

New Scientist

WEEKLY August 29–September 4, 2020

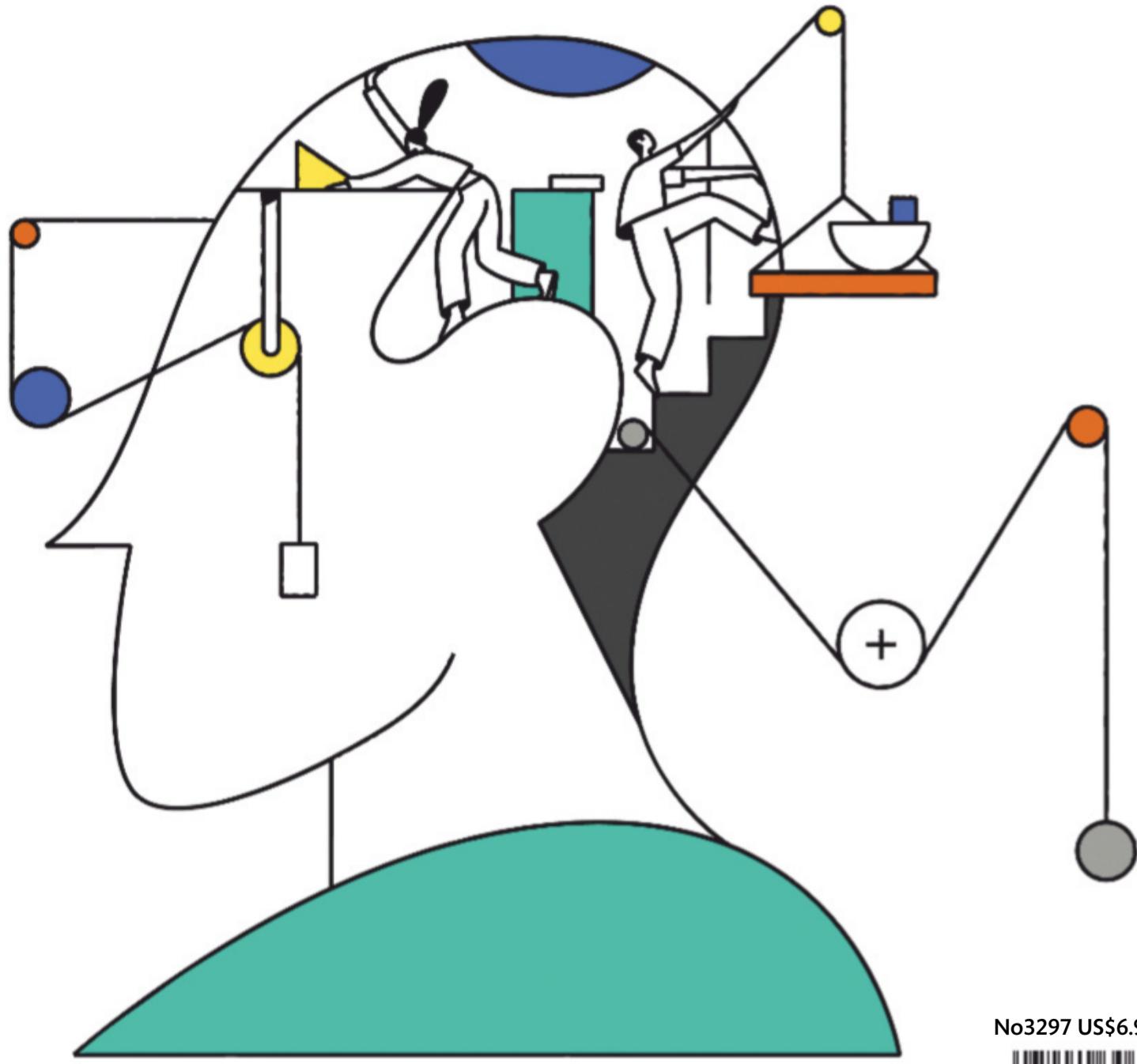
CORONAVIRUS LATEST
Is the virus getting less deadly?
The risks of rushing for a vaccine
Catching covid-19 on a flight

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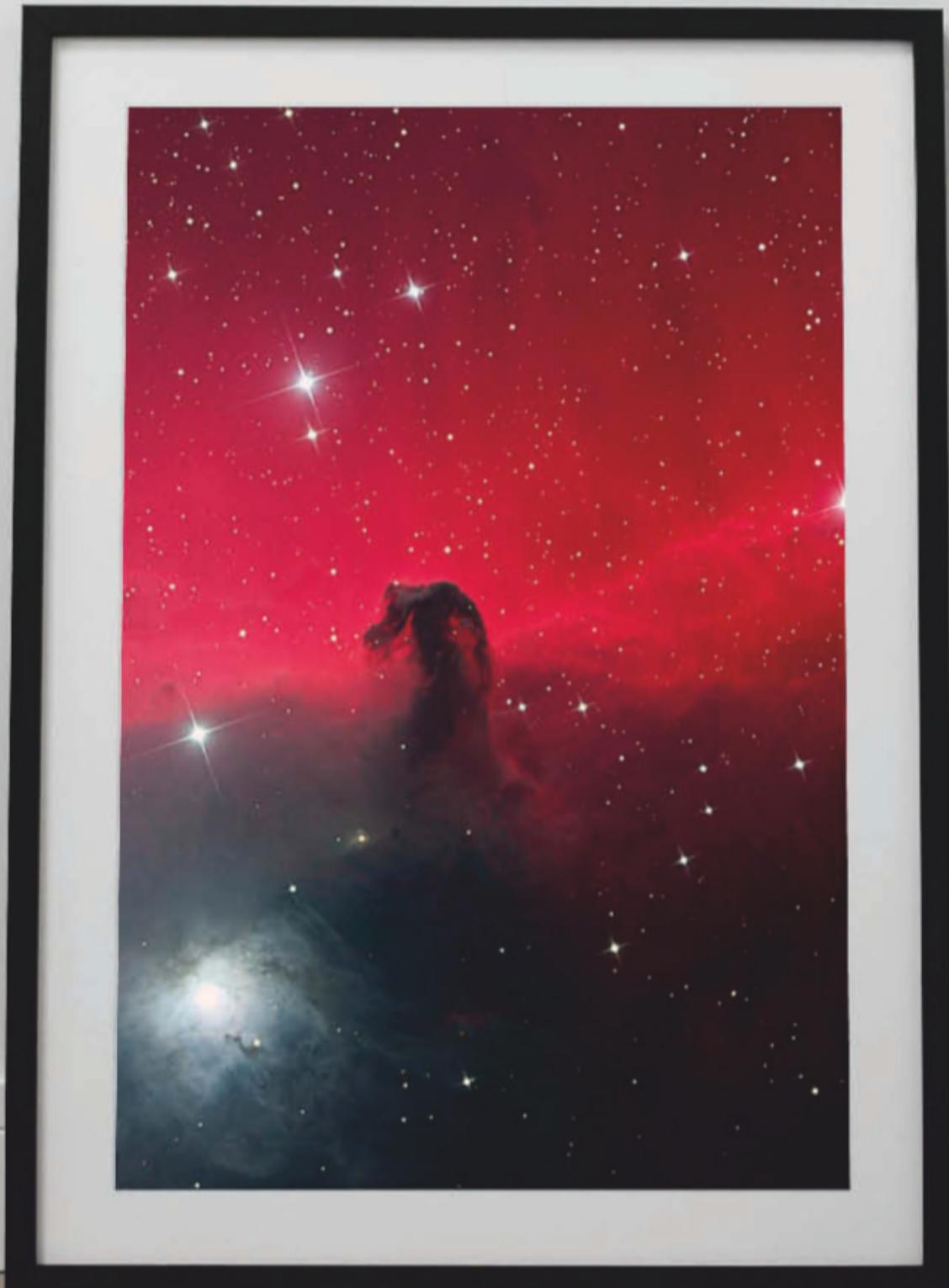
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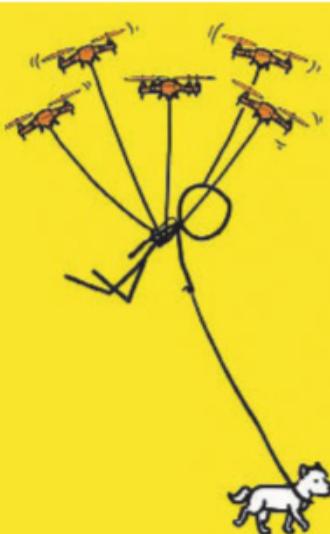
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Science with Sam Our new YouTube series kicks off with black holes

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How to... with Randall Munroe

The mind behind the webcomic xkcd reveals the world's most useless self-help guide with astrophysicist Katie Mack. Thursday 10 September at 6pm BST/1pm EDT.

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Science with Sam

In the first of our new video series, Sam Wong explains black holes.

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A note from the editor



There has arguably never been a time when human health has been higher up the agenda than now. That is why I am pleased to announce that my colleagues have been working on not one, but two health-related publications that we hope you will find both fascinating and useful.

The first is the third edition in our *Essential Guides* series (following *The Nature of Reality* and *Artificial Intelligence*). *Essential Guide: Human Health* has been guest-edited by Linda Geddes, a long-time *New Scientist* contributor and consultant. She is also the award-winning author of the books *Bumpology* and *Chasing the Sun*. Human health may sound like a big subject, but Linda has done a brilliant job of focusing on the areas in which cutting-edge research is making a profound difference to our knowledge of what contributes to a long and healthy life. To order a copy, just go to shop.newscientist.com.

The second of our new publications is dedicated to the biggest and most complex health story we are all dealing with right now: covid-19. My colleague Catherine de Lange has produced a special, digital-only edition of the *Essential Guides* series about the new coronavirus. In it, you will find out how the virus operates and spreads, who is most at risk of the disease and why, and what the evidence says about our chances of developing immunity, plus the latest on progress with treatments and vaccines. The special issue is available to buy in the *New Scientist International* app, which you can download from the Apple app store.

Finally, an apology. In our 15 August issue, we ran a two-page article on the Arctic by our chief reporter Adam Vaughan. Last week, in our 22 August edition, we then ran the first page of that article again – although, confusingly for anyone who had missed it the first time round, not the second page. We are endeavouring to ensure that such an annoying error cannot happen again. In the meantime, many apologies.

"Human health is a big subject, but our new guide focuses on the research making a difference"

Emily Wilson

New Scientist editor



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Redefining time, why mindfulness can cause problems and secrets of super-resilient tardigrades

Episode 29

Loneliness during lockdown, medical artificial intelligence beats doctors and who gets the coronavirus vaccine first

Episode 28

Origin of life on Earth, second wave of coronavirus and the science of miscarriage

Episode 27

Putting plastic back on the agenda, revisiting the iconic black hole image and how dinosaurs dominated the planet

Hosted by New Scientist's Rowan Hooper and Valerie Jamieson, new episodes are out each Friday. Follow us on Twitter **@newscientistpod**

Overcoming prejudice

Insights into the neural roots of bias suggest ways to fix the problem

FEW ideas from social psychology have captured public attention in recent years as much as unconscious bias, the catch-all term for the assumptions we make about other people without being consciously aware of the process.

That reach is partly down to the Implicit Association Test (IAT) created by researchers at Harvard University in the 1990s. Available online, it is widely seen as a quick and easy way to see how implicitly biased you are. The results can be unsettling: you may not think you are racist or sexist or ageist, but, in many cases, your unconscious preferences, measured by instant associations, suggest otherwise.

Another reason the idea has caught on is that it seems to offer an explanation for why prejudice clearly persists, despite measures of explicit racism showing a

steep decline. As the Black Lives Matter movement continues to draw attention to systemic racism in the US and Europe, many have begun to wonder about the extent to which their own biases are part of the problem.

"All of us harbour biases arising from a combination of what we learn implicitly from society and how our brains work"

As Pragya Agarwal explains on page 38, recent work has revealed that the IAT isn't as reliable a measure of individuals' propensity to be biased in real life as first thought, so the test should be treated with caution. But there is no doubt that implicit bias is a problem.

Neuroscientists have shown that all of us harbour deeply ingrained biases

resulting from a combination of the associations we learn implicitly from the societies we live in and how our brains work. The brain regions associated with fear light up when we see people who we have been conditioned to think of as threatening, for example.

Insights into the neural roots of prejudice suggest ways to overcome the problem. We can work harder to unlearn the associations we pick up, for instance, by spending more time with people from groups we don't identify with. We can also cultivate awareness. As neuroscientist Lasana Harris argues on page 43, if we educate ourselves to be more aware of our "unconscious" biases – if we teach people where the associations behind them come from and how systemic they are – we can use our conscious minds to control them. ■

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Getting less deadly?

The proportion of people in Europe dying after being infected by the coronavirus seems to be falling. **Adam Vaughan** investigates why

IT IS becoming increasingly clear that people are less likely to die if they get covid-19 now compared with earlier in the pandemic, at least in Europe, but the reasons why this might be the case are shrouded in uncertainty.

One UK doctor has said that the coronavirus was “getting a little bit less angry”, while an infectious disease consultant at the National University of Singapore claimed that a mutated version of the coronavirus, D614G, is making the illness less deadly.

In England, the proportion of people infected by the coronavirus who later died was lower in early August than it was in late June. Over the period, this infection fatality rate (IFR) dropped by between 55 and 80 per cent, depending on which data set you use, say Jason Oke at the University

of Oxford and his colleagues.

“This doesn’t seem to be the same disease or as lethal as it was earlier on when we saw huge numbers of people dying,” he says. For example, the week beginning on 17 August saw 95 people die and just over 7000 cases across the UK. In the first week of April, 7164 died and nearly 40,000 tested positive.

Dividing deaths by cases gives a crude case fatality rate of about 1 per cent in August, compared with nearly 18 per cent in April. These figures don’t represent the true IFRs at these times – because deaths lag behind infections by a few weeks, and because testing regimes have changed over time – but they are indicative of a shift in

the IFR. Oke and his colleagues used a more sophisticated method to estimate the change in IFR.

The situation isn’t unique to England and the rest of the UK, says Oke, who has found the same trend repeated across Europe.

Why this is happening isn’t clear. According to data for England, a larger proportion of younger people are being infected than was happening around the first peak of cases in April, with cases rates for 10 to 16 August the highest among 15 to 44 year olds.

Covid-19 is known to be less risky the younger you are, so the changing demographic of those being infected could be one plausible reason that the disease

London is getting busier as lockdown lifts, but the risk of the virus remains

currently seems less deadly. Yet Oke doesn’t think the change in age distribution alone is enough to account for what is happening. There are still a lot of older people testing positive, he says.

Several researchers have told *New Scientist* that the other main possible explanation is that cases are being treated more effectively in hospitals. Other possible

“The changing demographic of those being infected could be why covid-19 seems less deadly”

explanations include there being a seasonal nature to the disease like with flu or that even though more people are testing positive, many of those cases have relatively low levels of the virus because people are following social distancing guidelines, reducing the severity of the outcome.

Neither idea has been proven yet.

The jury is also out on whether one variant of the coronavirus, known as D614G, explains why covid-19 is becoming less deadly. Paul Tambyah at the National University of Singapore told Reuters that the rise of the D614G mutation had coincided with drops in death rates in some countries, suggesting that it might be “more infectious but less deadly”.

Other research disagrees, concluding that while D614G may be more contagious, there is no evidence it is less deadly. A study led by Erik Volz at Imperial College London, published this month but not yet peer-reviewed, looked at the genome of virus samples taken from 19,000 UK patients, along with whether they had died from covid-19.

“We do not see reduced risk of death due to the D614G variant,” says Volz. He adds that failing to control for the age of patients in modelling can lead to a “spurious conclusion” that the mutation “has less severe outcomes”. ■

Daily coronavirus news round-up
Online every weekday at 6pm BST
newscientist.com/coronavirus-latest

Vaccines

The rush to develop a vaccine

Streamlining the approval process could help produce an urgently needed coronavirus vaccine, but some shortcuts might undermine safety, finds **Michael Le Page**

US PRESIDENT Donald Trump is considering allowing the usual procedures to be bypassed so an experimental coronavirus vaccine can be made available to the public in time for the US election in November, according to a report in the *Financial Times*. AstraZeneca, the drug company developing the vaccine in partnership with the University of Oxford, has said there have been no talks with the US government about fast-tracking the vaccine.

But the race to develop a coronavirus vaccine is speeding up. On 11 August, president Vladimir Putin announced that Russia had approved a vaccine called Sputnik V for widespread use after only two months of small-scale trials, before the usual longer, large-scale trials. China has also allowed volunteers to be given a vaccine although human trials are still running.

These decisions have led to concern that too many shortcuts are being taken in the rush to roll out coronavirus vaccines.

"As long as there are no new, untested components in a vaccine, the need for animal tests is arguable"

"There is no possible room for movement on the highest safety standards," says Danny Altmann at Imperial College London. "The [covid-19] vaccines will be given to billions in the biggest ever medical endeavour on planet Earth. This needs to be effective and safe. Imagine even one in 1000 serious adverse events in a vaccine given to a billion people."

Vaccines typically take a decade or more to go through the development and testing phases required to ensure a safe and effective dosage that most people will tolerate. The first step



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is to make a potential vaccine, a process that can take many years. As of 20 August, 139 potential coronavirus vaccines are in this initial stage, according to the World Health Organization. A further 30 are already being tested in people (see "How vaccines get to the front line", right).

"The Russia vaccine approval was definitely rushed," says Ayfer Ali at the University of Warwick in the UK. "It had only been tested on 38 people."

But she says other research groups and pharmaceutical companies are going through the standard stages of vaccine development. Some are hoping for approval near the end of this year.



GALLO IMAGES/GETTY IMAGES

The University of Oxford is developing a vaccine in partnership with drug firm AstraZeneca

So how is the development of coronavirus vaccines proceeding so much faster than normal if researchers really are taking all the usual precautions? One reason is the unprecedented effort being made. When the pandemic began, thousands of researchers around the world dropped what they were doing and concentrated on the coronavirus instead.

"The research world is focusing on covid-19 with an intensity the likes of which we have not seen before," says Michael Head at the University of Southampton, UK. "With these resources available, and the urgency of the pandemic, research is happening much faster than in normal times."

The necessary technologies have also advanced greatly in recent decades. Genetic sequencing is now fast, routine and cheap, for instance. The full sequence of the coronavirus was made public by researchers in China on 10 January, just weeks after the first cases emerged.

A volunteer in Soweto, South Africa, taking part in the Oxford vaccine trial

Thanks to studies of other coronaviruses, including the ones that cause SARS and MERS, researchers knew which part of the genome coded for the so-called spike protein that protrudes from the outside of the virus. This is the part our immune system learns to recognise and the key target of most coronavirus vaccines. With this, researchers could get started on a vaccine as soon as they had the gene sequence.

What's more, several groups worldwide had been developing ways of making new vaccines quickly. A Massachusetts-based firm called Moderna, for example, was already working on RNA vaccines, which stimulate our cells to make a viral protein that provokes an immune response.

Once Moderna had the gene sequence for the coronavirus spike

protein, it pretty much had its candidate coronavirus vaccine, with a bit of tweaking to ensure the protein has the right structure.

Several other potential vaccines, including Sputnik V and the Oxford vaccine, work in much the same way, but use the shell of a cold-causing virus called an adenovirus to deliver the gene for the spike protein to human cells. Again, once these groups had the spike protein gene, they could create vaccines extremely quickly.

What is happening after candidate vaccines have been created is more debatable. Normally, a potential vaccine would be tested in animals and there would then be a pause while the results are assessed. It can take months or years for funders, regulators and ethics boards to give the go-ahead for the next step.

