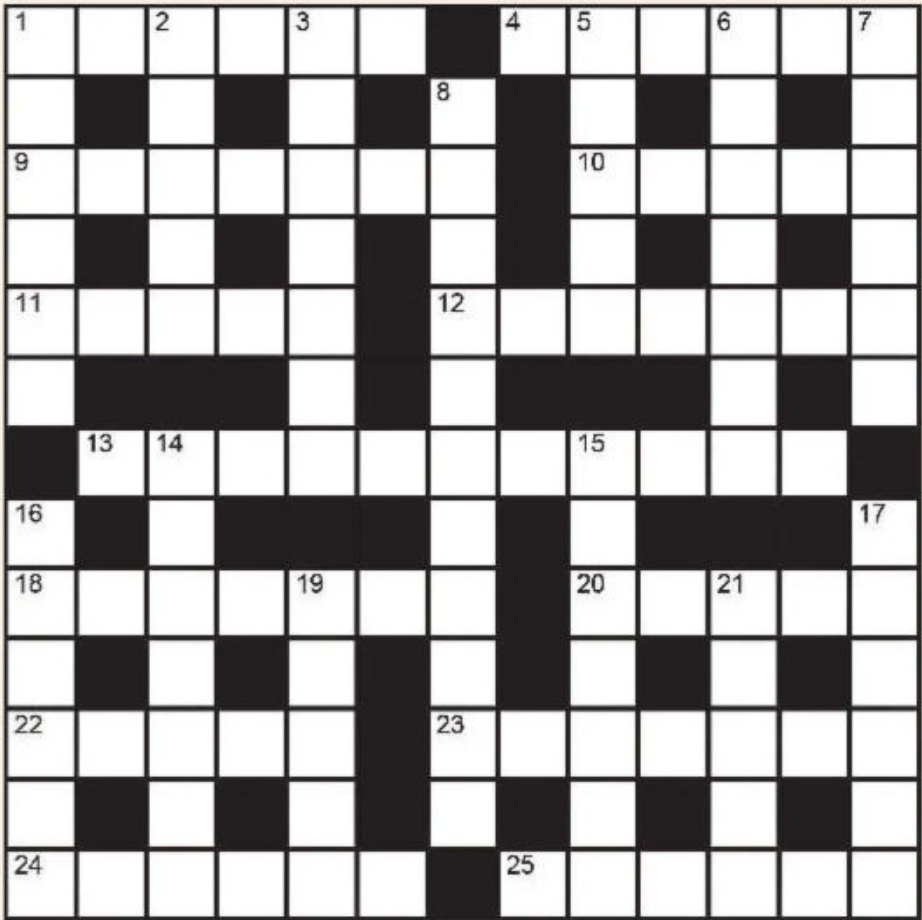
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Cryptic crossword #79 *Set by Wingding*



Scribble zone

Answers and the next quick crossword next week

ACROSS

- 1 Bird that's a novice (6)
- 4 Bird with alien food pipe (6)
- 9 Ancient city may clean lake every now and then (7)
- 10 Bird with new headgear (5)
- 11 Young animals given medicine first in research buildings (5)
- 12 Publicity for machine learning on Irish TV – I'm gripped! (7)
- 13 Son trusted dad would be moving, like the night sky (4-7)
- 18 Painters of Central Park birds eating sulphur (7)
- 20 Show of displeasure from South Carolina bird (5)
- 22 Bird with concave wings in the future (5)
- 23 A little bit of insect in tin (7)
- 24 Expensive bird with lubricant (6)
- 25 Pull bird in front of church (6)

DOWN

- 1 Run, walk and hike (6)
- 2 Zero carbon supported by Cambridge advocate of simple theories (5)
- 3 Pollution is eradicated, to some extent, by air purifying device (7)
- 5 Terribly cruel and sore (5)
- 6 Assign great importance to feline sensory organs in speech (7)
- 7 Somewhat smitten, reclusive mammal (6)
- 8 Spread tastes same after mixing with iodine (11)
- 14 Bird with obsession ditches male for moon (7)
- 15 Undisciplined soldiers left out report (7)
- 16 Force taken out of lightning strikes (6)
- 17 Student feeding bird gets frightened reaction (6)
- 19 Smooth, solid vegetable (5)
- 21 Rise of nitrogen agriculture shortened part of body (5)