That step is to test a candidate vaccine in a small number of people, usually fewer than 100, to check there are no serious adverse reactions. This is called a phase I trial.

Bridging the gaps

There would then be another pause before phase II, when the vaccine is given to more people – perhaps several hundred – and their immune responses studied to work out the most effective dosage, and how many doses are required.

Another gap then comes before phase III trials, in which typically thousands of people are given either the vaccine or a placebo to see whether the vaccine really can prevent infection.

But most groups developing coronavirus vaccines aren't pausing between stages. Instead, they are overlapping them.

"As soon as they get a good safety signal from phase I,

they are going to phase II," says Eleanor Riley at the University of Edinburgh, UK. "Essentially, the funders have said: 'Keep going, the money will be there'."

For instance, Moderna did hardly any animal tests before giving its experimental vaccine to the first volunteer on 16 March. The company didn't respond when asked to comment on this.

By contrast, there was extensive testing of the Sputnik V vaccine in rats, mice, hamsters, guinea pigs, rabbits and monkeys, said Alexander Gintsburg at the

Gamaleya Research Institute of Epidemiology and Microbiology in Moscow, during a press briefing on 20 August.

However, Riley thinks skipping animal tests may be justifiable because we have enough experience of using RNA vaccines to know that they are fairly safe, she says. "As long as there are no new, untested components in the Moderna vaccine cocktail, then the need for animal safety tests is arguable."

The question is, are vaccine groups taking risks by moving

to the next stage so fast? "I guess you could say that they possibly have not fully analysed phase I, but I'm not sure there's any evidence for that," says Riley.

If there is any extra risk, it is to the volunteers in trials.

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people received the Sputnik V vaccine before it was approved

"Once you've done your phase I and you're pretty sure the vaccine delivery and the few weeks after it is safe, then any other consequences tend to be rare and they don't rear their heads until you've vaccinated thousands of people," says Riley.

So, as long as large studies are done and the results are judged by the usual standards, coronavirus vaccines should be as safe as any other newly approved vaccine. Testing each one on large numbers of people matters more than time when it comes to spotting rare adverse events, says Riley.

However, it is unclear whether the usual standards are always being applied right now. Putin's announcement, for instance, suggested that Russia was going to skip phase III trials. That isn't quite the case, according to Gintsburg. He said that only people in high-risk groups will be given the vaccine straight away. At the same time, a trial involving 40,000 people will be carried out, ahead of the vaccine's mass deployment in October.

Regulators in most other countries haven't said what will be needed for a coronavirus vaccine to get approval, but in the US, the Food and Drug Administration has said it would only need to protect 50 per cent of people, and perhaps even just 30 per cent. ➤

How vaccines get to the front line

Moving a vaccine candidate through the standard phases of development can take more than a decade. Due to the urgency of the pandemic, researchers and regulatory bodies are trying to eliminate delays and teams are running some phases concurrently in the hope of making a coronavirus vaccine in just 12 to 18 months.

THE STEPS TO MAKING A VACCINE

Prototype development This usually takes years, depending on the technique used. For the current coronavirus, researchers had prototypes within hours due to new technologies that identify the bits of a virus a vaccine might use.

Animal trials These primarily test safety and the immune response generated by a vaccine. Skipping this stage can speed things up, but there may be safety trade-offs.

Phase I human trials The first tests in people usually involve 20 to 80 individuals and are used to demonstrate safety and ensure any side effects aren't too severe.

Phase II human trials Tests on larger groups of people reveal a vaccine's efficacy. Some vaccines can jump from here to regulatory approval if there is urgent need. Russia's vaccine is moving into use for high-risk populations while testing continues in the next phase.

Phase III human trials A new vaccine is tested on hundreds to thousands of people to clearly evaluate both efficacy and long-term safety.

Regulatory approval Based on human trial data, regulatory bodies determine whether the vaccine can be licensed for public use. Follow-up safety testing may also be required.

Mass production Vaccine manufacturing is ramped up under strict quality control and consistency standards.

Public access Once a vaccine is available, governments and public health authorities must determine which groups of people get it first.

"That is unusually low protectivity for an approved vaccine," says Jonathan Kimmelman at McGill University in Canada. With vaccines, it is all about the risk-benefit ratio, he says.

The big danger with approving a vaccine that only protects some people is that all recipients may assume they are shielded from covid-19 and engage in more risky behaviour than they would otherwise.

On the positive side, these vaccines may get far more scrutiny than is typical because of the immense interest in them and there being greater transparency than usual. Many vaccine groups are publishing their results as they go along, which are making headlines around the world.

"Clinical trial data is not usually available to the public, it is mostly the regulators that see it," says Ali.

There has been unprecedented openness and this needs to continue, says Derek Lowe, a drug discovery chemist based in Massachusetts. "The phase II and III data have to be out on the table, so everyone can see how we're making the decisions about which candidates are better or worse than others," he says. "Secrecy would be a disaster."

Multiple vaccines

Furthermore, never before have so many vaccines for the same disease been developed simultaneously. "A unique situation we have is that we'll likely have multiple vaccines," says Harald Schmidt at the University of Pennsylvania.

So even if the first vaccines to get approval are only partially effective, they may soon be replaced by better ones. After all, it is going to take years to vaccinate everyone on the planet.

"But nobody is yet through the big, difficult bottleneck of successful, safe phase III trials, so let's not count any chickens," says Altmann.

The duration of immunity given by a vaccine will also not be clear after early trials. "Given hopes to have a vaccine by year end and where we are with trials, by necessity, we'll only know that they protect for three months," says Schmidt.

People in the phase III trials are told to take all the usual precautions to avoid infection, not least because half of them were given a placebo rather than

the vaccine. So it could take many months for it become clear whether a vaccine works – especially in countries where case numbers are low – and far longer to know how long protection lasts.

But there is a big shortcut we could take: human challenge studies. With one of these, researchers would give people a vaccine and then deliberately infect them with the coronavirus to see if it works. Tens of thousands of people have already expressed a desire to volunteer. However, so far it has been regarded as too risky to try, given that there is no treatment that can guarantee survival from covid-19.

Assuming at least some vaccines do prove effective, the next challenge is churning out billions of doses. And even after any vaccines are rolled out to the public, monitoring will continue, in what is sometimes called phase IV. Many of the approvals are likely to initially be so-called conditional emergency use authorisations, with full approval coming later.

"It is still possible that some extremely rare events will not be captured in trials – that is true of any drug or vaccine – but after phase III trials, this is a minuscule risk," says Ali. "I expect scrutiny after approval will be immense for covid-19 vaccines, as it has been so far for covid-19 scientific research."

It is unusual for serious adverse events to emerge after vaccines are rolled out, says Riley, but it does happen occasionally. For instance, a vaccine against H1N1 swine flu was linked with cases of narcolepsy, though this finding remains controversial. There was also a rise in narcolepsy in China, where the vaccine wasn't used, probably due to the virus itself.

Even if any vaccine did turn out to cause a rare adverse effect,

people might still be better off being given it. Keith Neal at the University of Nottingham in the UK points out how deadly the coronavirus can be, especially in those aged 60 or above. "I doubt if the vaccines have anywhere near that risk," he says. "We are in a public health emergency."

"A rushed, unsafe vaccine for coronavirus could risk extending the pandemic by months or years"

It is also possible that coronavirus vaccines might turn out to have unexpected benefits, like some other vaccines. For instance, the HPV vaccine intended to prevent cervical cancer has also reduced the number of premature births.

Overall, Kimmelman thinks there are some increased risks from the shortening of the usual vaccine development process. But this is being offset by the far greater resources and scrutiny. "How that balances out is anybody's guess," he says.

Kimmelman also worries that politics and nationalism could influence the approval process, as seems to have happened in Russia.

Altmann echoes these concerns. "I have lost sleep that the knock-on from the Sputnik V announcement could lead to a cold war space race between populist politicians seeking to strong-arm regulatory bodies into rushed approvals," he says. So far, there is no sign of this, he says.

The stakes couldn't be higher. "A rushed, unsafe vaccine could undermine public confidence, feeding directly into the rhetoric of anti-vaccine activists, and add fire to their existing body of lies and misinformation," says Head. "That could risk extending the pandemic by months or years." ■



A researcher at Moderna, a Massachusetts-based firm working on a vaccine

30

Number of vaccines being tested in human trials as of 20 August

Air travel

How likely are you to catch the coronavirus on a plane?

Michael Le Page

SITTING in a confined space for hours with hundreds of strangers sounds risky during a pandemic. But while hard evidence is scarce, it appears the risk of being infected with the coronavirus during a flight is relatively low.

"Overall, planes are probably safer than poorly ventilated pubs, where similar densities of people do not wear masks and talk a lot and loudly," says Julian Tang at the University of Leicester in the UK.

If you use public transport, the risk depends firstly on the odds of an infected person being on the same bus, train or plane, and then the odds of them infecting you.

Travelling in South Korea, where just 1 in about 225,000 people test positive every day, is inherently safer than travelling in the US, where 1 in 6500 people test positive every day. In the UK, it is 1 in 60,000 people.

If you do sit on a plane near someone who is infected, how likely are you to catch the virus? We don't know for sure as there is little to go on, but some case studies offer clues.

One describes a 5-hour flight

from Singapore to China, where 11 of the 325 people on board were infected by one man. Passengers were screened before boarding, but the man developed a fever during the flight and wasn't wearing a mask.

However, when an infected couple flew from China to Canada on 22 January, none of the 350 passengers on the 15-hour flight were infected. Masks were worn.

Face coverings and filtered air could help minimise risk of catching the coronavirus

In a document on the evidence for in-flight transmission, the International Air Transport Association (IATA), an industry body, says that when four airlines followed up with 1100 passengers confirmed to be infected after flying, just one may have been infected by another passenger. It isn't clear how rigorous the finding is, as no details were published and the IATA didn't respond to queries from *New Scientist*.

There are reasons to think the risks are low. Many airports check people's temperatures before they

board, and airlines now disinfect planes between flights and require passengers to wear masks. The air on planes is also replaced every 3 to 5 minutes, and the air that is recirculated goes through HEPA filters that should remove most droplets containing viruses.

"The ventilation systems on planes are very effective in reducing the concentration of any airborne pathogen exhaled by passengers," says Tang. The main risk may be face-to-face talking where air can be swapped before being pulled away, he says.

In the US, the risk of infection is about 1 in 4000 if a flight is full, estimates Arnold Barnett at the Massachusetts Institute of Technology. If the middle seats are left empty, the risk falls to 1 in 8000. For the UK, the equivalent risks are about 10 times lower, says Barnett. That is, there is just a 1 in 40,000 chance of infection. These are just rough estimates, however.

It isn't clear how travelling on trains or buses compares as their ventilation systems vary. For instance, the air on Eurostar trains is replaced every 15 minutes.



FRED DUGIT/MAXPPP/PA IMAGES

Analysis

Why some people cannot wear a face covering

DO YOU get angry when you see someone without a face covering? They might have a good reason to avoid one, even if it isn't obvious.

Despite claims to the contrary, face coverings don't reduce the amount of oxygen in the blood or raise the level of carbon dioxide. So people with lung conditions such as asthma shouldn't assume they don't need to wear one. "For the vast majority of people with lung

disease, wearing a mask is fine. It's a mild irritation that they can put up with," says Nick Hopkinson at the British Lung Foundation.

The exceptions are some people who experience occasional breathlessness due to conditions such as emphysema and pulmonary fibrosis. This can be due to genuinely low blood oxygen, but the conditions also make the lungs stiffer, requiring the chest muscles to work harder to pull in air. That sends a misleading signal to the brain that oxygen is in short supply, which creates the feeling of being short of breath, even if you aren't.

Face coverings can also trigger anxiety and panic attacks in those who are vulnerable, says UK mental health charity Mind. People with autism may have issues if they experience heightened touch or smell – so that a mask feels smothering – or if they struggle with the change to their routine. Individuals with learning disabilities may need to see their carer's face for reassurance and to communicate.

"For the majority of people with lung disease, wearing a mask is a mild irritation they can put up with"

In the UK, people are legally exempt from wearing a face covering if they are unable to use one because of disability or if it causes them severe distress. This is subjective, so we should accept the choice of individuals going unmasked, says Tim Nicholls at the UK's National Autistic Society.

Those exempt can wear a badge explaining their medical reasons if they wish, but they aren't obliged to do so. "We have to encourage people to wear a mask if they can, but be understanding if they can't," says Nicholls.

Clare Wilson

AI outguns a human fighter pilot

Artificial intelligence defeats a human pilot in simulated air combat

David Hambling

AN AI pilot has defeated a human 5-0 in virtual air-to-air combat in the first contest of its kind.

The AlphaDogfight Trials, staged by the US Defence Advanced Research Projects Agency (DARPA), were streamed online and proved so popular that the final had to be transferred to YouTube because of lack of capacity on the original platform.

"The AI showed no hesitation in flying at very low altitudes that human pilots tend to avoid"

While the US already operates many uncrewed drones, these are flown remotely by pilots, whereas simulated F-16 fighter aircraft in the AlphaDogfight Trials were controlled by artificial intelligence. In two previous events, AIs competed against each other. This time the organisers decided the technology was ready to take on a human.

Initially, eight teams from industry and academia went through three competition stages to find a machine champion, battling each other in various forms. This was won by AI specialists Heron Systems. Its AI then took on a human F-16 pilot known as Banger, who wasn't named for security reasons. The AI beat Banger in all five encounters.

Every encounter started with the aircraft in random positions with neither having the advantage. The combats involved almost continuous turning, with both pilots pushing their aircraft to the limits to try to reach a firing position. This generally involved the aircraft chasing each other in tight circles.

Simulated fighter aircraft dogfights were streamed on YouTube

The Heron AI was particularly aggressive in its manoeuvring, and, like the other AIs, showed no hesitation in flying at very low altitudes that human pilots tend to avoid. The human vs AI combats were notably shorter than many of the AI vs AI battles.

The Heron AI was, like most of the others, based on deep reinforcement learning, a technique in which algorithms learn through many attempts at a task. Unlike some others in the competition, it wasn't combined with any pre-packaged responses, and the AI learned everything itself. Although some of the AIs updated their decisions up to 50 times a second, the Heron AI only updated 10 times a second to make its movements smoother.

This smoothness was particularly evident when Heron took on Lockheed Martin in the AI vs AI final. When the two aircraft were flying straight towards each other, the Heron AI could line up better to score more hits, destroying the other plane first.

Not out of a job yet

The competition is part of DARPA's Air Combat Evolution project, which envisages a future in which a pilot could have autonomous



STOCKTREK IMAGES/GETTY IMAGES

drones fly alongside them, or AI might manoeuvre an aircraft while the pilot selects targets. This would require a lot of confidence in the AI's ability.

The competition is really to help pilots gain respect for the AIs, says Dan Javorsek, manager of the DARPA programme. "Fighter pilots have an almost institutional requirement to experience proof at the hands of one of their own before adopting a new tactic or technology."

He says the plan is to load algorithms into the flight control system of an aircraft. The type hasn't yet been confirmed, but F-16s retired from front-line service have recently been converted so that they can be controlled remotely. The AI software converts them into autonomous dogfighters.

Dogfighting isn't a big part of modern air combat, says Justin Bronk at defence think tank RUSI in London. Bronk says exchanges of fire are likely to start with radar-guided missiles well beyond visual range, with agile heat-seeking missiles used at closer range and guns as a last resort.

Bronk says that combat pilots require many other skills, for example, when they intercept

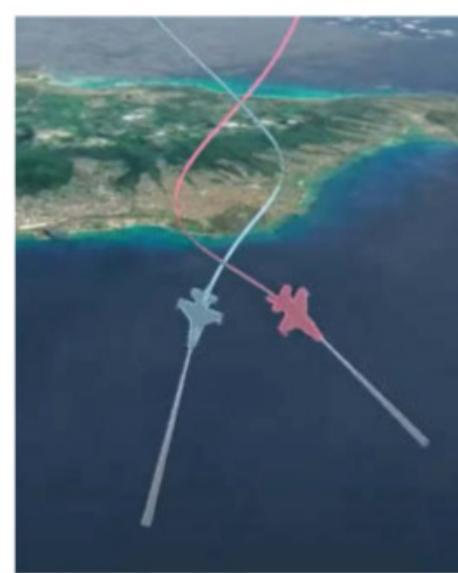
Some F-16 fighter aircraft are being adapted so they could be controlled remotely

an aircraft that isn't responding to air traffic control and may be a threat. They need to be able to determine from context if it is a communications malfunction or a hijack situation. "For example, is a pilot slumped over, or is there someone else in the cockpit?" he says.

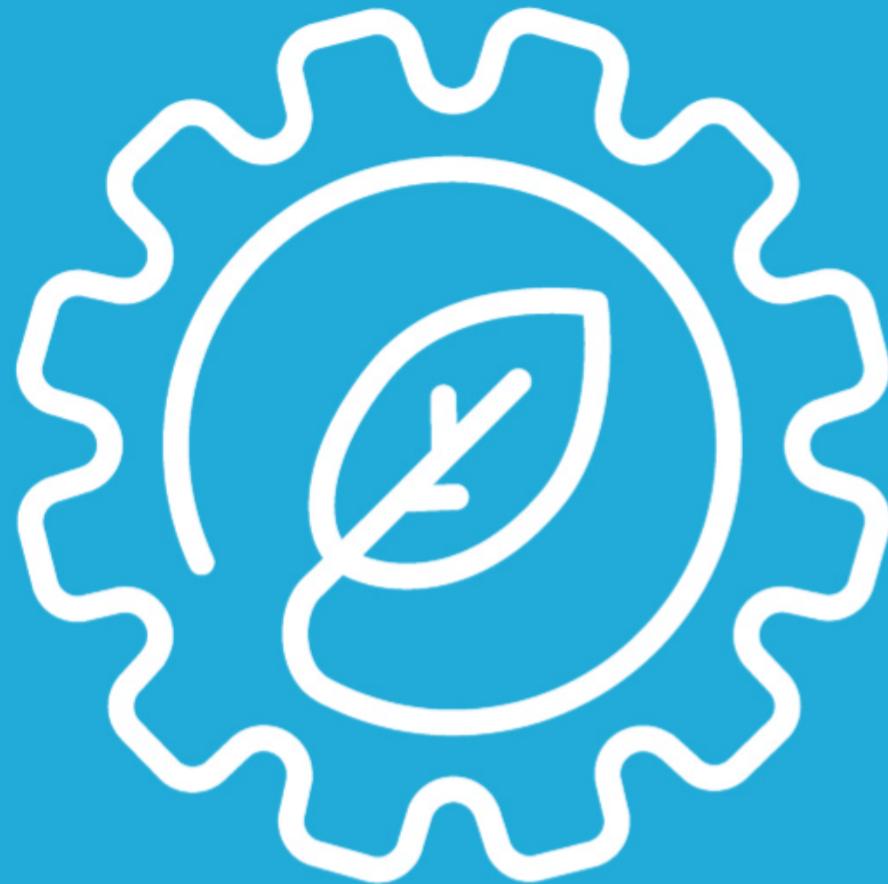
"The pilot needs understanding of the broader political context, whether the geopolitical background is normal or there is an elevated state of tension," says Bronk. "This is needed to help classify what constitutes hostile behaviour, and how to respond appropriately."

Deploying AI-controlled fighter jets in action may be some way off, because the US Air Force is committed to maintaining human control over lethal systems to ensure responsibility and to prevent "unwanted engagements".