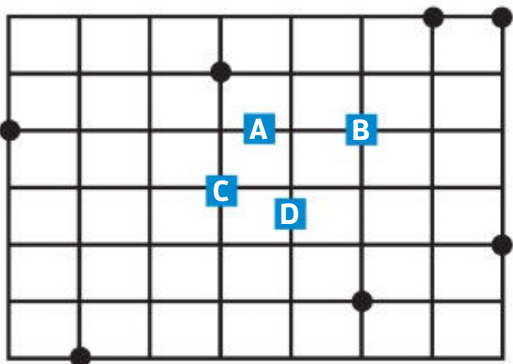
Quick quiz #143

- 1 Males of which group of animals experience "musth"?
- 2 Which chemical element has the atomic number 33?
- 3 Where in the solar system are the volcanoes Olympus Mons and Ascræus Mons?
- 4 Which mass extinction came first: the Permian-Triassic, the Devonian or the Cretaceous-Tertiary extinction?
- 5 In the human spine, how many vertebrae are typically found in the sacrum?

Answers on page 55

Puzzle

set by Derek Couzens
#159 Express coffee



The streets of New Addleton are set out in a rectangular grid. Seven coffee vendors (the circles in the diagram above) have stalls at metro stations and want to set up a central depot to collect supplies from each morning. They want to minimise their combined cycling distance from stall to depot. Pat has four candidates for the depot location: A, B, C and D.

"Are you sure one of those four is optimal?" asks Shahin. "I suppose we could work out the total vendor-depot distance for every point on the grid."

"No need, I can tell you the best place just by looking at the diagram," announces Kim.

Which location does Kim recommend and why is she so confident?

Solution next week



Our crosswords are now solvable online
newscientist.com/crosswords

Sticking it out

Why does sticking my tongue out seem to help me concentrate?

Gillian Forrester

Birkbeck, University of London, UK

It isn't so much that sticking your tongue out helps you to concentrate, rather it is something that most people naturally do when engaging in fine manual motor actions, such as threading a needle.

We think this behaviour has a long evolutionary history. When humans became bipedal, around 4 million years ago, our hands became busy with competing activities like manipulating tools and communication gestures. We also think that the modern human language system originated from a visually based gestural communication system incorporating the hands, face and posture.

These competing hand actions created problems if we wanted to simultaneously communicate and act, for example when teaching

“Hand and mouth actions are closely linked, and the mouth mirrors hand actions during fine motor activities”

someone to make or use a tool. This may have created a pressure for our communication system to move from gestures to another signalling channel: the voice.

Neuroscientific evidence backs this up, showing that our hand behaviour for tool use engages the same brain regions used in speech. Behavioural evidence also shows that these two motor systems are closely linked and that the mouth mirrors hand action when engaging in fine motor movements.

Experiments show that when people are asked to pick up large objects and then smaller ones, their mouth will open and close in proportion to the grip size

they are using with their fingers.

Most children stick out their tongues when making fine motor hand actions. Adults probably still make these tongue actions too, but social pressures teach us to keep our mouths closed so our tongues aren't visibly hanging out.

Contee Seely

Berkeley, California, US

Sticking out one's tongue and wiggling it seems to stimulate a part of the brain that can make a difference in one's mental state. Doing this almost unfailingly clears headaches from the back of my head.

Drew Barlow

Kerikeri, New Zealand

I have noticed a similar phenomenon with many



JANE AYTO

This week's new questions

Lichen this sign Why are the lichens distributed in this way on this road sign? The surfaces have the same texture, just different colours. *Jane Ayto, Plymouth, UK*

Planetary fly-through Would it be possible to fly a spaceship through the centre of a gas giant planet? *Bob Yelland, Alton, Hampshire, UK*

professional snooker players, who twitch the middle finger of their “bridge” hand while concentrating on lining up a shot. It really stands out once you notice it.