The next stage of the DARPA programme will involve more complex actions with multiple aircraft on each side. This may give AI, which can easily track many objects simultaneously, even more of an edge over humans. ■



DARPA/YOUTUBE



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Adam
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Archaeology

Strange burial mystery unearthed in Spain

Colin Barras

AN UNUSUAL 3700-year-old grave unearthed in Spain shows how little we know about some ancient burial practices. At the Humanejos site, 20 kilometres south of Madrid, there are about 100 ancient tombs. None is quite as strange as grave 31.

Inside the 1.2-metre-deep grave, the body of a 15-year-old youth was placed, sitting upright. He was then partially buried, leaving his head and shoulders exposed to the elements. Eventually, the body decayed and the youth's upper body collapsed – at which point more dirt was added to the grave to seal his remains.

It is a strange sequence of events, but it is the only obvious way to explain the arrangement of bones in the grave, according to Ana Herrero-Corral at

"It's very rare to find ancient inhabitants of Spain, or anywhere else, buried in a seated pose"

the Complutense University of Madrid and her colleagues.

They found all of the bones of the boy's lower skeleton preserved in their correct anatomical position – in a seated pose – suggesting that this part of his body was held in place by earth as the body decayed.

But the bones of the boy's upper skeleton, including his skull, were scattered in a jumbled mess, indicating that this part of his body wasn't buried as it decomposed.

Nothing about the grave is typical. It is very rare to find ancient inhabitants of Spain, or anywhere else, buried in a seated pose, write the researchers.



These bones suggest the owner was buried up to his shoulders in a sitting position with head exposed

They say that it is even more unusual in the Spanish archaeological record to find evidence of "exposure" rituals where the body, or parts of it, were deliberately left unburied, although there are places in the world where this is done today.

It is difficult to interpret such an unusual burial. It is possible, write the archaeologists, that the boy received special treatment because he was a high-status individual. Arguing against that idea is the isotopic evidence in his bones, which suggests he ate a poorer diet than other members of his community.

Perhaps, instead, the funerary ritual was a punishment, but the boy's bones show no evidence he was executed. However, the grave did contain a single flint



A.M. HERRERO-CORRAL, ET AL.

This flint arrowhead, found in the grave of a sitting boy, might have given him a fatal injury



A.M. HERRERO-CORRAL, ET AL.

arrowhead, which might indicate he died from a violent injury that damaged a vital organ without leaving a mark on his skeleton (*Journal of Archaeological Science: Reports*, doi.org/d6z8).

It is a "tough call" to interpret the burial, says Tobias Richter at the University of Copenhagen, Denmark. But he leans towards the idea of punishment or sacrifice. "It is certainly possible that the person could have been buried alive and then shot [with the flint arrow]," says Richter. It may also have been important for part of the body to then be left on display for others to see, he suggests.

"The exposure of death and corporeal decay [in former times] is such a mystery to us," says Mette Løvschal at Aarhus University in Denmark. "It is so different from how we consider our bodies today."

But Richter says archaeologists are increasingly comfortable about recognising this fact, and not trying to explain ancient behaviour through modern conventions. "We do now have a bit more of an awareness of how 'strange' the cultural practices in the past appear to us," he says. ■

Neuroscience

Man sees half of every face like it's melting

Jason Arunn Murugesu

A MAN with a rare brain lesion may help increase our understanding of how we process faces.

Known as A.D., the man noticed three years ago that the faces he saw on TV were distorted, saying that they looked as if they were melting. He then discovered that when he looked in the mirror, his own face was also affected. In each case, it was only the right half of a person's face that was distorted. Doctors then found that A.D. has a lesion in the fibres connecting the brain's two hemispheres.

Jorge Almeida at Coimbra University in Portugal and his colleagues showed A.D. pictures of 20 faces and 20 other objects, like a car and a bell. They found that distortions only occurred when A.D. looked at faces. They also discovered that regardless of the angle at which the faces were presented, A.D. only ever saw the right half of the person's face as if it were melting. This was true even when the faces were presented upside down (*Current Biology*, doi.org/d65f).

This suggests two new key aspects of typical face processing, says Brad Duchaine at Dartmouth College in New Hampshire, who worked on the study with Almeida.

"We already knew that faces were processed differently to other objects, but now we know that we automatically fit new faces into a template, so that we can compare [them] to other faces stored in our memories," he says. This would explain why A.D. always saw the same part of the face as distorted.

"It also suggests that the two halves of a face are processed in separate hemispheres at some point," says Duchaine. He speculates that this may increase visual processing speed, as we normally look at the middle of a person's face and so each of our eyes initially takes in information from opposite sides of a face. ■

Return of the dolphins?

Four common dolphins spotted in the Adriatic Sea

Chelsea Whyte

COMMON dolphins (*Delphinus delphis*) were once relatively easy to find throughout the Adriatic Sea, but large groups were last seen in the 1940s. There were no reports of individuals in the area after the 1970s until the late 2000s.

There have been some sightings since 2009, so Tilen Genov at the Slovenian Marine Mammal Society has reviewed them to get a sense of the current population. He believes there have been four common dolphins in the region recently, three adults and one calf.

Why they have returned is unclear. Some threats to the species, such as culling campaigns, have ceased, says Genov. But others, like fishing that may limit their prey, have increased (*Aquatic Conservation*, doi.org/d64v).

Is the population of common dolphins growing in the Adriatic? "I wouldn't call it a comeback," says Genov. "They are still super rare." ■



Supercomputer reveals tardigrade secrets

THE most resilient animal known to science – the tardigrade – is yielding its secrets, with the first work at the atomic level to investigate how it survives extreme stress.

Tardigrades are microscopic, eight-legged animals sometimes referred to as water bears.

Under environmental stress, such as dehydration or extremes of temperature, they shrink into a “tun” state in which their metabolism all but stops. In this state, they can survive without water for decades, tolerate high doses of gamma and X-ray radiation and survive temperatures from -272°C to 150°C. They have also breezed through

10 days in the vacuum of space.

In most other organisms, these sorts of stresses destroy the DNA in cells, but tardigrades have a damage-suppressor protein (Dsup) that somehow shields the DNA. Now, Marina Mínguez-Toral and her colleagues at the Centre for Plant Biotechnology and Genomics in Madrid, Spain, have performed a simulation of the interaction between Dsup and DNA that suggests an explanation.

The team modelled a system of two Dsup molecules and DNA, comprising more than 750,000 atoms, which required “days and days” on a supercomputer. “The equations of motion must be solved for each of these atoms

50 million times to get a simulation lasting 100 nanoseconds,” says Mínguez-Toral.

The researchers’ modelling shows that the protein is “intrinsically disordered” and highly flexible, and seems to be able to adjust its structure to precisely fit DNA’s shape. This may offer the DNA a form of “electric shielding” that protects it from damage, says Mínguez-Toral (*Scientific Reports*, doi.org/d62f).

Figuring out precisely how tardigrades tolerate such extremes

“Modelling the motion of 750,000 atoms in and around the DNA took days and days”

could be useful in several ways.

“Right now, the main applications we are actively working on are the stabilisation of pharmaceuticals and the engineering of stress-tolerant crop plants,” says Thomas Boothby at the University of Wyoming.

Other possibilities include cancer treatment. There are futuristic applications too – people going to Mars might be modified to be more resistant to radiation, for example. In the lab, human kidney cells have been genetically modified to express Dsup from tardigrades, and the cells showed a reduction of 40 to 50 per cent in the DNA damage caused by X-rays. ■

Rowan Hooper

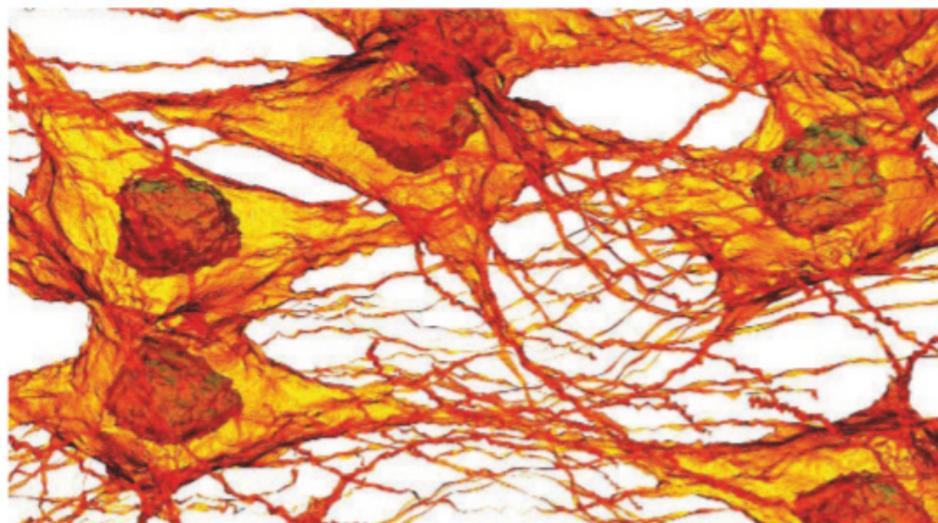
Tumour microbiome may predict chances of cancer survival

Jessica Hamzelou

THE microbes that surround and exist in cancer tumours may help predict how a person's disease progresses and which drugs they are most likely to respond to. A better understanding of this "tumour microbiome" may also lead to new cancer treatments.

Cancer tumours are laced with bacteria and viruses, which can be found inside, between and in the space surrounding tumour cells. Until a few years ago, researchers thought they ended up in tumours as a result of handling cells in the lab and were merely a sign that the samples were contaminated, says Eytan Ruppin at the US National Cancer Institute in Maryland.

More recently, we have learned that these microbes may play a role in how a cancer forms, develops and spreads. Research on gut bacteria has shown, for example, that microbes seem to interact with a person's immune system and can influence how their metabolism works. Cancer could be influenced by microbes in a similar way.



SCIENCE PHOTO LIBRARY/ALAMY

Tumour cells have many microbes living in and around them

Earlier this year, Rob Knight at the University of California, San Diego, and his colleagues assessed the presence of microbes in about 18,000 tumour samples – covering 33 types of cancer – that were taken from more than 10,000 people.

They found that the presence of certain kinds of microbes was associated with specific cancer

types. Based on the presence of bacteria alone, the researchers were able to predict the type of cancer a person had.

Ruppin wondered whether the presence of microbes might also predict how well people with cancer respond to treatment and how likely they are to survive the disease. To find out, he and his colleagues trained an algorithm on some of the same data employed by Knight's team to use the bacteria to forecast survival.

Although the prediction was only correct around 60 to 70 per cent of the time, it was more accurate than clinical estimates based on a person's sex, age and tumour stage, says Ruppin.

They also looked at whether the presence of some microbes might influence how well tumours respond to drug treatment. The researchers specifically assessed the impact of 30 drugs on the size of tumours and how long people survived once they had started treatment. For five of these drugs, the algorithm could predict how well the tumour responded to treatment (*bioRxiv*, doi.org/d6z6).

Ruppin hopes that analyses of tumours' microbiomes might improve the accuracy of "liquid biopsies", tests currently being developed to diagnose cancer based on tumour cell fragments or DNA in the blood.

We may also be able to develop new cancer treatments that specifically target the tumour microbiome, says Ruppin. ■

Robotics

Alcohol-powered beetlebot flexes its muscles

ONE of the world's smallest microrobots can carry 2.6 times its own body weight thanks to a muscular system powered by alcohol.

The "muscles" of small robots are often tethered to an external power source or powered by batteries. This limits robot efficiency and size, because the best batteries have an energy density of around 1.8 megajoules per kilogram, a fraction of what you get from animal fat, which is about 38 MJ/kg.

Nestor Perez-Arcibia at the University of Southern California says the methanol-powered muscles used by RoBeetle, an 88-milligram microrobot that he helped create, use catalytic combustion to reach energy levels up to 20 MJ/kg.

The methanol, stored in a fuel tank that weighs 95 milligrams when full, triggers an energy-releasing chemical reaction with oxygen that causes the microrobot's composite wire muscles to twitch, allowing it to crawl like a beetle.

It is still able to move when carrying a cylindrical object weighing 230 milligrams on



its horns – 2.6 times the weight of RoBeetle itself, or 1.3 times the weight of RoBeetle and its fuel tank (*Science Robotics*, doi.org/gg8qwb).

"I like the idea of replicating and engineering biomimetic systems like the RoBeetle, but using

RoBeetle, a small but powerful robot that runs on methanol

chemical reactions as highly powered energy sources," says Samuel Sánchez at the Institute for Bioengineering of Catalonia, Spain.

Research is under way to improve RoBeetle's performance by using other fuel sources, including propane, which has an energy density of 50 MJ/kg.

Perez-Arcibia also hopes to give RoBeetle wings in future.

"We want to create the first completely autonomous flying robot at beetle scale," he says. ■
Chris Stokel-Walker



Launchpad

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Leah
Crane

Solar system

The sun's lost sibling may have nabbed Planet Nine

Leah Crane

BILLIONS of years ago, there may have been two suns in our solar system. If so, that could explain how the solar system caught its outermost objects, including the hypothetical Planet Nine.

Our solar system is far bigger than just the space occupied by the eight official planets: it extends out to the Oort cloud, a belt of icy objects that sits about 2000 to 100,000 times as far from the sun as Earth does, and is only loosely gravitationally bound to the sun.

How the Oort cloud formed is a mystery, as is the origin of a proposed extra planet that may reside about 500 times as far from the sun as Earth does. Nicknamed Planet Nine, the existence of this world could explain the orbits of certain objects far out in space. Amir Siraj and Avi Loeb at Harvard University have come up with a way to solve both of those mysteries at once.

The sun, like most stars, was almost definitely born in a cluster with many siblings. If it had a companion star

"If the sun had a companion, which is not unusual, they would act as a sort of fishing net"

orbiting with it billions of years ago, that would have made it much better at catching space rocks like Planet Nine and those in the Oort cloud.

"If the sun had a companion, which is not unusual because more than half of all sun-like stars have a binary companion, that would have produced a very important effect on the solar system because the sun and its companion would act as a sort of fishing net," says Loeb.

DETLEV VAN RAVENSWAAY/SCIENCE PHOTO LIBRARY



He and Siraj calculated that the sun being part of a binary system in its youth, exerting more gravitational pull over a larger area, could increase the chances of our solar system having the sort of Oort cloud we see now by a factor of about five compared with if it has always been a lone star. When it comes to capturing Planet Nine, the likelihood increased by a factor of around 20 (*The Astrophysical Journal Letters*, doi.org/d63g).

If Planet Nine exists, researchers suspect that it didn't form where it seems to be now. Instead, it was probably either ejected from the inner solar system shortly after it arose or it was filched from another passing star.

"There is no simple way to make Planet Nine," says Konstantin Batygin at the California Institute of Technology, one of the researchers who spotted early hints that this distant world may exist. "This is something that could potentially work."

Once the sun and its companion gathered all these

An artist's concept of a world in a binary star system

objects, the sibling would have been pulled away by another passing star, a process that is common in young star clusters, says Loeb. This would have also blown away most of what was then the Oort cloud, resulting in the relatively sparse belt that we see now.

Evidence for this idea could come from our search for proof of Planet Nine's existence if we find many other worlds like it in the solar system. "If there was a companion star to the sun, it wouldn't have just captured one Planet Nine, it would have captured a bunch of those objects just like it captured a lot of Oort cloud objects," says Loeb. "When I go to the kitchen and find one ant, I know there are more ants walking around."

Just like those ants are a hint at the state of the kitchen, the objects in the outer solar system could hint at the sun's distant past and the possibility of a long-lost companion. ■

Climate change

Greenland lost a record amount of ice in 2019

Michael Le Page

MORE of Greenland's ice was lost in 2019 than in any year since measurements began. The ice sheet lost 15 per cent more ice than in 2012, the year the previous record was set.

"It is worrying, but not that much surprising," says Ingo Sasgen at the Alfred Wegener Institute in Bremerhaven, Germany.

The finding is partially based on data from the GRACE satellites that launched in 2002. They revealed just how much of Greenland's ice is disappearing due to melting and glacier flow into the ocean. There was less ice loss than usual in 2017 and 2018, but a new record decline of around 530 gigatonnes followed in 2019 (*Communications Earth & Environment*, doi.org/d626).

The expectation is that ice loss will accelerate as warming continues, but the satellite record is too short to show such a trend. It is clear that weather in Greenland is becoming more variable, however.

In some years, such as 2019, there are more high-pressure systems over Greenland, drawing in warm air from North America that causes lots of melting. In others, such as 2017 and 2018, low-pressure systems are more prevalent, producing lots of snow. Even in high-snow years, the ice sheet still loses mass due to global warming, as glaciers flow faster and dump more ice in the sea.

The loss of all Greenland's ice would add at least 6 metres to global sea level. It is thought that this would happen gradually over millennia rather than suddenly. However, the process might already be unstoppable. Some studies suggest we have triggered positive feedbacks that mean the decline will continue even if the planet stopped warming today. Sasgen thinks that we don't know enough to say for sure that we have passed the point of no return. ■

Defeating the IQ test

Simple tutorials boost scores, undermining the validity of IQ tests

Douglas Heingartner

PEOPLE given instructions on how to succeed at a widely used type of IQ test end up with far higher scores than those who take the test without learning these tips beforehand – throwing into question the validity of these kinds of tests and contributing to critiques of IQ tests in general.

That is the main finding of a study on “progressive matrices”, a kind of IQ test that displays a series of changing shapes. The test-taker has to figure out which shape would logically come next.

The most popular version, Raven’s Progressive Matrices, has been around since the 1930s. In the current study, Benedikt Schneider at Saarland University in Saarbrücken, Germany, and his colleagues used a competing test called the DESIGMA-Advanced.

The team asked 341 students to complete the test. About half of them were randomly assigned to watch a video on information unrelated to the test. The other half watched a 13-minute video that explained the “rules” behind the test. Although matrices tests vary in design, most are based on

the same five or six basic rules: for example, an element might rotate clockwise or anticlockwise from one picture to the next.

The group that watched the unrelated video got an average of nine correct answers on a test consisting of 28 questions. The tutorial group averaged 18 correct answers. That difference equates to about 18 extra IQ points, though a typical IQ test uses more than

You can boost your IQ score by watching an explainer video

just progressive matrices (*Intelligence*, doi.org/d629).

The researchers are quick to point out that nobody’s actual intelligence level increased; only their test scores rose. But what does that mean for these tests going forward? If subjects can increase their scores by simply watching a short video – and there are many such YouTube videos that have millions of views – how can the tests still be valid?

“This might mean curtains for tests like Raven’s,” says Stuart Ritchie at King’s College London.



“It’s basically as if someone posted up all the vocabulary test words online so people could look them up in the dictionary just before they do an IQ test. It makes the gains hollow.”

Though Schneider’s team didn’t investigate Raven’s Progressive Matrices, a 2015 study found that a brief video tutorial also increased gains on that test, albeit less than in the current study. Pearson, the publisher of Raven’s tests, didn’t respond to requests for comment.

The risk of video tutorials compromising the validity of some tests “is indeed possible”, says Schneider. Two of the paper’s co-authors designed the DESIGMA test that was analysed, so they are quite aware that their research might undermine the test.

One way to get around this, says Schneider, would be to have all test-takers watch a video of the rules, or even to incorporate such a tutorial into the test itself.

Ritchie thinks this should already be the norm. “This is what a good intelligence tester should be doing when they give the instructions for the test,” he says. ■

Animal behaviour

Walking catfish are the first fish known to ‘smell’ on land

WALKING catfish are sometimes literally fish out of water, but they function quite well as a landlubber – and they are now the first fish confirmed to “smell” through air.

Native to South-East Asia, walking catfish (*Clarias batrachus*) aren’t content to glide through one body of water their whole lives. They can travel to a new pool by leaving the water and “walking” on their fins over land, breathing the air.

Similar amphibious fish were assumed to use their vision to navigate on land, says Noah Bressman at Chapman University in California. But walking catfish commonly come ashore at night, and have tiny, underdeveloped eyes.

Curious to find out if the fish were sensing chemicals in the air, Bressman and his team caught 150 walking catfish and placed each in an enclosure on land to expose them to a battery of odiferous substances. The fish flopped away from noxious hydrogen sulphide, but chased down the scent of pond water and alanine – a compound

that induces a strong taste response in submerged catfish (*Journal of Fish Biology*, doi.org/d63j).

The findings suggest that walking catfish are the first fish known to use “chemoreception” out of water, and Bressman says they may use this sense to orient themselves on land. Fish weren’t thought capable of this because their olfactory and taste systems evolved in water.

“Underwater, taste and smell

“The catfish may be using a form of aerial tasting thanks to the taste buds that blanket their bodies”

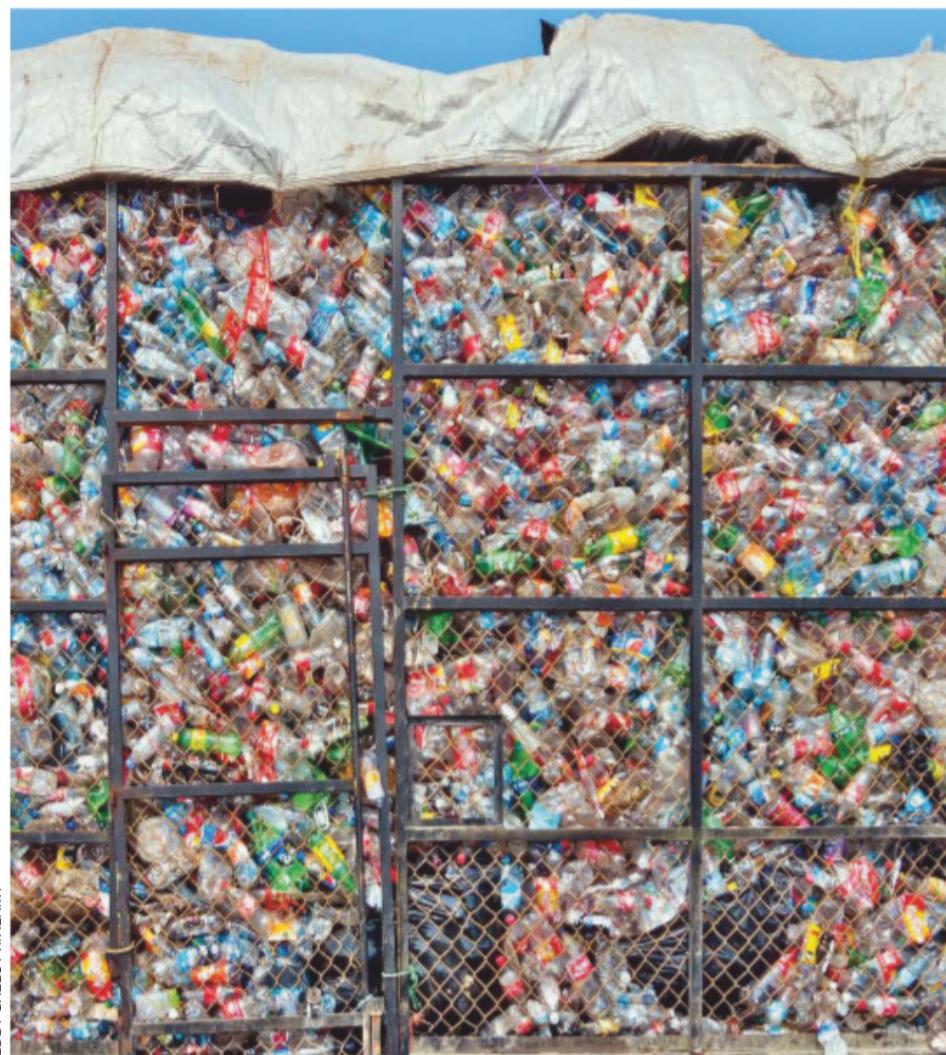
go hand in hand,” says Bressman. Unlike humans, who taste with direct contact but can smell from afar, fish “can both taste and smell compounds that are originating from a long distance because of the liquid environment”, he says.

Bressman says the catfish may be using a form of aerial tasting thanks to the taste buds that blanket their entire body, even their sensitive whiskers.

Walking catfish are invasive in the south-east US. Knowing how they make their pond-hopping decisions could help stop their spread. ■

Jake Buehler

Environment



New type of plastic may be infinitely recyclable

THE amount of plastic waste ending up in landfill could be reduced with a new type of plastic that can be easily broken down into its chemical building blocks and reassembled into high-quality products.

More than 300 million tonnes of plastic are produced globally each year and only a small fraction – about 10 per cent in the US, for instance – is recycled. The rest is put into landfill, incinerated or gets into the environment.

One reason why so little plastic is recycled is because it is hard to break down, and remoulding it can weaken its chemical structure. As a result, recycled plastic is normally only used to make low-value products, such as outdoor benches.

Now Eugene Chen at Colorado State University and his colleagues have developed a plastic, called

PBTL, that can maintain its qualities when recycled. It is made by joining together chemical building blocks called bicyclic thiolactones. PBTL has excellent strength, toughness and stability, says Chen, so could be used to make items including plastic packaging, sports equipment, car parts and construction materials.

The plastic can be recycled by heating it at 100°C in the presence of a chemical catalyst for 24 hours. This breaks the plastic into its original building blocks, which can then be reassembled into new high-quality PBTL (*Science Advances*, doi.org/d645).

PBTL can only be broken down and remoulded like this when it is on its own, says Chen. So it would need to be separated from other types of plastic before recycling, he says. **Alice Klein**

Oncology

Cancer cells grab a coat to keep them safe

SOME cancer cells may be more likely to seed distant growths because they pick up “coats” made of monounsaturated fatty acids.

Sean Morrison at University of Texas Southwestern Medical Center and his team injected dyed human melanoma cells into the veins or lymph nodes of 520 mice and then traced how those cells moved through the body.

The team found that more cancer cells survived in the lymphatic fluid – which flushes infection-fighting cells through the body and helps remove cellular debris – than in the blood. The ones in the lymphatic fluid were also more likely to seed distant tumours. Those in the blood were more likely to have undergone high levels of oxidative stress, a process by which free oxygen radicals can damage fatty cell membranes.

Isolating cancer cells from the blood and the lymph nodes revealed that the cancer cells in the lymph nodes had a higher level of oleic acid, a monounsaturated fatty acid, in their cell membranes (*Nature*, doi.org/d643).

The oleic acid in the cells exposed to lymphatic fluid diluted the polyunsaturated fats and shielded them from oxidative damage when the cells later travelled through the blood to distant parts of the body, says Morrison.

He says this gives researchers another target in the fight to prevent cancer progression in patients.

In addition to drugs that might disrupt this protective membrane, Morrison and his team are testing the effects of feeding mice a “cheeseburger diet”, heavy in fats that could keep the membrane vulnerable to damage and slow cancer progression. **Emma Yasinski**

Weather

Sea turtles work as hurricane forecasters

SEA turtles carrying location and temperature sensors have been used to gather data on water temperatures near hurricanes, which could help us forecast how strong such storms will be.

Hurricanes are difficult to model in the Mid-Atlantic Bight, a coastal region along the eastern US from around New York to North Carolina, because the waters there are very stratified in

summer, with warm water at the surface and cold water far below.

Hurricanes get their energy from warm water, so water temperature affects their behaviour. But models of hurricane intensity don’t account for the way forces ahead of the storm’s eye cause water to mix, because it is hard to get water temperature data during storms.

During 2011, Leah Crowe at the Northeast Fisheries Science Center in Massachusetts and her colleagues tagged 26 loggerhead turtles that forage in the Mid-Atlantic Bight in hurricane season. When Hurricane Irene struck in August that year, 18 of the turtles came within 80 kilometres of the eye of the storm. As they swam, they logged temperatures throughout the water column (*Movement Ecology*, doi.org/d644).

The turtles cover a large area and their measurements should improve models of ocean temperature and hurricane forecasts. **Liz Kalaugher**



DOUG PERRINE/NATUREPL.COM

Really brief



Palaeontology

Ancient marine reptile was killed by its meal

ONE ancient marine reptile seems to have bitten off more than it could chew. A fossil of a 5-metre ichthyosaur has the body of a 4-metre-long animal in its stomach. The ichthyosaur seems to have died soon after consuming the massive meal.

Ichthyosaurs, which resemble dolphins, thrived from around 250 to 90 million years ago. The shape of their teeth suggests that some of them were top predators that

tackled big prey, but there is little direct evidence of what they ate.

In 2010, Ryosuke Motani at the University of California, Davis, and his colleagues found a large ichthyosaur fossil in a quarry in south-west China, identified as being in the *Guizhouichthysaurus* genus. Preparing the fossil revealed a surprise. "There was something in its stomach that was protruding," says Motani.

The meal was another marine reptile called a thalattosaur. This lizard-shaped animal was nearly as long as the ichthyosaur, but much skinnier, says Motani.

The ichthyosaur bit off the head and tail of the thalattosaur, probably by shaking it. It then swallowed the body whole (*iScience*, doi.org/d64x).

But at some point, perhaps during the attack, the ichthyosaur injured its neck. "The neck was broken to the extent that it could not hold its skull," says Motani. "It could not breathe."

The body of the thalattosaur shows no sign of being broken down by digestive juices and its tail was found nearby, suggesting the ichthyosaur died quickly after the meal. Michael Le Page

Strange clouds at our galaxy's core

Astronomers have spotted two clouds of cold, dense gas speeding away from the centre of the Milky Way at 300 kilometres per second – faster than they should move in theory. The clouds carry a type of hydrogen used to build stars, so its expulsion may be slowing star birth at the galaxy's core (*Nature*, doi.org/d62b).

Dinosaurs had lightweight bones

We have discovered a feature of dinosaur biology that helps explain the huge sizes they achieved. Scans of fossils show that some of their bone was less dense than that of other animals, but still strong, so their skeletons could grow large without being too heavy (*PLoS One*, doi.org/d6z9).

AI speeds up MRI scans

An AI built by researchers at Facebook and NYU Langone Medical Center in New York can create magnetic resonance imaging (MRI) scans with only a quarter of the data normally required. It is hoped the system could speed up scans (*American Journal of Roentgenology*, doi.org/d6z2).

Sex ratios



Millions of missing female births predicted in India

AN ESTIMATED 6.8 million fewer female births could be recorded in India between 2017 and 2030 than would be expected without practices such as sex-selective abortion.

India's ratio of male to female births has been imbalanced since the 1970s, largely driven by a rise in families choosing to abort female fetuses because they want sons.

Fengqing Chao at King Abdullah University of Science and Technology in Thuwal, Saudi Arabia, and her colleagues have modelled future sex ratios at birth in 29 Indian states and territories that encompass more than 98 per

cent of the country's population. The team used birth data as well as national survey data on people's preferences to have a son or daughter to come to the 6.8 million figure. The prediction started from 2017 because this is the year after the most recent birth data.

The model projected that the highest deficits in female births would occur in the state of Uttar Pradesh in the north of India (*PLoS One*, doi.org/d647).

Identifying regions with strong biases could enable the targeting of policies or campaigns to prevent abortions of female fetuses, says Chao. Layal Liverpool

Wearable technology

Eye-tracking mask gauges reactions

A MASK that tracks the wearer's eyes and measures their pulse could be used to study people's reactions to things they see.

Trisha Andrew at the University of Massachusetts Amherst and her colleagues have developed fabric-based electrodes that enable continuous monitoring of the wearer's eye movements and pulse for up to 8 hours.

This could make it useful for monitoring sleep, for example, because the eye's behaviour is an indicator of rapid eye movement (REM) sleep, says Andrew.

Andrew and her colleagues tested their mask – which they have named Chesma – on three volunteers. They are now using it for sleep studies in larger groups of people alongside smart pyjamas to monitor sleep posture and breathing.

The mask could also be useful for human-computer interactions. It can tell which quadrant of a screen your eyes are drawn to, says Andrew (*Matter*, doi.org/d646). "Coupled with pulse, that provides insight into awareness and emotional state," she says.

In future, this could allow the wearer to communicate with a computer using their gaze alone. LL

Signal Boost

Welcome to our Signal Boost project – a weekly page for charitable organisations to get their message out to a global audience, free of charge.
Today, a message from [Myelopathy.org](https://www.myelopathy.org)



Scientists urgently needed to tackle common spinal cord disease

Degenerative cervical myelopathy (DCM) is the world's leading cause of spinal cord impairment and disability, estimated to affect 2 per cent of adults. Even with surgery, the gold standard treatment, fewer than 5 per cent of people with this "slow-motion spinal cord injury" will make a full recovery. Most will be left with life-long disability, including loss of manual dexterity and balance, chronic pain, incontinence and even paralysis.

DCM is under-recognised, underdiagnosed and poorly understood. People can wait 10 years or more to get the correct diagnosis. This reduces the effectiveness of treatment, and only around half are able to return to work.

Myelopathy.org was founded by Cambridge University neurosurgeons Mark Kotter and Ben Davies, to research DCM, raise awareness and improve access to quality care. The academic team were later joined by Iwan Sadler, a person with DCM who frustrated by the lack of accurate information about his condition, had formed a

Myelopathy Support Facebook group. Myelopathy.org was registered as a charity in 2018 and now hosts an international support community of more than 3000 individuals.

Little is known about the aetiology of DCM, with its devastating consequences, or how best to manage it. Degenerative arthritic changes ("wear and tear") in the cervical spine gradually press on the spinal cord but there is no direct link between their severity and symptoms. Even mild compression may cause severe progressive neurological decline and deteriorating quality of life, while people with severe damage may only discover it incidentally.

DCM needs a new generation of scientists to tackle the fundamental questions that could dramatically change outcomes.

Myelopathy.org, in partnership with AO

Spine, a non-profit organisation, has recently completed a global consensus project, AO Spine RECODE-DCM, to identify the top 10 research priorities. This was hailed by Prime Minister Boris Johnson, in recognition of "how you are improving understanding and care of cervical ... myelopathy, redirecting the research agenda".

Vital funding and support for this programme is now needed, to turn these questions into life changing answers: to understand how long-term spinal cord compression causes damage; who its effects; when to operate; the need for rehabilitation and new treatments.

There are key educational needs, too, to raise awareness of DCM among health professionals, the public and service providers. People with this condition need timely access to MRI, diagnosis, and life-changing surgery.

Want to help?

Can you answer a research priority, and help improve outcomes for 1/50 adults?
Please visit aospine.org/recode for more information.

The columnist

Wholesome memes could save us, writes Annalee Newitz **p24**

Letters

The nuclear threat must remain a priority **p26**

Aperture

Stunning nature photography prizewinners **p28**

Culture

A better way for society to think about reproduction **p34**

Culture columnist

Simon Ings is moved by a film about a UFO hunter **p36**

Comment

The fight for the internet

The internet's infrastructure is starting to fall apart, and that is leaving us all insecure, says **James Ball**

IN JANUARY 1989, two engineers – Cisco's Kirk Lougheed and IBM's Yakov Rekhter – sat down in the cafeteria at a technology conference in Austin, Texas.

The two men were looking to work out a short-term fix to help address problems with the way data flowed across the fledgling internet, which at the time connected about 100,000 computers across the world.

In the spirit of finding a fudge, they scribbled a new protocol across either two or three napkins. (They can't recall how many and didn't keep the originals.) This protocol was adopted as the new standard for determining which physical routes data would take to traverse the network.

More than 25 years later, the "three-napkin protocol" is still in place. But in the meantime, the internet has become critical global infrastructure – central to the business operations of many of the world's largest companies, the planet's information ecosystem and the daily behaviour of about half the people on Earth.

The protocol that Lougheed and Rekhter devised – known as Border Gateway Protocol (BGP) – in their lunch break was far better than either realised, but it isn't what you would design for a secure global network that we all rely on.

The process works a little like transponders to guide aeroplanes: computers on the network can tell you whether you are heading in the right direction to get to,



for example, Paris. But there is nothing stopping someone from lying.

In one famous example, Pakistani authorities looked to block a YouTube video they had deemed offensive and ordered their internet providers to do this. One company did so by using BGP to direct anyone looking for YouTube in Pakistan to a dead end.

No one had hacked or damaged YouTube, but no one was directed towards it. Unfortunately, this new "route" to YouTube wasn't restricted only to this firm's users. Thanks to human error,

the Pakistani internet provider recommended its new route across the world, taking down YouTube for millions of users.

This is just a single example of what happened with one protocol. Users can be misdirected, intercepted, blocked and put at risk by numerous vulnerabilities built into the creaking infrastructure of the internet, and efforts to fix it are painfully and dangerously slow.

The internet was born as a US-funded collaboration between universities, with rules agreed by common consent between

the academics involved. To this day, the operation of the protocols to make it work are set out not in a rulebook, but in a collection of "Requests For Comment", a passive-aggressive title chosen to avoid conflict, and one that has stuck for five decades.

The internet turned 50 last year. For its first two decades, it grew slowly between institutions that already knew and trusted each other, then exploded through the 1990s and beyond to what we have today. The opportunity to retool the network, if it ever existed, wasn't taken. We can't rebuild from scratch; we have to fix what we have.

One of the biggest challenges in doing so is that the internet is largely operated by consent and by slow, grinding consensus. There is no overseeing authority, no one setting global laws.

This has happened not least because, for most governments, the only thing worse than no one controlling the internet is someone else controlling it. Yet this lack of authority is a worry, because our lives, our data, our communications and our physical infrastructure are moving online.

None of these issues will get easier. The best time to decide who runs the internet was decades ago. The second-best time is now. ■



James Ball is the author of *The System: Who owns the internet, and how it owns us*

This changes everything

Wholesome memes could save us all It is time to rekindle the idea of netizens – upstanding internet citizens who band together to tackle important global problems, writes **Annalee Newitz**



Annalee Newitz is a science journalist and author. Their latest novel is *The Future of Another Timeline* and they are the co-host of the Hugo-nominated podcast *Our Opinions Are Correct*. You can follow them @annaleen and their website is techsploitation.com

Annalee's week

What I'm reading

The Numenera Player's Guide, so that I can finally mix science with my sorcery.

What I'm watching

A wholesome mutant family show called *The Umbrella Academy*.

What I'm working on

Writing my novel about talking animals (some are fluffy but not cute).

This column appears monthly. Up next week: James Wong

IT STARTED with *Animal Crossing: New Horizons*, the anodyne casual game where you are on an island populated by cute, talking animals. You can go fishing for bits and bobs, or try out other gentle activities like fossil collecting, shopping and chatting with your friends. Released for the Nintendo Switch in March, just as the coronavirus was spreading across the world, it became an enormous hit and continues to be a cultural obsession.

Shoot-em-all games like *Fortnite* are still popular during what some Californians are calling “the ronie times”, but *Animal Crossing* is the clear winner in the war to distract us from death and politics. This game is the apotheosis of fluffy. It also offers a comforting dose of nostalgia – kids who grew up playing the early-2000s titles in the series are now adults who really don’t want to think about how their jobs are disappearing.

As the pandemic encroaches on every part of our lives, from schooling to elections, the hunt for internet fluff has reached fever pitch. The most recent example is the strawberry dress created by New York designer Lirika Matoshi to look like a pink cloud of strawberry studded candyfloss. People are obsessing over the dress on Instagram and TikTok, taking selfies in it and even sewing their own versions. Wearing it makes them feel like fairy princesses hiding away in flowery castle gardens – rather than disease-fearing moderns in hot, lonely city flats.