Burn out

Why does a candle make more smoke just after it has been extinguished?

Philip Bradfield

Edinburgh, UK

The plume visible after extinguishing a candle flame is a stream of unburned fuel particles rather than smoke. It is powered by the residual heat of the wick. This can be tested by collecting the stream on absorbent paper.

There is a delightful poster of candle combustion in *The*

Why has the lichen grown more in certain areas of this sign?

Chemical Atlas by Edward Livingston Youmans, which was published in 1856.

David Muir

Edinburgh, UK

When you light a candle, the flame melts the wax to form a pool at the base of the wick. This liquid rises through capillary action up the wick to the flame, where the wax is vaporised. The hydrocarbon wax molecules burn to make carbon dioxide and water if enough oxygen is present. These products are invisible.

When a candle is extinguished, the smoke comprises wax vapour, intermediate breakdown products and unburned carbon, altogether a very combustible fuel. This can be demonstrated by snuffing out a candle, then putting a flame to the rising smoke and watching the flame shoot down the smoke to relight the wick.

During decades of noisy competitions in science classes, I have watched pupils make flames jump down smoke columns up to 6 centimetres long, given careful flame-snuffing, still air and the right wick.

David Jackson

Gosport, Hampshire, UK

My preferred way of putting out a candle is to lick my thumb and forefinger then pinch out the flame. This prevents the plume of white “smoke”, which is actually condensing paraffin wax.

If a candle wick gets too long in the flame, some wax gets drawn up into the cooler part of the flame where there is insufficient oxygen for complete combustion. This results in black carbon smoke above the flame.

In days gone by, wicks were regularly trimmed with small scissors to prevent this, but they are now specially woven so that they bend over and trim themselves by burning off in the flame edge.



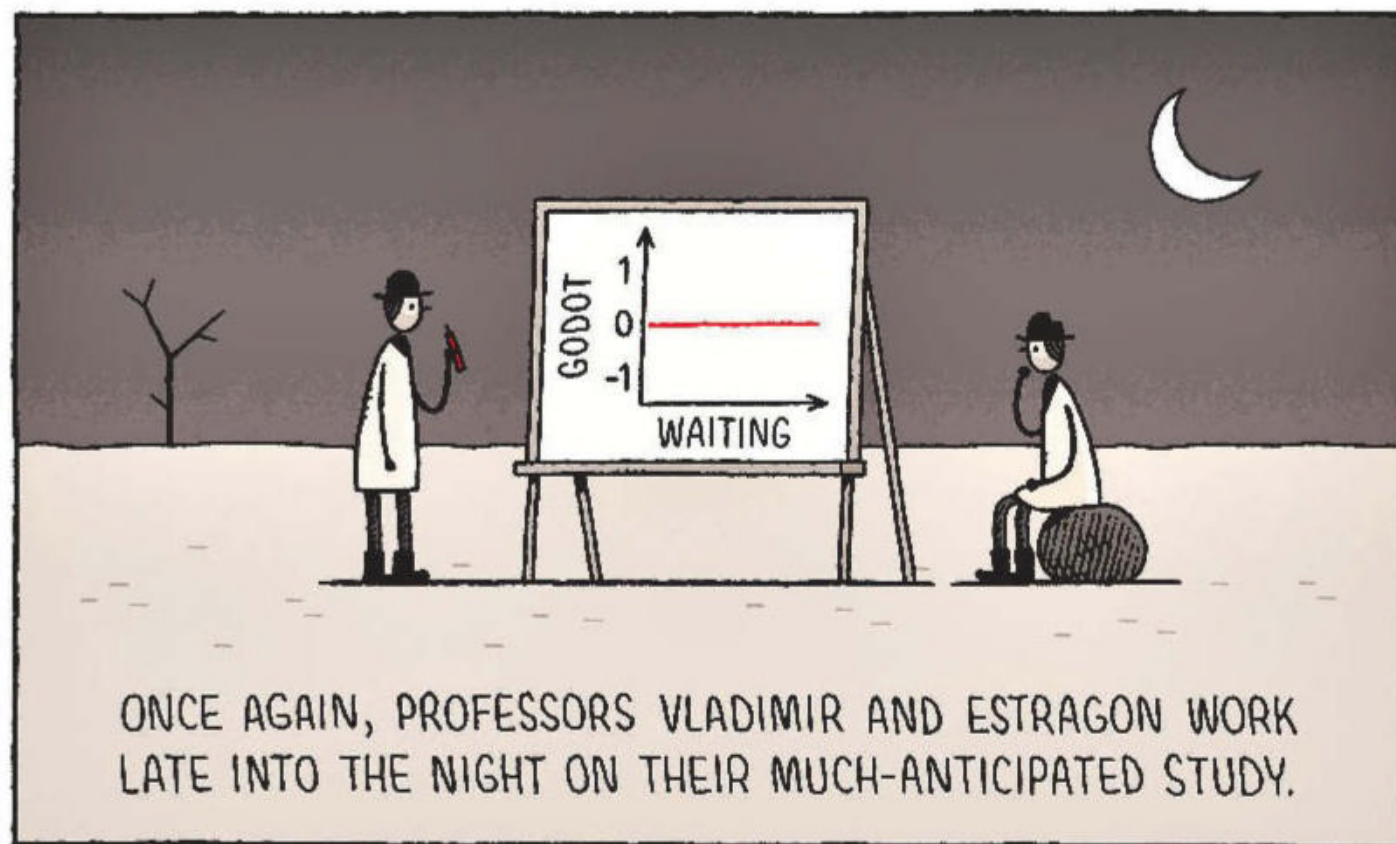
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Tom Gauld
for *New Scientist*