This is truly the era of the “wholesome meme”. Online entertainment has become like *The Great British Bake Off*, with conflict reduced to fears about the structural integrity of sugary toppings. The original *Bake Off* presenters, Sue Perkins and Mel

Giedroyc, have even managed to make assassination wholesome in their delightful new series *Hitmen*.

In the US, psychologists are calling this phenomenon toxic positivity. We are acting like we can cure any ill with aggressive optimism. Sadly, this urge to cheer up can make us more unhappy – and unprepared for the inevitable setbacks to come. That doesn’t mean we should shut down our computers. Instead, we could embrace a very different class of wholesome meme that was viral back when people were playing

“Netizenship and fluff seeking online both reflect an urge to turn to the internet for comfort and support”

the original *Animal Crossing* almost 20 years ago. I’m talking about the netizenship meme.

Popularised by a young internet theorist named Michael Hauben in the mid-1990s, the term netizen referred to people on early forums and chat rooms who became actively engaged in their communities. Hauben believed that the world was on the brink of recognising a new kind of citizenship, global in scope, where people could form political alliances that had nothing to do with nationalism, traditional party systems and the old bureaucratic ways.

Though he died in 2001 at the age of 28, Hauben’s ideas stayed relevant in the noughts and teens. Researchers like Zeynep Tufekci and Molly Sauter took the notion of netizenship in new directions, exploring “networked protests” in Turkey and digital activism in electoral politics.

What Hauben couldn’t have

foreseen was the degree to which nation states would get involved in online politics: surveilling protesters, arresting people who liked allegedly subversive topics on Facebook and shutting down access to platforms like TikTok when it suited them. Not exactly wholesome.

That is why it is time to reinvent the idea of the netizen, an upstanding citizen of the internet, for the twenties. We may be restrained by what our nations do to us online, but we are also part of larger, international communities on social media. We are helping each other out with apps such as GoFundMe, like good neighbours. Now it is time to act as netizens to solve global issues like election meddling and misinformation about the pandemic.

Two internet companies that own platforms where good citizenship really matters are Google and Facebook. They are wealthier than many nations and arguably wield as much power. What sets them apart from other corporations is that their status comes directly from the content their users put into them – just the way nations’ wealth can come from the people who live within their borders.

In a sense, netizenship goes hand-in-hand with fluff seeking online. Both are wholesome memes that reflect an urge to turn to the internet for comfort and support. The difference is that netizenship demands that internet companies give us more than escapism. We also need rights and protections. We deserve accountability from the corporations whose products are built on our shared personal information and public debates.

Put another way: come to the internet for the cute bunnies, but stay for the growing body politic. ■

A feast of learning for children...

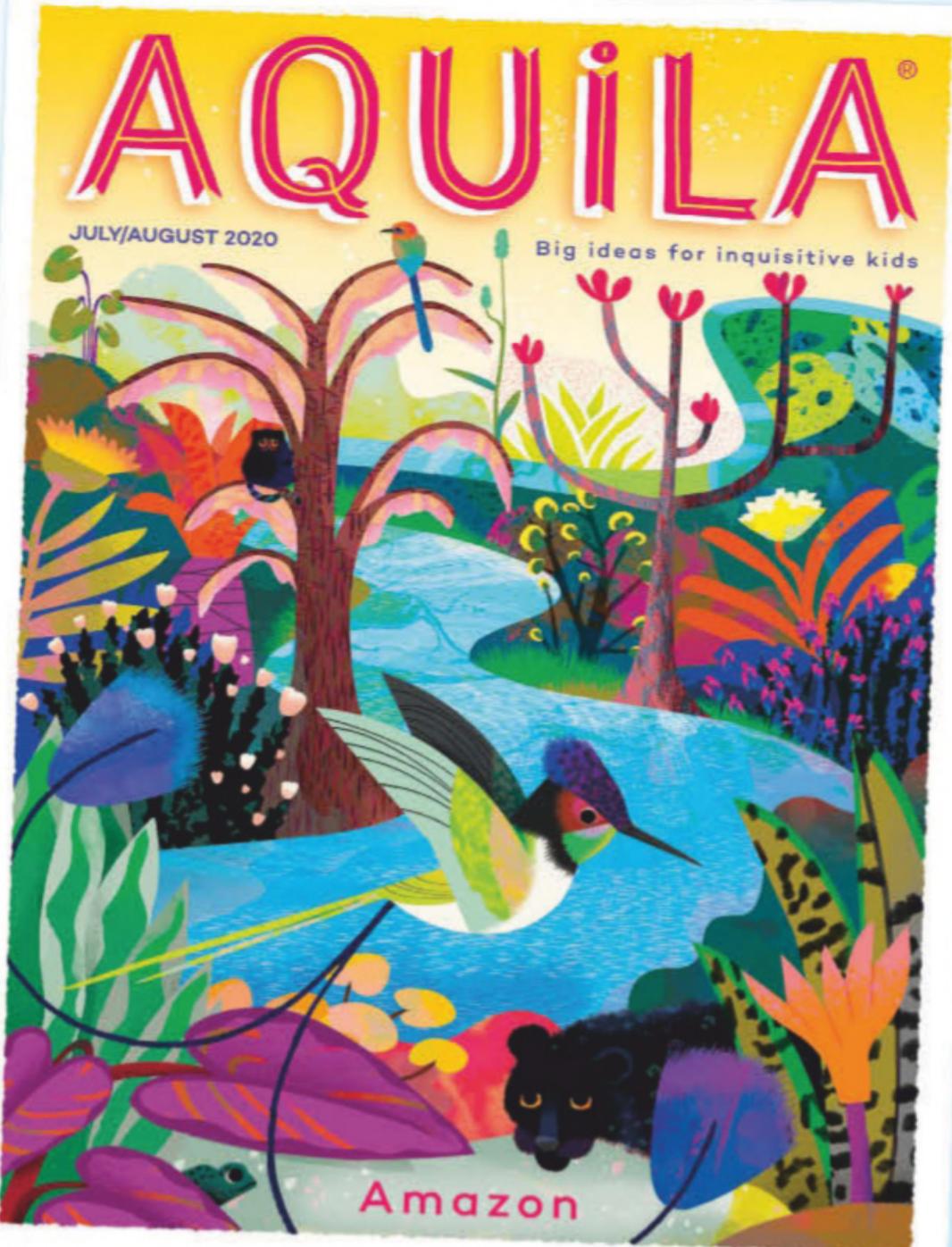
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RICHARD ROBINSON - BRIGHTON SCIENCE FESTIVAL

Editor's pick

Nuclear threat must remain a priority

8 August, p 21

From Alastair Cardno, Burley in Wharfedale, West Yorkshire, UK

Reading Anders Sandberg and Thomas Moynihan's article on the 75th anniversary of the dropping of atomic bombs on Hiroshima and Nagasaki in Japan brought back other reflections from visiting these cities several years ago.

Amid the heart-rending stories and factual accounts, I found it hard to understand why it was felt necessary to drop a second bomb, with a different design, so soon after the first. I concluded that one aspect of these events was that they were large-scale and horrendous scientific experiments, in preparation for the anticipated next conflict between the US and the Soviet Union.

Consistent with this was the choice of densely populated cities rather than military targets. The flat grid layout of Hiroshima seemed to me ideal for conducting extensive observations of the effects of the explosion that occurred.

Subsequently, scientists have also made important contributions to initiatives aimed at negotiating for the reduction or elimination of nuclear weapons. The risks remain, from intentional or accidental use, but seem to be less prominent in our public and political consciousness. I hope this anniversary acts as a reminder that nuclear weapons are still among our existential threats.

Even 'bad' decision can sometimes make sense

1 August, p 46

From John Stevens, Bad Münstereifel, Germany

The article promoting *The Brain: A user's guide* discusses the difficulty we face in making the right decision as our brains have inbuilt biases. However, it too falls foul of "blind-spot bias" when it assumes what constitutes a good decision.

For example, when discussing

the endowment effect, it fails to consider the emotional satisfaction an "irrational" decision may give, such as someone "refusing to swap an item for something of higher value". Sentimental value is something that can't be expressed in money and is therefore hard to measure.

The growing dangers with our biological data

15 August, p23

From Sam Edge, Ringwood, Hampshire, UK
I agree with Maninder Ahluwalia about the problem of using biological material without the subject's consent or knowledge. The complete disregard for Henrietta Lacks, whose cancer cells were used in labs without her consent, is the tip of the iceberg.

We also need to protect against the use of our genome, epigenome, iris and retina patterns, fingerprints, voice, facial structure and so on. As technology advances, this list grows – gait analysis to distinguish people from video, for example.

The default should be that a person's explicit prior permission is needed to keep, publish or share a copy of any of this information if it can be used to learn about health, habits, employment, associations or whereabouts.

Is there a hug-free way to get the same boost?

8 August, p 11

From Grant Hutchison, Dundee, UK
Those of us who come from cultures in which one seldom, if ever, hugs a friend or relative have watched the covid-19-related agonising of the more hug-dependent with a mixture of sympathy and bemusement.

This reached a crescendo for me with your story, which contained a detailed list of instructions for low-risk hugging.

How desperate for a hug would anyone have to be to follow through on the spontaneity-destroying and buzz-killing strictures offered therein? (I ask out of genuine curiosity.)

The usual references to the psychological benefits of hugging are offered up, but as far as I can see the relevant research has, for obvious reasons, all been carried out in societies that value hugging. This is like carrying out research on the psychological benefits of watching cricket solely on the spectators at cricket matches.

Presumably those of us who are contentedly hugless in our social lives manage to raise our oxytocin and diminish our cortisol in other ways. This would seem to be a useful focus for research, particularly at a time when the alternative seems to be the self-conscious and stilted bodily contact described in your article.

Still not convinced life's parts arrived all at once

8 August, p 34

From Robert Bywater, London, UK
I enjoyed reading "Life's big bang" and its new take on the origin of life on Earth. Michael Marshall covered a large part of recent research in this area, notably that by David Deamer, Jack Szostak and John Sutherland. But there were omissions.

Marshall alludes to the widely accepted idea of "chemical-rich pools" on land (Darwin's "warm little ponds"), but the key feature of these ponds is that they regularly dry out, causing reaction rates to increase enormously as chemicals get concentrated, thereby generating new chemical

species very rapidly. Then the pools get replenished by new cycles of incoming water with more "chemical feedstock". This cyclic process would have been driven by the moon, which cycled around Earth at shorter intervals at the time we think life began, about 4 billion years ago.

These events speeded up the process of chemical evolution enormously and, although there weren't yet any enzymes, there were mineral catalysts. The effect of this tidal process was critical.

I also take issue with the "everything first" notion that the key ingredients of life occurred together. I believe there had to be a clear sequence of events whereby certain chemicals accumulated first and then there was interplay with new chemicals that arrived in due course as chemical evolution progressed.

Plenty more work on new covid-19 treatments

1 August, p 9

From Simon Goodman, Griesheim, Germany

Your pandemic coverage asks: "What are the most promising medicines?" Vaccines are among them, but we don't yet know if they will work well. In any event, many people will be without a vaccine for a very long time. So, as you say, we also need therapeutics to treat those people acutely ill with covid-19.

On this front, Adam Vaughan chiefly looks at attempts to repurpose existing anti-inflammatory and anti-viral drugs, only briefly acknowledging that some firms are developing new ones to tackle covid-19.

In fact, there is a lot of work on antibody therapeutics against covid-19. The Antibody Society, of which I am the science and technology program manager, has noted 13 clinical trials in progress from nine companies, including several phase III late-stage trials. Fifteen more antibody therapies are planned to enter clinical trials before 2021. ■



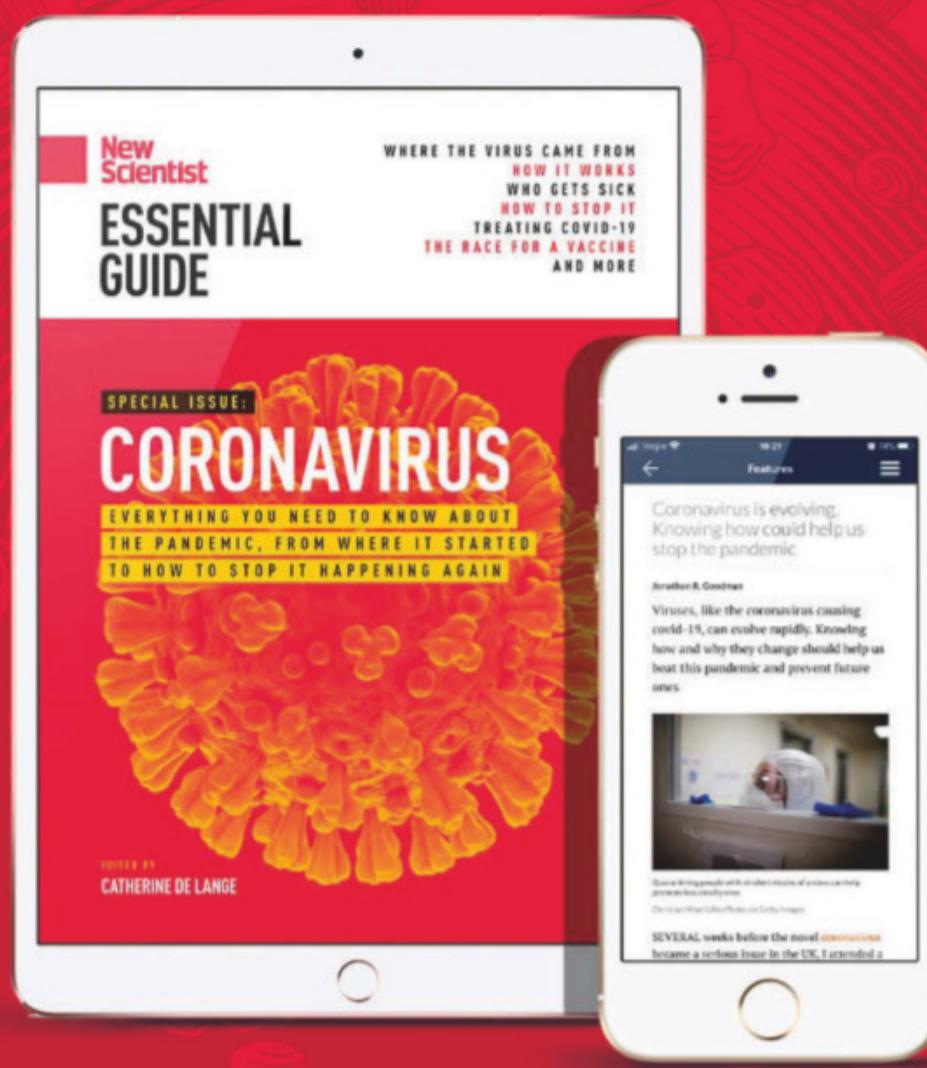
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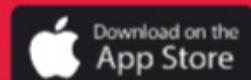
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Mating moves



The Australian Geographic Nature Photographer of the Year competition is produced by the South Australian Museum. Photographers **Mat Beeston, Ben Blanche, Jari Cornelis, Kevin De Vree, Alex Kydd, Tess Poyner**

THIS tangled mass of rays was spotted on the Ningaloo Reef, off the coast of Western Australia. Titled *A Fever of Cownose Rays*, this photo by Alex Kydd may be a rare look at the animals' courting rituals, in which males try to grasp the fins of females.

The image won the Animal Behaviour category at the 2020 *Australian Geographic* Nature Photographer of the Year competition. Pages 30 to 31 show other entries in the contest, including its overall winner, *Border Fire Mt Barney*.

Taken last November by Ben Blanche, the photo depicts Mount Barney in Queensland during the recent bushfires that devastated more than 180,000 square metres of forest, killing billions of animals.

Tess Poyner was dubbed the Junior category winner for *Graceful and Green*, an image showing a dainty green tree frog in Daintree rainforest, Queensland. Jari Cornelis's *Storm Dragon* won the Animal Habitat category and it stars a central bearded dragon in the Northern Territory.

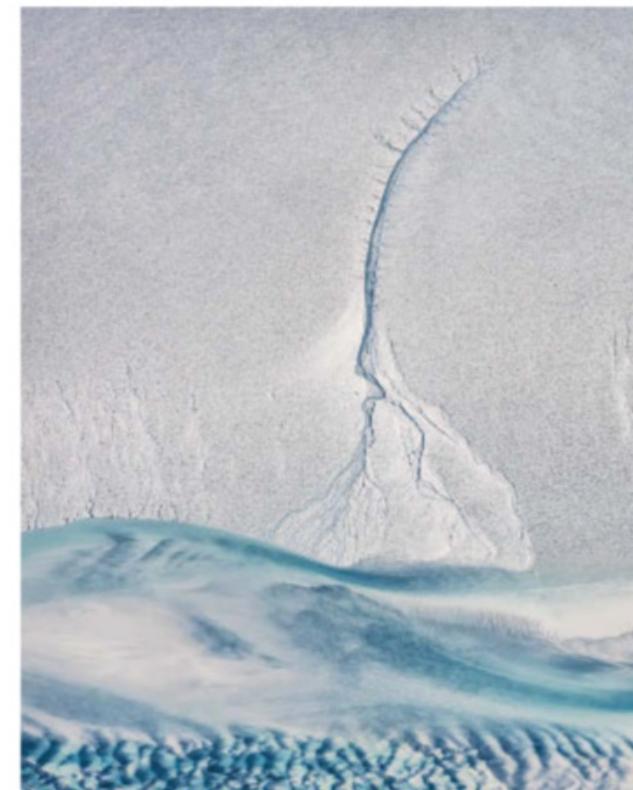
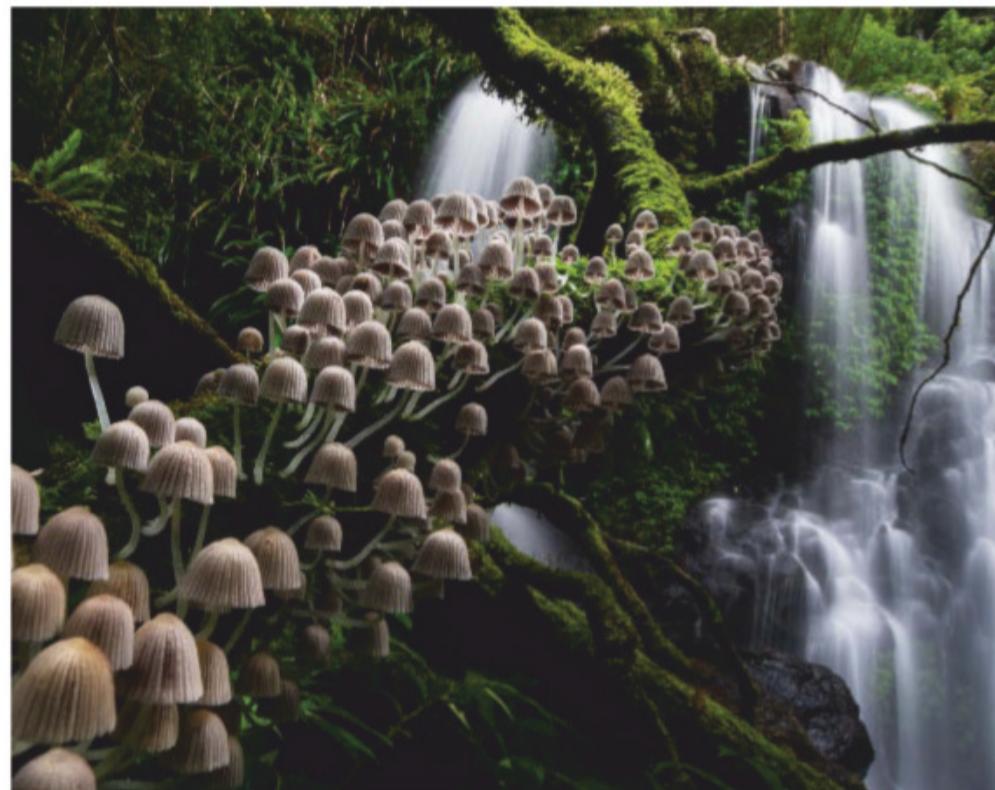
In *Bolt on Stormy Ocean* by Mat Beeston, winner of the Landscape category, water etches a path along this white, sandy creek bed near Broome, Western Australia. *Enchanted Forest* by Kevin De Vree won the Botanical category, featuring a fungal "stairway" in Lamington National Park, Queensland.

All the finalists are on display at the South Australian Museum in Adelaide until 15 November. ■

Gege Li



Clockwise
from top left:
Border Fire
Mt Barney by
Ben Blanche;
*Graceful and
Green* by
Tess Poyner;
Storm Dragon
by Jari Cornelis;
*Bolt on Stormy
Ocean* by
Mat Beeston;
Enchanted Forest
by Kevin De Vree





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Rewriting reproduction

Moving away from outdated, gendered ideas about reproduction could transform our health and improve society, finds **Jessica Hamzelou**



Book

Guynecology: The missing science of men's reproductive health

Rene Almeling

University of California Press

MALE bodies have long been seen as the norm when it comes to science. It is men and male animals that have been studied to understand what good and poor health looks like, as well as how to treat disease – except, that is, when it comes to reproduction.

Historically, baby-making has been viewed as the defining function of women's bodies, so much so that other aspects of their health have been neglected. For example, heart attacks are less readily identified in women, who are 59 per cent more likely to be misdiagnosed despite the fact that cardiovascular disease is the leading cause of death in women.

Meanwhile, research into men's reproductive health has lagged behind. Attempts to understand their contribution to fertility, miscarriage risk and long-term risk of a child developing some mental health conditions, for example, have only recently gained ground.

In *Guynecology*, Rene Almeling, a sociologist at Yale University, explores how attempts to kick-start the study of men's reproductive health failed. Even now, as the role of health in sperm function and in the well-being of future children becomes clear, information is still scarce and gendered notions about a woman's role in making babies persist, she writes.

Take the age-old notion of the coming together of “aggressive” sperm and “passive” eggs. The idea that conception is largely the role of the sperm cell is still a very

JAUNTY JINTO/GETTY IMAGES



popular one, but it isn't true. We now know eggs release chemicals to sperm when they are ready to be fertilised, and recent research suggests that these might help select some sperm over others.

When it comes to men's role in reproduction, the focus has been on sex rather than fatherhood,

“Shifts in how we understand gender might transform how reproduction and fertility are studied”

centring on sexually transmitted infections and conditions like erectile dysfunction. While women's reproductive health has long been seen as key to their well-being, “men's genitals were never seen as core to their health and psychology as women's genitals were [to women]”, says Almeling.

Her book tackles an important subject, but there are some dry sections. Best to skip to her

coverage of recent research. One of the most important findings is how lifestyle choices significantly influence the health of sperm, and consequently of children. Men, too, have a “biological clock”, and their age, diet and smoking habits have been linked to issues such as miscarriage and risks of low birth weight.

These factors seem to have lasting “epigenetic” effects, conferring changes to the genome that mean new genetic risks of disease can be passed on to children. The field is still young, but there does appear to be a link between certain “paternal effects” and the risk of schizophrenia, for instance.

Yet while dietary advice abounds for women trying to conceive, men may be less aware of the dos and don'ts, warns Almeling. She points out that there is little to no information on paternal effects offered to these would-be parents by US federal bodies and health agencies.

Men's reproductive health is affected by their age and diet

Almeling rounds off her book with recommendations for scientists, healthcare providers and policy-makers. She thinks part of the problem is seeing gender as binary, with men and women as opposites, and that shifts in our understanding of gender might transform how reproduction and fertility are studied and treated.

A greater understanding of men's reproductive health could also “reshape gender politics in surprising ways” and change gendered expectations of women about reproduction, she writes. Almeling suggests such changes may help reduce the gender pay gap and inequalities caused by the assumption that women (but not men) with children are less committed to their jobs.

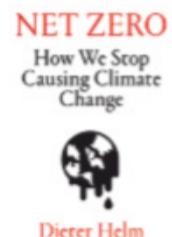
Nice theory, but considering how long it has taken for women to get this far, I won't hold my breath. ■

Don't miss



Watch

I'm Thinking of Ending Things is a time-looped psychological horror from cinema's greatest living magician, Charlie Kaufman (*Being John Malkovich*, *Eternal Sunshine of the Spotless Mind*). It will be on Netflix from 4 September.



Read

Net Zero: How we stop causing climate change sees economist Dieter Helm arguing that a carbon pricing system – one that applies to everything from flights to farming to food – is the only fair and sustainable way out of the climate crisis.



Listen

Science for the People, a long-running interview radio show and podcast, devotes a recent instalment to Eva Holland discussing her book *Nerve: Adventures in the science of fear*, inspired by her own traumas and phobias.

Wake up to plant power

From murder to magic mushrooms, Kew's first podcast challenges us all to appreciate the role plants play in our world, says **Gege Li**



Podcast

Unearthed: Mysteries from an unseen world

Royal Botanic Gardens, Kew

MY FIRST trip to London's Royal Botanic Gardens, Kew, was spectacular. I set out on an unusually mild February day to visit this year's annual orchid festival, which was celebrating the 4000-plus specimens that grow in Indonesia.

Aside from the delightful orchids, Kew and its out of London home, Wakehurst in West Sussex, together have more than 27,000 taxa of living plants, around 8.3 million specimens in its herbarium and fungarium, and more than 40,000 species in its seed bank. Unsurprisingly, this sheer diversity ranks Kew's collection top in the world. I left with a sense of amazement and fresh appreciation for plants.

In its new podcast, *Unearthed: Mysteries from an unseen world*, Kew builds on this awe, using real stories to show why the plants and fungi it houses are far more than beautiful distractions. Hosted by botanist and *New Scientist* columnist James Wong, each episode delves into the events that have been shaped by botanical or mycological discoveries and the species at the heart of them.

It does something more, too. The four episodes I listened to (there are six in the first series) make a powerful argument that the future of plants and fungi is made more uncertain by a kind of "plant blindness", which derives from a human tendency to feel more connected to animals than to plants.

Kew's 2020 orchid festival showed species from Indonesia

Wong works to overcome this problem, ranging far and wide, examining everything from the workings of fungi to miracle plant cures to the illegal trade in endangered plants. He tells some compelling tales. In one episode, there is a "true crime" feel as it sets out to explore the high-profile death of Lakhvinder Cheema after eating a curry in 2009, where the cause of death – a poisonous plant called aconite, or wolfsbane – was confirmed by Kew scientists.

Wong's rapport with scientists, horticulturalists and assorted other guests also makes entertaining listening as they "geek out", as he puts it, about the details of the species they discuss. It is hard not to get caught up in their enthusiasm and passion as they show us the big picture and importance of such organisms – and help us overcome a little of our plant blindness.

The challenge, though, is to shift the mainstream, where the blindness shows up everywhere, from the limited prosecution of plant thieves versus those who steal animals to the recent discovery that

psilocybin – the hallucinogenic chemical found inside magic mushrooms – can treat depression where other treatments have failed.

Kew and other global gardens do their bit by preserving plant and fungi biodiversity, helping species to thrive and publicising the important work that goes on there. But without people engaging with the collections for themselves, all that wonderful research, as well as Kew's huge archives, may go largely unnoticed.

"We need to really open the door for visitors so they can get a glimpse into the story of any plant and why it is interesting and important," says Richard Barley, Kew's director of horticulture, learning and operations, in one episode.

"Perhaps when we have a culture where people are educated on the crucial role plants play, we'll be able to better protect life on Earth," says Wong. This is *Unearthed*'s big shtick. If you have never really appreciated the importance to our world of plants and fungi before, this podcast is here to convince you why you should. ■



JEFF EDEN/RBG KEW

The film column

Short, but long on ambition A brief documentary about eccentric UFO hunter John Shepherd, who built his own kit to contact aliens by broadcasting reggae and jazz into space, is extraordinary and moving, says **Simon Ings**



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



COURTESY OF NETFLIX

Beyond the UFO folk hero, Shepherd emerges as both sad and inspiring

It would have been the easiest thing in the world for Killip to play up Shepherd's eccentricity. Until now, Shepherd has been a folk hero in UFO-hunting circles. His photo portrait, surrounded by bizarre broadcasting kit of his own design, appears in Douglas Curren's *In Advance of the Landing: Folk concepts of outer space* – the book TV producer Chris Carter says he raided for the first six episodes of his series *The X-Files*.

Instead, Killip listens closely to Shepherd, discovers the romance, courage and loneliness of his life, and shapes it into a paean to our ability to out-imagine our circumstances and overreach our abilities. There is something heartbreakingly sad, as well as inspiring, about the way Killip pairs Shepherd's lonely travails in snow-bound Michigan with footage, assembled by teams of who knows how many hundreds, from the archives of NASA.

Shepherd ran out of money for his project in 1998, and having failed to make a connection with ET, quickly found a life-changing connection much closer to home.

I won't spoil the moment, but I can't help but notice that, as a filmmaker, Killip likes these sorts of structures. In one of his earlier works, *The Lichenologist*, about Kerry Knudsen, curator of lichens at the University of California, Riverside, Knudsen spends most of the movie staring at very small things before we are treated to the money shot: Knudsen perched on top of a mountain, whipped by the wind and explaining how his youthful psychedelic experiences inspired a lifetime of intense visual study. It is a shot that changes the meaning of the whole film. ■



Film

John Was Trying to Contact Aliens

Matthew Killip
Netflix

Simon also recommends...

Films

The Diatomist (2014)

Matthew Killip
An introduction to Klaus Kemp, whose fascination with German microscopist J.D. Möller inspired him to recreate the Victorian art of arranging diatoms in extraordinary patterns.

Close Encounters of the Third Kind (1977)

Steven Spielberg
Ufology was a global phenomenon by the time this blockbuster arrived. Countless imitations followed, but none with the charm and sincerity of the original.

YOU have to admire Netflix's ambition. As well as producing Oscar-winning short documentaries of its own (*The White Helmets* won in 2017; *Period. End of Sentence.* won in 2019), the streaming giant makes a regular effort to bring festival-winning factual films to a global audience.

The latest is *John Was Trying to Contact Aliens* by New York-based UK director Matthew Killip, which won the Jury Award for a non-fiction short film at this year's Sundance festival in Utah. In little over 15 minutes, it manages to turn the story of John Shepherd, an eccentric inventor who spent 30 years trying to contact extraterrestrials by broadcasting music millions of kilometres into space, into a tear-jerker of epic (indeed, cosmological) proportions.

Never much cared for by his parents, Shepherd was brought up by adoptive grandparents in rural Michigan. A fan of classic science-fiction shows like *The Outer Limits* and *The Twilight Zone*, Shepherd never could shake off the impression that a UFO sighting

made on him as a child, and in 1972 the 21-year-old set about designing and constructing electronic equipment to launch a private search for extraterrestrial intelligence. His first set-up, built around an ultra-low frequency radio transmitter, soon expanded to fill over 100 square metres of his long-suffering grandparents'

"In 1972, 21-year-old John Shepherd set about building equipment to hunt for extraterrestrials"

home. It also acquired an acronym: Project STRAT – Special Telemetry Research And Tracking.

A two-storey high, 1000-watt, 60,000-volt, deep-space radio transmitter required a house extension – and all so Shepherd could beam jazz, reggae, Afro-pop and German electronica into the sky for hours every day, in the hope any passing aliens would be intrigued enough to come calling. He could also monitor any returning signals and UFOs.

Fellowships for Postdoctoral Scholars



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Departments - Applicants who wish to conduct research on topics of general interest to one or more of the departments are encouraged to apply. Interdepartmental research, including with the Marine Policy Center, is also encouraged. The Departments are:

- **Applied Ocean Physics & Engineering**
- **Biology**
- **Geology & Geophysics**
- **Marine Chemistry & Geochemistry**
- **Physical Oceanography**

A joint **USGS/WHOI** award will be given to a postdoc whose research is in an area of common interest between USGS and WHOI Scientific Staff. The individual will interact with both USGS and WHOI based advisors on their research.

The **Center for Marine and Environmental Radioactivity (CMER)** will award a fellowship for research on natural and human-made radioactive substances in the environment including the study of their sources and fate or use as tracers of ocean processes.

The **National Ocean Sciences Accelerator Mass Spectrometry Facility (NOSAMS)** will award a fellowship in the development and implementation of new techniques in marine science radiocarbon studies.

The **Ocean Bottom Seismic Instrument Center (OBSIC)** will award a postdoctoral fellowship for research on the earth's internal structure and earthquake processes using seafloor seismic measurements.

The **Ocean Twilight Zone (OTZ)** project will award a fellowship for research on twilight zone (100-1000 m) ecosystems and processes, including biomass, biodiversity, life histories and behavior, trophic interactions, links to the global carbon cycle, and ways to engage scientists with stakeholders.

Recipients of awards are selected competitively, with primary emphasis placed on research promise. Scholarships are awarded for 18-month appointments with a stipend of \$62,250 per year, a health and welfare allowance and a modest research budget. Recipients are encouraged to pursue their own research interest in association with resident Scientific and Senior Technical Staff. Communication with potential WHOI advisors prior to submitting an application is encouraged. Completed applications must be received by October 15, 2020 for the 2021/2022 appointments. Awards will be announced in December. Recipients of awards can initiate their study and research period at the Institution any time after January 1, 2021 and before December 1, 2021.

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

www.whoi.edu/postdoctoral

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Exposing unconscious bias

How much of the prejudice that shapes our worlds is unconscious, and can we truly measure it, asks **Pragya Agarwal**

YOU are biased. So am I. We all discriminate. It is both a source of concern and comfort that we don't necessarily do so deliberately and that our prejudices aren't always wilful.

If societies are to truly confront the pernicious effects of racism and prejudice, the importance of examining these biases and how they become etched into the brain is becoming increasingly clear. The death of George Floyd under the knee of a police officer in Minneapolis on 25 May shook the world to attention, but it was no isolated incident. Every day there are stories of people being treated with suspicion – or far worse – based on their skin colour while going about their daily lives.

This is in spite of the fact that, for the past 40 years, opinion polls show a steady decline in racist views in the US, UK and other countries. That has led some researchers to suspect that, as explicit racism has been driven underground, unconscious bias is playing a critical role. This suspicion inspired the creation of the Implicit Association Test, a tool that aims to reveal unconscious biases with a few clicks of the mouse.

Unfortunately, the accuracy and reliability of this widely celebrated test isn't what it once seemed. Pinning down the nature and extent of hidden bias is proving to be extraordinarily complicated. Eradicating it is far from straightforward, too – and it turns out that some efforts to do so may further entrench the very prejudices they are meant to uproot. But we are making progress, not least in understanding the processes in our brains that perpetuate bias – and what we can do to change them.

What exactly is unconscious or implicit bias? In psychological research, the label "implicit" refers to processes that aren't direct, deliberate or intentional self-assessments. When we can't retrieve a memory explicitly, we might still behave in a way that is shaped by our past experiences, for instance. The conscious mind governs deliberate actions, rational thoughts and active learning, while the unconscious carries on with processes that occur automatically or aren't available to introspection. The unconscious is a busy place: the brain is capable of processing approximately 11 million bits of information every second,



879

drug-related arrests take place per
100,000 black people in the US, compared
with 332 per 100,000 white people

Source: US National Survey on Drug Use and Health



but our conscious mind can handle only 40 to 50 of them.

As all of this information comes in, our brains categorise it without our deliberate attention. When we process information on a more superficial level – when we are in a hurry, tired or distracted, for example – we are more likely to rely on existing templates. Occasionally, such cognitive shortcuts can be useful, such as when we need to decide something quickly. But they can also be problematic, especially if these shortcuts were formed based on mistakes, misinterpretations, stereotypes or other biased information. When we use them,

77

black men per 100,000 will be killed by police in the US, based on current trends, compared with 33 white men per 100,000

Source: PNAS, 2019

we may then be relying on and reinforcing these very mistakes and biases. When that happens with people in positions of power and authority, it can have far-reaching consequences, from discriminatory hiring practices to poorer healthcare treatment or prejudice in the legal system.

The idea that we could pin down and study implicit bias was first hinted at in 1995 when social psychologist Anthony Greenwald, then at Harvard University, and his colleagues invented the Implicit Association Test (IAT) to measure the strength of links between different concepts and words. For instance, participants would be shown black or white faces and asked to pair them with descriptors such as angry, clever, good and bad (see “How the bias test works”, page 40). This was adapted for the web in 1998 by Greenwald and fellow Harvard psychologist Mahzarin Banaji.

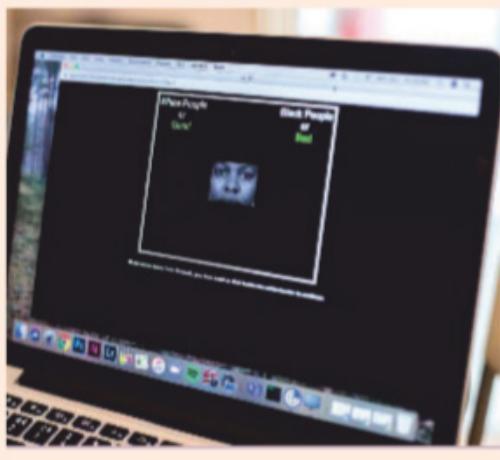
There have since been several adaptations of the test, measuring views on race, body type, gender and even names. The array of applications and easy online access have amplified the test’s appeal. It is hard to ➤

How the bias test works

The Implicit Association Test (IAT) is an online exercise that involves sorting pictures and words as quickly as possible in a series of tasks using the "E" and "I" keys on a keyboard. For instance, in the weight IAT, you might initially click E if the silhouette of a larger person comes up, and I for a thin one. In the next task, you then sort words with good and bad connotations. Later, you are asked to sort good words and thin silhouettes with one key, bad words and larger silhouettes with another. Then the association is switched.

After completing several sorting tasks, you are given your results in the form of a statement, such as: "Your response suggests a slight automatic preference for fat people over thin people." You can then click through to a page that explains this result: "[O]ne has an implicit preference for Thin people relative to Fat people if they are faster to categorize words when Thin people and Good share a response key relative to when Fat people and Good share a response key."