Iron mussel

Exploring slate mines in north Wales, UK, my son and I often find structures that resemble a mussel or similar bivalve on rusting iron metalwork (pictured). What's going on?

David Aldridge

University of Cambridge, UK

This looks very much like a member of *Ancylus*, a genus of freshwater limpets. So this could be a gastropod (snail) rather than a bivalve.

Snails are part of the Mollusca phylum. Molluscs lay down shell material continuously and can produce rings that mark daily patterns, annual patterns and even disturbance events, just like tree rings.

Mollusc shells are also very good at absorbing metals, which would give rise to the rusty coating from the surrounding ironwork seen in the picture.

Given the high humidity found in some disused mines, it is plausible that the snails can spend prolonged periods



of time out of water to graze on exposed surfaces.

Chris Daniel

Glan Conwy, Conwy, UK

Similar shell-like objects have been found in abandoned mines in the Pyrenees mountains.

These objects can be formed when bacteria are deposited on the surface of steel pipes from which fungal filaments grow by sequestering mainly iron ions and depositing them as fibre-like iron oxide crystals.

Such growths build up in layers to form symmetrical clam-like shapes. This interplay between microbes and the iron-rich water is known as biomineralisation.

In hot water

I am right-handed and I find it difficult to accurately judge the temperature of bathwater with my left hand. Why? (continued)

Neville Owen

Melbourne, Australia

Some years ago, while investigating how best to protect gas industry workers from the ignition of escaped gas, it became clear that our skin can be thought of as a thermal flux sensor rather than just a thermometer. This is why hot steel feels hotter than hot charcoal at the same temperature.

When exposed to hot, or cold, water, you can get used to it. This happens as the body responds and moves more blood to the exposed region, thereby dispersing more heat so the thermal skin sensors get less signal. If you find it easier to judge water temperature with one of your hands, it may be due to a difference in blood flow to the dominant hand because of greater use of that hand, leading to better blood circulation. ■

Answers

Quick quiz #143 Answers

- 1 Elephants
- 2 Arsenic
- 3 Mars
- 4 The Devonian extinction
- 5 Five

Quick crossword #103 Answers

ACROSS 1 Bubble, 4 Bit depth, 9 Twitch, 10 Lollipop, 12 Medusoid, 13 Larynx, 15 Nape, 16 Hypocapnia, 19 Metabolism, 20 Area, 23 Tomtit, 25 Heath hen, 27 Godzilla, 28 Minute, 29 Numbness, 30 Emetic

DOWN 1 Bitumen, 2 Blind spot, 3 Locust, 5 Iron, 6 Delta ray, 7/17 Poppy Northcutt, 8 Hypoxia, 11 Bicycle, 14 Monster, 18 Obsidian, 19 Mutagen, 21 Apnoeic, 22 Atrium, 24 Modem, 26 Plus

#158 League of nations Solution

England vs Scotland and Wales vs Ireland were the last two matches.