Through its website, the Project Implicit research group currently offers 15 versions of the test, including on gender, religion, age, skin tone, race, disability and sexuality.



overstate just how influential it has been in both academic research and the public understanding of implicit bias. In his 2005 book *Blink: The power of thinking without thinking*, journalist Malcolm Gladwell summed up the prevailing view: "The IAT

**38
per cent**

of people from ethnic minorities in the UK report being wrongly suspected of shoplifting, compared with 14 per cent of white people

Source: 2018 Guardian attitudes survey

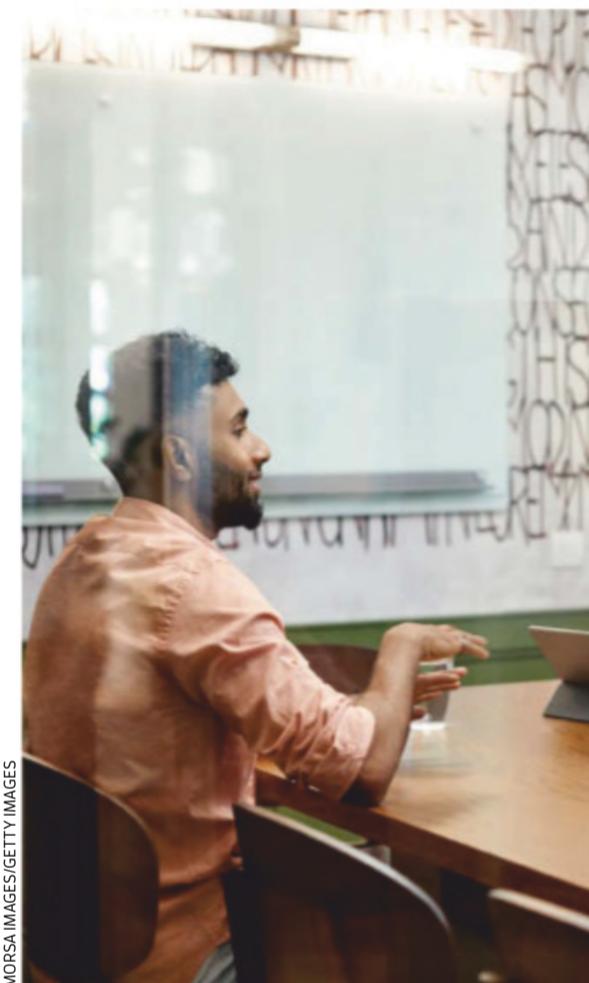
is more than just an abstract measure of attitudes. It's a powerful predictor of how we act in certain kinds of spontaneous situations."

Yet for all this, its results are inconsistent and hard to reproduce. Many studies have challenged the idea that the IAT reveals only unconscious processes. The reliability of results also appears to decline the more times you take it in a sitting.

What the IAT really measures is reaction time, based on the assumption that the speed with which we make associations reflects underlying mental processes. But everything from reflexes and physical ability to whether the user is distracted can influence this. Several studies have now shown that, for individuals, carrying an implicit attitude is only weakly linked to biased behaviour in the real world.

Part of the problem may be with how the test is used. Neuroscientist Calvin Lai at Washington University in St Louis, Missouri, studies implicit bias and is on the executive committee of Project Implicit, the non-profit research collaboration that studies implicit social cognition and examines the data gathered using the different versions of the IAT. He and others admit that the test is imperfect, but stress that it isn't intended to be a one-off measure. "IAT results should be used as an educational experience for

Anonymised hiring practices can help reduce the influence of bias against people with minority backgrounds



self-reflection but should not be treated as a tool for diagnosing one's self or others," he says. "A single administration of the race IAT tells you as much about your enduring racial attitudes as a single measure of your blood pressure tells you about your blood pressure over time: not very much."

The nature of bias

But aggregated IAT results do tell us something about the nature of unconscious bias within societies. Information from Project Implicit reveals that, of the 630,000 people around the world who have taken a version of the IAT that examines associations between gender and science-related abilities, more than two-thirds correlate males more strongly with science roles and females more strongly with humanities, for instance. Test results from more than 1.8 million people

Ways to tackle your prejudice



We are still getting to grips with the most effective ways to identify and address bias. What is clear is that it is a difficult task that requires concerted, consistent effort. But there are strategies that make a difference.

A first step is to make biases visible. This can include taking the Implicit Association Test to raise awareness, but this needs to be complemented by active reflection – including recognising triggers for bias and examining how our life experiences have shaped our biases.

Research has shown that using blind or anonymised hiring practices may help weaken biases that can limit opportunities for women and minority groups. One study found that using blind auditions increased the likelihood that women musicians were hired by an orchestra by up to 46 per cent. Research in France, Germany, Sweden and the Netherlands has showed that removing names from applications increases the likelihood that candidates from minority groups will be invited to interview.

We can tackle generalised assumptions

by being clear that a particular attribute is associated with an individual rather than their whole group, for example “This boy is good at maths”. This approach can help to diminish stereotypes and the pressure to conform to them.

Taking our time with important decisions can also help us avoid cognitive shortcuts that perpetuate bias. When this isn’t possible, rehearsing reactions to high stress situations can help prevent biased snap decisions, research with police has shown.

Finding ways to identify with members of different groups by forging links with your own sense of self can diminish bias. In one study, nurses from diverse ethnicities who were shown videos of white or black patients in pain recommended the same amount of pain relief regardless of the patient’s race if first asked to imagine how they felt. When not prompted this way, the nurses suggested more pain relief for white patients. Metaphorically stepping into someone else’s shoes can have a big impact.

in the US showed that in geographic areas where white residents show higher implicit race bias measured by a version of the IAT, there is also greater use of force by the police against black people.

Unfortunately, the IAT is still widely perceived as a diagnostic tool. Most anti-bias courses in the US and UK begin with the test, then give the results as a score that is seldom followed up by a deeper explanation. Occasionally, training programmes give examples illustrating the impact of unconscious bias and tips for how to reduce this influence (see “Ways to tackle your prejudice”, above right).

Yet even with this kind of guidance, bias training is no magic wand that will cure individuals of their prejudices. It doesn’t seem to have a lasting impact on attitudes around diversity within corporations, for example. And while it appears to help reduce

discriminatory behaviour by individuals for up to two weeks after attending, there is no evidence it leads to long-term change. Some kinds of training may even reinforce stereotypes, particularly if the participants are distracted or rushed.

That isn’t to say that we are without options. Advances in brain scanning techniques have helped reveal the neural

41

black women die each year during pregnancy in the US for every 100,000 women who are pregnant, compared with 13 white women and 30 Native American women

Source: US Centers for Disease Control and Prevention

underpinnings of our biases and in particular how prejudices about other groups of people activate brain areas associated with threat and fear (see “The roots of racism”, page 43). In an influential 2005 study, Mary Wheeler and Susan Fiske at Princeton University asked white volunteers who were in an MRI scanner to perform tasks while looking at black or white faces. They found that when the task involved thinking of the person whose face they saw as part of an out-group, rather than as an individual, the participants showed increased activity in the amygdala, the part of the brain that governs our threat response. Other brain scanning studies show greater activity in the amygdala when people view others from different ethnic backgrounds to their own.

Skin colour isn’t the only way our brains can automatically categorise people. Our response to different accents may be ➤

similar. In 2014, Patricia Bestelmeyer at Bangor University in the UK and her colleagues found that when people heard accents similar to their own, there was increased activity in brain areas associated with positive emotional response; the opposite was true for different accents. "There is an increasing perception of the importance or relevance of those accents that are similar to ours," she says.

Yet the imaging revolution in bias research has also demonstrated that our brains can change with experience and environmental influences. In 2013, Eva Telzer, then at the University of Illinois, and her colleagues conducted a study of 49 children and adolescents born in Asia, Europe and the US. They showed that the difference in amygdala activity in response to faces from different races wasn't innate, but developed over a period of time.

This landmark study quashes any suggestion that we are somehow born prejudiced. What's more, Telzer and her team found that study participants with a more

15 per cent

of job applications from ethnic minority candidates in the UK received a positive response compared with 24 per cent of those from a majority group – despite both sets of CVs having identical qualifications

Source: GEMM Project, Centre for Social Investigation, Nuffield College, University of Oxford

The diversity of peer groups can influence who we perceive as threatening

diverse set of peers had less of a heightened threat response in the brain when shown faces from other racial groups. That suggests simply having more contact with people from different groups can reduce the importance of race in how we respond to people and that we can change our biases.

This wasn't always a given. In social psychology there was a long-standing assumption that traces of past experiences linger on whether we want them to or not. But we now know that unconscious bias isn't as stable as previously believed. Our biases are shaped by how we are brought up, what we see around us and the media we are exposed to. Knowing we can change their influence also means we can no longer shrug them off as beyond our control.

One day we may even have a tool that helps us to reliably measure them. "There is ongoing research to develop longer or more sophisticated versions of the IAT or other implicit measures that are reliable enough for diagnosis," says Lai. Unfortunately, none are yet ready for public use.

We needn't wait for new tools to assess the harms of bias, though. "Your best bet for understanding inequities in your organisation is collecting data about inequities within your organisation, not taking the IAT," says Lai.

Even as efforts are under way to better measure the influence of unconscious bias, a growing number of researchers argue that we actually need to simplify this debate – to drive home that bias is bias, and whether it is unconscious or overt, whether individual prejudices shape social institutions or are shaped by them, they can cause irreparable damage. Unconscious bias is easier to ignore, but it cannot excuse discriminatory behaviour. It is important to remember that even if we cannot precisely measure our biases just yet, we can still overcome them. ■



SIMON SONGHURST



Pragya Agarwal is the author of *Sway: Unravelling unconscious bias* (Bloomsbury). Follow her @DrPragyaAgarwal



The roots of racism

Our prejudices arise from learned responses. That means we can unlearn them, neuroscientist **Lasana Harris** tells Daniel Cossins

WHY are we prejudiced? What happens in our brains when we make assumptions about people who look or speak differently to us? As movements such as Black Lives Matter work to expose the systemic racism in the US and Europe, such questions are taking on new and long overdue urgency. If we are to overcome our biases, we need to understand their neural and psychological roots.

Lasana Harris, a neuroscientist and experimental psychologist at University College London, is among those striving for such an understanding. His research focuses on how we think about other people's minds, known as social cognition, and more specifically on how we perceive others. Working with Susan Fiske at Princeton University, his research on the brain mechanisms underlying dehumanisation has revealed the surprising ease with which we can stop ourselves from having empathy for the plights of others.

Such insights have informed his thinking on racism, too. Harris views what many people call unconscious bias as an inevitable result of the associations we learn and the way our brains react to perceived threats. Rather than something we engage in unconsciously, he argues that it is something we know we are doing but struggle to control.

Here he tells *New Scientist* why societies condition people to be prejudiced and what the science says we can do about it.

Daniel Cossins: Dehumanisation is a horrifying word and yet your work suggests it is something we all do. Why is that?

Lasana Harris: Firstly, if I want to do something to another human being that is something I don't typically like doing to human beings, then I'm going to need to not think about their mind while I do it. The other reason is that dehumanisation is a way to regulate emotional responses, preventing us from identifying with suffering and feeling negative ourselves. Take homeless people, for instance. If you have to feel empathetic towards every single person you see living on the streets, you would be exhausted before ➤

you got home. Or you might feel worried about them and guilty that you didn't help. That's a feeling you want to avoid having every time you leave your house.

We have demonstrated that the brain regions that are always engaged when you think about other people aren't engaged when you think about different types of people – in this case, what we call “extreme out-groups” like drug addicts and homeless people.

Where does unconscious bias, and particularly racism, fit in to all this? Is it also a form of dehumanisation?

When we did the first dehumanisation studies, a lot of people said it represented the worst kind of prejudice. But it turns out that when you look at the brain, prejudice is a slightly different function. They are both the result of a learning process, but whereas dehumanisation is linked to disgust, prejudice is linked to fear.

The reason why we are prejudiced – and I like to say that we are all prejudiced – is because we live in cultures where certain things get associated. For instance, if you constantly see African Americans committing violent criminal acts in the media, your brain associates violent criminal behaviour with African Americans.

Bias against LGBTQ+ people is often rooted in disgust and fear, with the perception being that they threaten traditional values around marriage and male-female gender roles. Not that every form of social bias is threat-based; elderly people, for example, are passively harmed by being ignored.

When you see an out-group member who you have tagged as threatening, regardless of whether they really are, a region of the brain called the amygdala is activated. This is what processes fear. So prejudice is essentially a threat response. This is part of the reason I have always had an issue with the term implicit bias, because you are always aware

Our fear response, governed by the amygdala (in red), seems to underpin prejudice

of your threat response. It's not really about being aware and unaware; it is a basic survival response. It is going to shape how you behave, and you are going to at least be aware of your behaviour.

What is a more accurate way to describe our feelings of prejudice towards others?

I think a better term is just bias. Saying that you are biased doesn't mean you are a morally bad person. It's not like you decided to have these thoughts. You just happen to live in a society where that is the way things are structured. But you can still be held accountable for your bias, because you have the ability to regulate and override it.

How can people override their biases?

There are a few ways. The first and perhaps most prevalent is to encourage that

awareness we just mentioned. It's like if you know you are afraid of spiders but you also know that fear is silly because, in the UK at least, they aren't going to hurt you. So if you are cleaning the bath and a spider pops up, you move it. Your ability to do that, even though you are terrified, is the same ability that lets you override bias, racial or otherwise. Your awareness of the threat response that you have to an out-group can allow you to regulate it.

Another way is to undo the learning. Even though the associations we learn can be hard to shake, you can do it if you have enough experiences with members of an out-group to realise they are actually not threatening. This is known to psychologists as the contact hypothesis – the idea that if different groups interact, you can reduce bias.

The third way, and the one that is least tried, is to get rid of the categories in which we put people. Prejudice begins because you have made that person a member of a category that is threatening. If you had put that person in a different category from the beginning, you wouldn't have the threat response.

The problem is that by default we categorise people by demographic characteristics like age, gender and race. That is how we like to see the world. But you can see the world in many different ways: you can see a person as a member of a particular occupational group, for instance, or any number of categories that aren't necessarily tied to this threat response that has been instilled over centuries and is now fundamental in our cultures.

Lots of companies are now offering implicit bias training. Does it work?

No. There has been a lot of research looking at implicit bias training, and it doesn't work for a variety of reasons. One is that it is usually mandatory, which means that people aren't motivated. The second reason is that it usually serves a legal checkbox function, which I think then spills over to the people who do it. So they think “I've done unconscious bias training, so I'm not biased”.

“Saying that you are biased doesn't mean you are morally bad, but you can still be held accountable”





REUTERS/SIMON DAWSON

I think bias training can work but only if it builds that awareness, if it puts the bias in a historical and cultural context, so that people understand where these associations come from, and they begin to realise how systemic it is. That is one of the great things about the Black Lives Matter movement compared with what I have seen before. It's really causing a lot of people to ask those questions.

What is the relationship between this bias and the systemic racism that Black Lives Matter has shone a spotlight on?

I think the bias results from the systemic racism. Historically, bias against black people was a way to appease the public so they would view slavery as civilised. There was a tonne of “scientific” research to demonstrate they weren’t quite human, and there were religious arguments that they were uncivilised. All of this painted people of African descent as subhuman.

So it is really important to take this long view, to understand how that history has influenced our brain processing. It also highlights how difficult it is to change this systemic bias, and why you need systemic change.

Do you think science can help achieve that sort of systemic change?

Social psychology has always been geared towards solving these problems. The field was created in response to the second world war, in response to the Holocaust. You had a bunch of researchers in Europe who were Jewish, who fled to the US and wanted to study obedience and conformity and prejudice and dehumanisation.

We have had decades of research now, to the point where we fully understand these mechanisms I have been describing. Since those early days, establishing shared goals between groups has been identified as a possible way of changing biased behaviour, a realisation that we are all in this together. It is kind of like the climate change problem: we have the knowledge to fix it – it is there – what we are missing is the political will.

It feels flippant to talk about anything else, but presumably the coronavirus pandemic will have a big effect on how we interact with one another.

The important concept here is disgust, which is an emotional response that evolved to protect our bodies from harm. Disgust has

Protests in London in June were part of the global Black Lives Matter movement to draw attention to systemic racism

also been co-opted into the social domain, particularly with regard to the pathogens and diseases people carry. In the past, this response might have been reserved for people who look sick. We have now associated that threat response with everybody, because we have been told for months that anyone can be contagious.

Our brains have learned this response. But I don’t think it is going to last because we are such intensely social creatures. As things gradually ease up and we interact more and more, I imagine this urge to keep away from others will pass.

Social psychology has a bit of a reputation problem, largely because some of its most arresting findings couldn’t be replicated in repeat experiments. Do you think social psychology can survive this crisis?

The replication crises are something that hit all science, but social psychology is everybody’s favourite whipping boy because we study what everybody is an expert on. We all have social cognition, so we all have theories about why people do stuff. There has always been this pressure on social psychology to do better than other sciences.

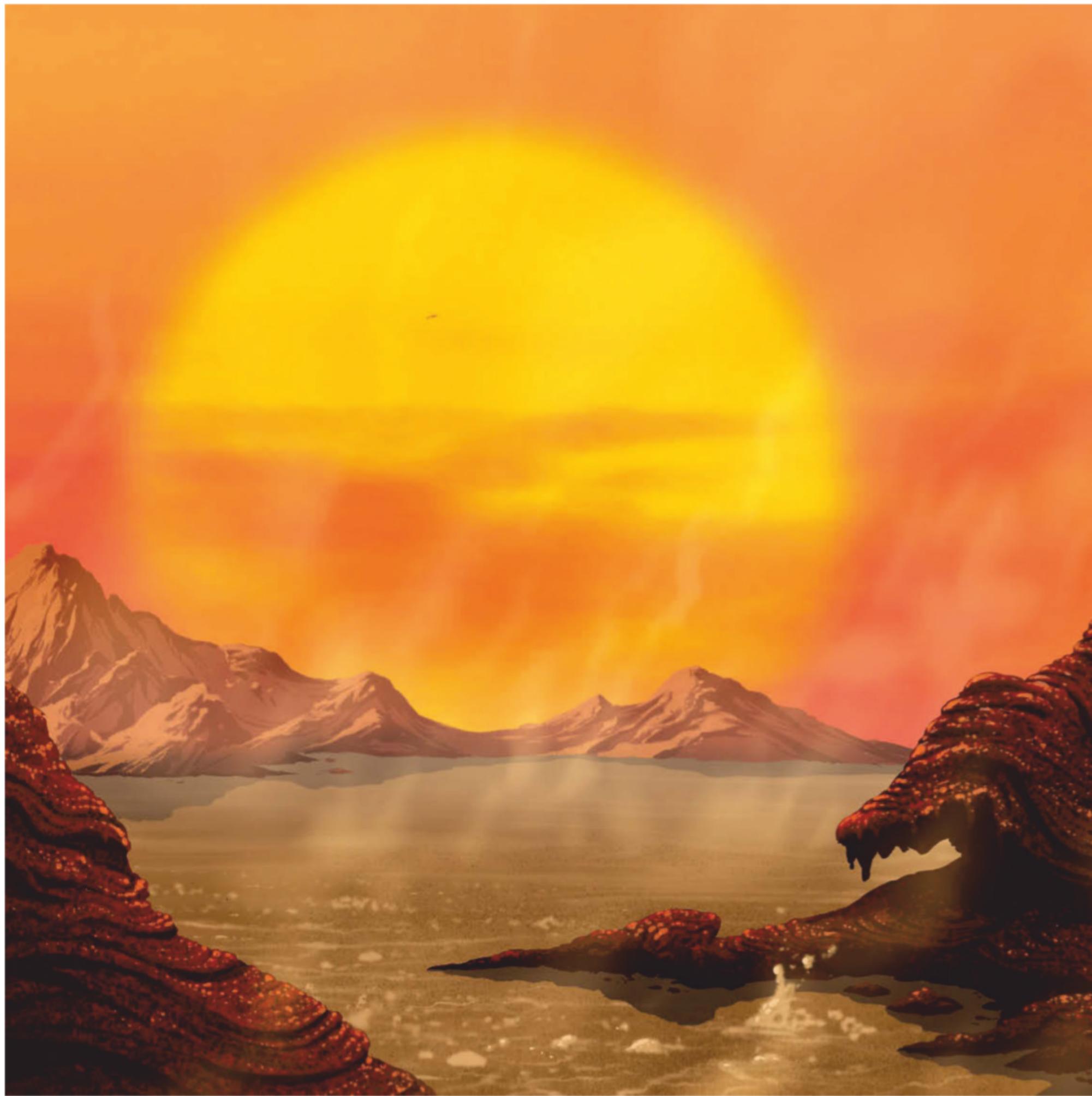
What makes social psychology important is that it is the scientific study of how we think about others. Social psychology really values the scientific method, so every one of these crises actually pushes the field forward. I think we have done a lot to address this replication crisis. It really raised the standards in our field. We do preregistered studies, for example, where we design the study and it gets peer reviewed before the data is collected. If it gets accepted, then I collect the data and it gets published. That lifts the pressure for researchers to produce spectacular results.