First up were Ireland vs England and France vs Wales. So Scotland played every round after that. Wales were at home for the third set of matches. And since home/away alternated, Wales missed round two, meaning Ireland and France were away that round. So Scotland and England must have been at home, and Scotland played Ireland and England faced France. Following through, we get:
Round 3: W vs E and F vs S
Round 4: I vs F and S vs W
Round 5: E vs S and W vs I

These were the actual 1975 Five Nations rugby contest fixtures.

Hybrid learning

A man in a hide jerkin and disposable face mask sits knapping flints against the backdrop of an unaccountably large, bright red tractor. Rounding a corner, a 3-metre-high luminous yellow grinning gummy bear suddenly looms over us, from which we flee through a door into a side room where Greater Manchester mayor Andy Burnham is talking soulfully about 100 per cent renewable trams.

Not Feedback's latest cheese dream – although close – but sure signs we were on the shop floor at New Scientist Live Manchester, as part of our drive to bring the office stationery cupboard to you.

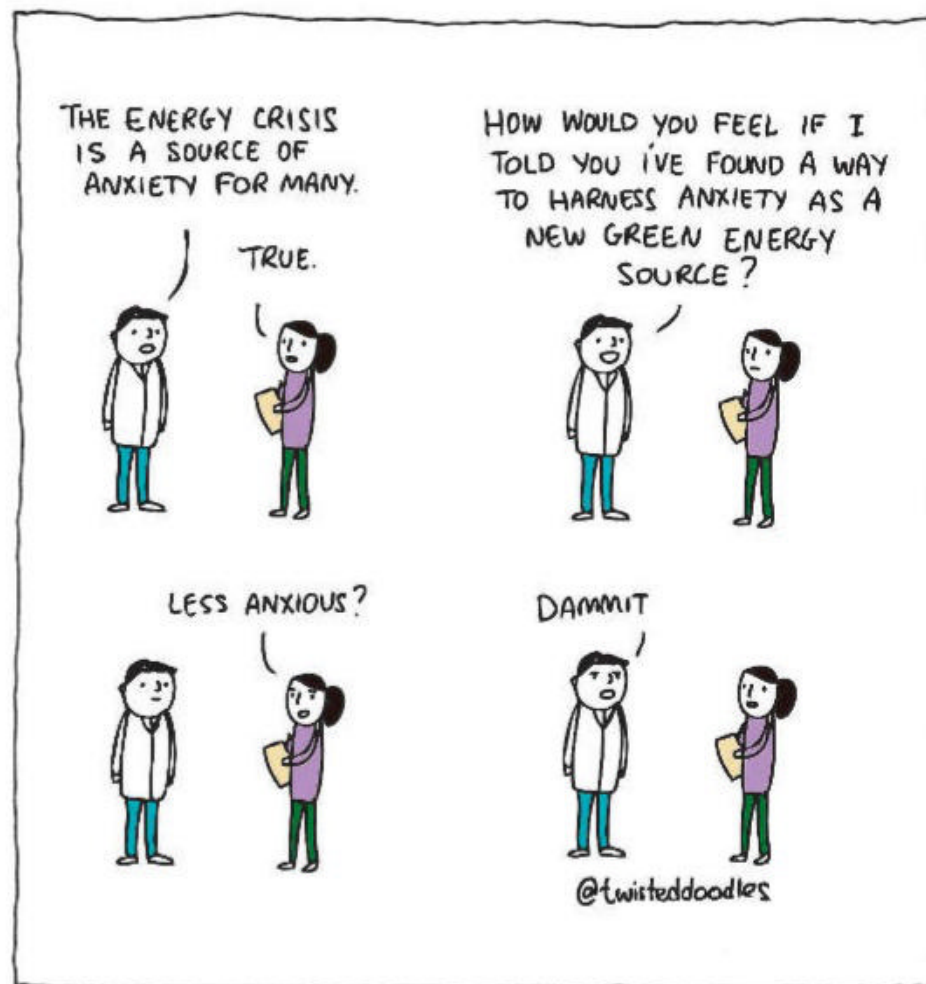
Like many people, Feedback currently finds being in real places with real people a discombobulating experience that requires several deep-breathing exercises and us remembering to wear something on our bottom half. Many attendees in Manchester weren't actually in Manchester, but watching it all from the safety of their own underpants at home, which brings its own challenges, it turns out. When digital attendees complain that the main stage is freezing, getting someone to turn up the thermostat in the hall doesn't cut it. Lesson learned as the boundaries between the virtual and physical worlds slowly melt, as indeed the people in the hall did.

The truth is out there

"Don't think of a black hole as a Hoover, think of it as a couch cushion". Astrophysicist Becky Smethurst – Dr Becky to her legion of YouTube fans – won the prize for the most unexpected metaphor of the event, her point being that you are less likely to get sucked into a black hole than to lose your car keys down the side of one. Or something like that.

Meanwhile, we were delighted to learn from Dallas Campbell and Suzie Imber's talk on how to leave Earth about the 1638 book *The Man in the Moone*, written by Church of English bishop Francis

Twisteddoodles for New Scientist



Got a story for Feedback?

Send it to feedback@newscientist.com or New Scientist, Northcliffe House, 2 Derry Street, London W8 5TT. Consideration of items sent in the post will be delayed.

Godwin, in which the protagonist flies to the moon in a chariot towed by moon geese. We would take this option, which strikes us as classier than the unspeakably vulgar rockets favoured by today's billionaire class.

We also now know the current location of the first sandwich in space, what an industrial vacuum does to a marshmallow and how to make a rocket with half an Alka-Seltzer and a 35-millimetre film canister. That's definitely one not to try at home. For anyone tempted, all the talks are available in the metaverse.

Going nuclear

The 3-metre-high mutant gummy bear was, it turns out, advertising the benefits of nuclear power. Feedback regards this as brave, as we also do the UK Atomic Energy

Authority titling a talk "Nuclear Fusion: Forever 30 years away".

Still, we learn that a gummy bear is about the same size as a uranium fuel pellet, that one fuel pellet produces enough power to drive an electric car 20,000 miles and so a 3-metre-high gummy bear would make enough electricity to power 2 million electric cars for a year in the UK. This makes us happy.

Blowing in the wind

Meanwhile, out in the real world, the real world was still going on. The gummy bear is possibly a more appropriate unit of power for a family magazine than that contained in a tweet from the Victorian Trades Hall Council that Paul Campbell forwards us following our session on "how big is a gigawatt?" in last week's Feedback.

It celebrates the announcement of 2 gigawatts of wind power capacity to be installed off the Australian state's coast in the coming 10 years, or as the tweet has it in an accompanying picture: "SH**LOADS OF POWER. SH**LOADS OF JOBS".

Clue: it wasn't "shed". We idly wonder if this is now a unit of power and how many horses it would take to produce it. Around 2.7 million, we make it. They would be a truly magnificent sight riding in the waves, although we do wonder whether any of this counts as clean energy.

Butt out

While our back was turned, we also discover that a portion of Twitter declared 1 to 8 March InverteButt Week in celebration of the backsides of creatures without backbones.

We doubt the world truly needed this, but then again, with past headlines in this august publication such as "Comb jelly videos are rewriting the history of your anus", perhaps people in glass houses shouldn't throw... slugs.

This leads us to delve rather more deeply than we might otherwise have done into the lifestyle and morphology of the bristle worm *Ramissyllis multicaudata*, a detailed study of which, published last year, seems to have been a prime mover of InverteButt Week. The worm lives, with delightful specificity, within sponges in Darwin Harbour, northern Australia. Its single head is buried deep within the sponge, but its body randomly branches out into up to 1000 rear ends that poke hopefully out of it. The gut is continuous throughout all these branches, yet doesn't seem to process any food, leading to speculation that the worm has "adopted a fungal lifestyle".

This sounds pleasingly louche, like flying with the moon geese. Even more fun is that, when it comes to reproduction, new heads – complete with brains and eyes – start forming and bud off from the worm's butts. Cute. ■

Did you know 60% of those who need a hearing aid don't have one?

The vast majority of us suffer some degree of hearing loss as we get older. Many of us believe we just have to accept it, or for some, the decline is so gradual that they don't realise how bad their hearing has become. And some of us just simply put off getting checked and doing something about it.

Unfortunately ignoring your hearing loss can have serious consequences.

Nationwide charity 'Action on Hearing Loss' reveal that the risk of developing depression can double where hearing loss is present. The report also links hearing loss with cardiovascular disease, diabetes, stroke and obesity. Another study by 'The Lancet' suggests that seeking effective treatment for your hearing loss could reduce the risk of dementia. Untreated hearing loss can lead to social withdrawal, minimising brain stimulation, and potentially accelerating the onset of dementia.

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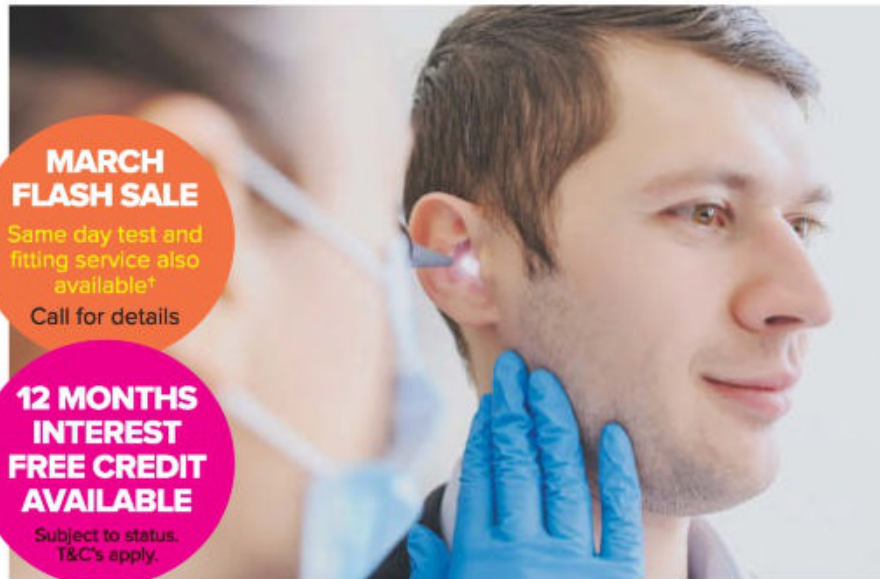
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We hope to hear from you soon, all the best.

Asa Richards

Asa Richards
MSHAA HAD
Head of Audiology



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DEMENTIA AND HEARING

"Hearing aids may reduce the risk of cognitive decline and dementia. Older people with hearing loss are more than twice as likely to develop mild cognitive impairment, a precursor to dementia, according to a report in Alzheimer's and Dementia: Translational Research and Clinical Interventions. The raised risk was erased if they wore hearing aids."

7 QUESTIONS to ask yourself about your potential hearing loss

1. Do you regularly suffer the embarrassment of having to ask people to repeat themselves?
2. Do you struggle to hear clearly in crowded places amidst chatter and background noise?
3. Do you often find yourself feeling confused by conversations you have misunderstood?
4. Does it seem to you that others are mumbling?
5. Is your much loved music gradually becoming less clear on the ear?
6. Does anyone complain to you or your family about the volume of your TV or radio?
7. Do you struggle to decipher high-pitched children's voices?

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audiologist to my home on the Thursday! The process and the test was easy, friendly and professional... Afterwards, my audiologist discussed the results and explained a range of solutions specific to my hearing requirements. I recommend Hearmore UK for your at-home hearing test."

Official Review 2021
Diane Bignall, Kettering

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SEAMASTER AQUA TERRA

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