We have done things that other fields are still not doing, and I think it will take them years to catch up. ■



Daniel Cossins is a features editor at New Scientist

Features





Brave new worlds

The hunt for extraterrestrial life has always focused on Earth-like planets. It is time for a radical rethink, reports **Colin Stuart**

IN A dark and seemingly barren universe, our pale blue dot of a world is a beacon of hope that life is possible. The confluence of factors that help sustain life here are astonishing: from the planet's rocky crust, broken into tectonic plates that help maintain a breathable atmosphere by releasing and trapping gases, to its distance from the sun. Earth orbits at the inner edge of a Goldilocks region called the habitable zone: a narrow ring that is neither too hot nor too cold to allow liquid water to exist. Every living thing we know of, from a bacterium to a blue whale, needs water to survive.

Given this, it is no surprise that our efforts to find life elsewhere have focused on spotting a carbon copy of our world. Frustratingly, these seem to be few and far between. Of the thousands of exoplanets discovered to date, only a handful are thought to have conditions remotely like ours. Most orbit either scorchingly close to their host star or keep a frosty distance. Others move in loops around two stars, circle long-dead suns or wander the cosmos alone, without the benefit of stellar heat at all. Life on such planets would once have been considered impossible – but that view is changing.

Recent research suggests that these weird and wonderful worlds could be capable of sustaining life after all. It is time to tear up the rulebook and go on an incredible interplanetary journey.

ARIK ROPFER

HELL OR HEAVEN?

Planets in searing proximity to their stars

Evidence that planets very different from Earth could nevertheless be balmy havens for life might not be too far away. Leave the safety of our planet and travel towards the sun, where Venus and Mercury orbit, and conventional wisdom says that soaring temperatures would make liquid water and life impossible. Today, Venus is a hellscape with temperatures in excess of 400°C. Yet data collected by NASA's Pioneer Venus project in the 1970s hints at a much wetter past. "Venus could have been temperate for billions of years," says Michael Way at NASA's Goddard Institute for Space Studies in New York.

Until now, the issue has been how to reconcile that liquid past with Venus's proximity to the sun. Way believes the answer may lie in the planet's long days, each of which lasts for nearly eight Earth months. According to Way's climate model of Venus, published in March, the planet's slow rotation allowed a large cloud to settle directly under the sun's glare, making it capable of reflecting back much of its heat. ➤

"That means Venus spent much of its life with surface liquid water," he says. If true, that has profound consequences for which planets should be considered habitable. "For slowly rotating planets like Venus, the habitable zone is much further in towards the star," says Way.

If one interpretation of recent observations is correct, this might even extend as close as Mercury. Our solar system's furthest-in planet is dominated by an ancient impact scar known as the Caloris basin, which is more than twice the size of France. In 1974, a fly-by mission discovered so-called "chaotic terrain" on the other side of the planet. The usual explanation is that the impact generated seismic waves travelling in opposite directions around Mercury, which crumpled the surface as they met on the other side of the planet.

VOLATILE PLANET

Alexis Rodriguez at the Planetary Science Institute in Arizona has another idea. Based on data from the more recent Messenger mission to Mercury, he says "the basin is 2.5 billion years older than the chaotic terrain". In other words, they can't be connected.

Rodriguez's work, published in March, suggests a different reason for the jumbled terrain: a collapse triggered by the evaporation of materials such as salts and sulphates, collectively known as volatiles. The process would have resembled the formation of a sinkhole, "except that we are talking about entire mountain ranges collapsing", he says.

Crucially, those volatiles could have included the building blocks of life and even water, says Rodriguez. "We've been too hasty ruling out planets like Mercury as not habitable." And this matters, because we know that there are plenty of these kinds of worlds out there.



"We have been too hasty in ruling out planets like Mercury as not habitable"



TWIN SUNS

Planets orbiting two stars

Imagine a world with two sunrises and two sunsets, in which you would have two shadows. That would be the reality of living on a circumbinary planet – one that orbits a pair of stars. NASA's Kepler space telescope has found a handful of these unusual worlds, and the new Transiting Exoplanet Survey Satellite found another in January this year. Some have been in the habitable zone, but so far they have all been gas planets, with no chance of the plate tectonics so essential to life on Earth. We are yet to find a rocky circumbinary planet.

Othon Winter at São Paulo State University in Brazil thinks he can change that. He is part of a team of astronomers that has recently modelled terrestrial planet formation in the habitable zones of known circumbinary systems. Their calculations suggest that if a circumbinary planet has already been found, then there is a fifty-fifty chance that a terrestrial planet also exists in the system's habitable zone. Winter is keeping an eye on two systems in particular that have had rocky planets forming in every simulation he and his team have run. Even more tantalisingly, their simulations suggest that such planets may have remained habitable for billions of years. "They are stable for a very long time," says Winter, "enough time for life to develop".

Signs of habitable circumbinary planets may already be hiding in existing observations, just waiting to be identified. "There could be 30 or 40 lurking in existing Kepler data," says David Martin at Ohio State University. Kepler looked for the telltale dip in the brightness of a star as a planet passed in front of it, an event known as a transit. For an Earth-sized planet circling a sun-like star, the brightness dips are so small – just 0.01 per cent – that astronomers use a technique called folding to firm up their finds. This involves stacking the various transits on top of each other in order to make the dips more obvious. With two suns, however, the process isn't quite so simple. Martin is working hard to hone an algorithm to do the job, in the hope of recovering habitable circumbinary planets from the Kepler data archive over the coming months.

"Planets with two suns could remain habitable for billions of years"

ZOMBIE WORLDS

Planets circling dead stars

The sun isn't going to last forever. In around 5 billion years, it will have expanded to engulf the inner planets and belched its outer layers into space, leaving behind a small core called a white dwarf. This hardly seems like an ideal environment in which to find a habitable planet, but Thea Kozakis at Cornell University in New York thinks otherwise. "It's actually a pretty stable environment," she says. According to calculations published in April, she believes planets could exist in the habitable zone of a white dwarf for up to 8.5 billion years – longer than Earth's residence to date in the sun's habitable zone. The catch is that as white dwarfs kick out less heat than normal stars, the habitable zone would be much closer in. "The planet would orbit in a matter of days," she says. Unless the planet's orbit was almost perfectly circular, that would lead to tidal forces far greater than those on Earth.

Such planets would be easier to find than those in circumbinary systems – a combination of a

small star and a close planet would lead to transits where up to 50 per cent of the white dwarf's light would be blocked, compared with 0.01 per cent for the sun and Earth. The trouble is that no one has really been looking for them. That could soon change, says Kozakis. "It may be possible to find them with Hubble and the upcoming James Webb Space Telescope."

Other people believe life around white dwarfs may be discovered another way: by seeking signs of a civilisation dealing with the demise of its star. John Gertz is on the board of the Search for Extraterrestrial Intelligence Institute, a US research organisation. In a paper published last November, he explored the dilemma an alien world would face as its star began to die. "I wanted to look at it from ET's point of view," he says. His ultimate conclusion is that fleeing a dying sun would be too difficult, forcing an advanced civilisation to undertake unprecedented engineering projects that Gertz thinks may be detectable. "White dwarfs have been added to the target list of Breakthrough Listen," he says, a \$100 million project to scour the skies for alien signals. "We need to shift our entire paradigm of looking at stars for signs of life."



LONE SURVIVORS

Planets without a star to orbit

If we are throwing out the established rules, then why bother with a star at all? Joseph Glaser at Drexel University in Pennsylvania studies rogue planets – orphan worlds ejected from their birth solar system to roam space alone. Glaser's modelling work, published in February, found that 38 per cent of solar systems lose a planet at some point. This suggests the universe is full of lone wanderers, with potentially hundreds of billions of them in the Milky Way alone.

Smaller planets like ours are the most

likely to be ejected, especially those with rocky crusts. It also takes time for a planet to become unstable. "It can take half the lifetime of the star," he says. So what are the chances of an Earth-sized rocky planet in the habitable zone going rogue? According to Glaser, "it's hard for it to happen, but it is definitely possible".

In fact, we have already found Earth-mass rogue planets thanks to a technique called gravitational microlensing. If planets pass in front of a distant, unrelated star,

their gravity acts as a lens that temporarily magnifies its light. The duration of these events, which can last from hours to weeks, depends on the mass of the planet. "We recently found several events that lasted a few hours," says Przemek Mróz at the California Institute of Technology. "These events are caused by Earth-mass planets."

Mróz estimates that there are between one and three Earth-mass rogue planets for each star in the Milky Way, which itself contains at least 100 billion stars. We could

LUNAR LIFE

Moons where the conditions are just right

Maybe we shouldn't only be considering planets as places where life might exist. "The largest amount of habitable real estate in the universe could be in the form of moons," says Jesper Tjøa at the Max Planck Institute for Solar System Research in Germany. We already know that some satellites of Jupiter and Saturn – including Europa and Enceladus – harbour subsurface oceans of liquid water, despite being far outside the habitable zone of the sun. "If this is replicated around other stars, then habitable moons would vastly outnumber habitable planets," says Tjøa.

In research published in April, he discussed a "subsurface habitable zone". By modelling the interiors of small, icy moons, he found that the gravity of the planet they circle is more important than heat from the sun. Moons are stretched and squeezed as they orbit, and those distortions inject enough tidal energy to melt the subsurface ice. "It is, in principle, possible to have a habitable moon a thousand times further from the sun than Earth, as long as you have the right planetary environment," says Tjøa. The more the moon's orbit deviates from a circle, the better. Upcoming telescopes such as PLATO, a space-based observatory due for launch in 2026, should be able to find moons the size of Ganymede,

the solar system's largest satellite, which orbits Jupiter and has a diameter almost half that of Earth's.

NEW MOONS

Not all habitable moons have to exist in such far-flung locations, however. Gas planets in a sun's habitable zone could possess warm, rocky moons not dissimilar to Earth. José Caballero at the Spanish Centre of Astrobiology was part of a team that recently looked at moons in the habitable zone of smaller, cooler and very long-lived stars called red dwarfs. They started by looking at more than 100 red dwarfs already known to have exoplanets orbiting them, before modelling the long-term stability of hypothetical moons. Out of all of these systems,

"four planets in the habitable zone could host stable moons", says Caballero. The number is relatively low because you need a very big planet to prevent the moon from being pulled out of orbit. "It would be similar to the planet Polyphemus and its moon Pandora in the movie Avatar," says Caballero.

According to the study, published last December, these four moons – if they exist – would range in size from that of Earth's own satellite up to Saturn's largest moon, Titan. Crucially, the team's calculations predict that this quartet of moons could remain in orbit around their gas giant planets for a period equal to the current age of the universe, plenty of time for life to emerge and evolve.

"The largest amount of habitable real estate could be in the form of moons"

soon be finding a lot more of them thanks to the Nancy Grace Roman space telescope that will launch in 2026 and observe microlensing events. "It will be a revolution similar to Kepler 10 years ago," says Etienne Bachelet at Las Cumbres Observatory, referring to Kepler's discovery of thousands of exoplanets orbiting stars. Bachelet co-authored a paper last year on the impact the new mission will have on finding rogue planets. "It's going to detect a lot of them and we'll have a better understanding of

how many there are in the galaxy," he says.

The big question is whether primitive life can persist on a once-habitable planet if it no longer has a star as its primary energy source. To survive, it might have to rely on heat from within, partly due to radioactive decay below the surface. For Earth, this is 15,000 times less than the energy we receive from the sun. "The planet will freeze unless it has a thick atmosphere," says Mróz, "but you never know – nature is unpredictable." ■

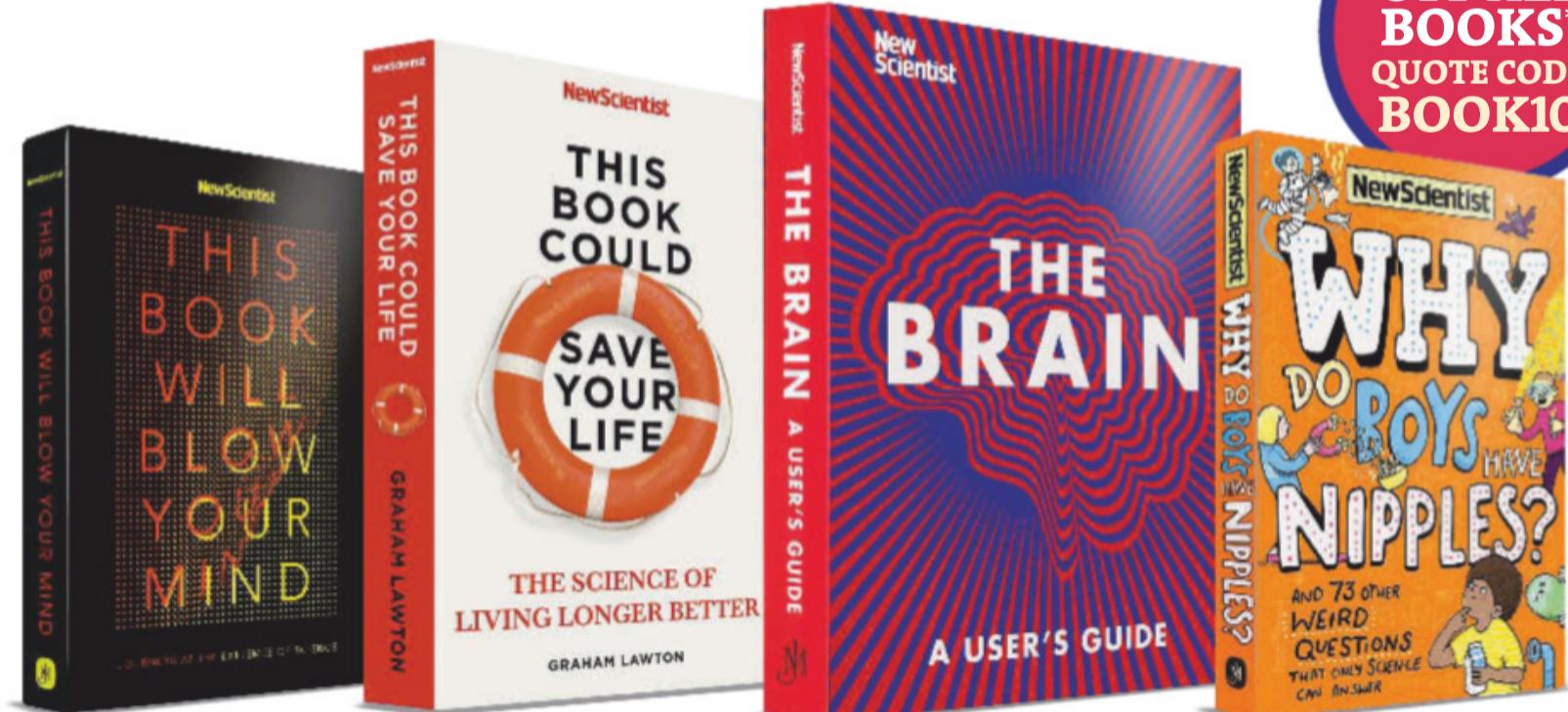


Colin Stuart is an astronomy author and speaker. You can follow him on Twitter @skyponderer

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The back pages Puzzles

Puzzle

Can you work out what Twaddle knows? **p54**

Cartoons

Life through the lens of Tom Gauld and Twisteddoodles **p54**

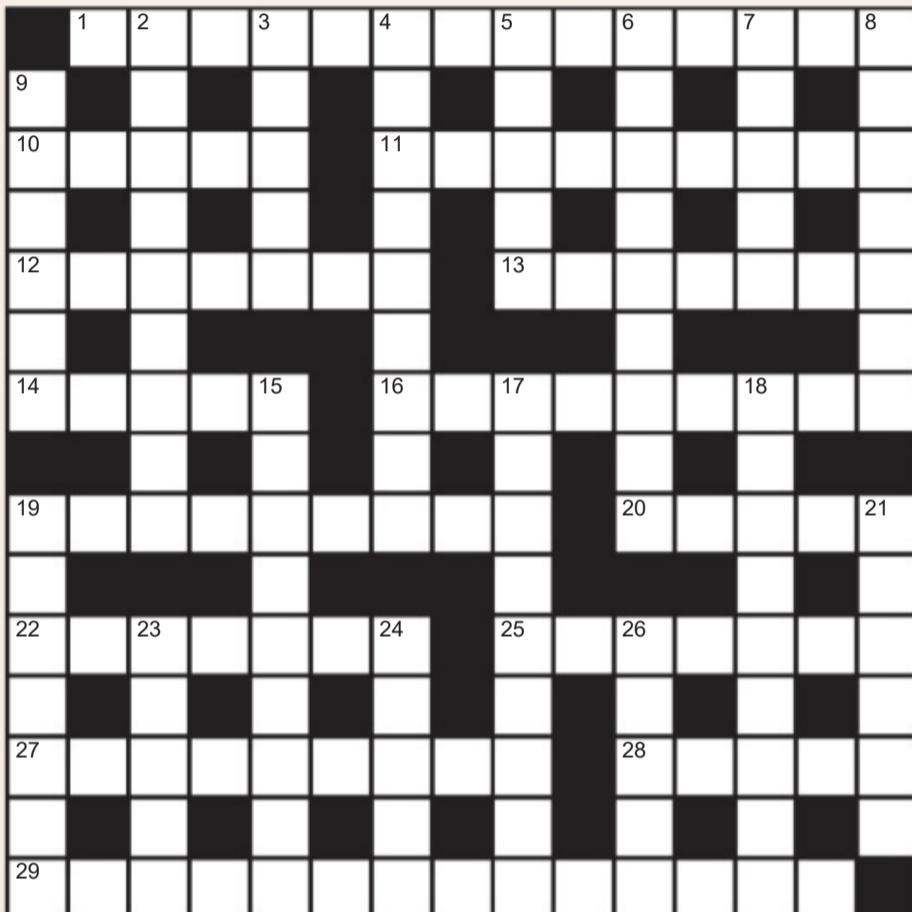
Feedback

An Attenborough AI and penguin pursuits: the week in weird **p55**

The last word

My little dog takes the same number of steps as me. Why? **p56**

Quick crossword #65 Set by Richard Smyth



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

- 1** The world's smallest bird, *Mellisuga helenae* (3,11)
- 10** ___'s razor, principle in logic (5)
- 11** Surgical procedure (9)
- 12** Lise ___, Austrian-Swedish physicist (7)
- 13** Windpipe (7)
- 14** Yorkshire city, once home to the chemist Joseph Priestley (5)
- 16** Small North Atlantic gull (9)
- 19** Five-pointed star (9)
- 20** Relating to the olfactory organ (5)
- 22** Swarming grasshoppers (7)
- 25** Tympanum (7)
- 27** Spiral galaxy also known as Messier 31 (9)
- 28** Archived; rasped (5)
- 29** Senior public health official in the US (7,7)

DOWN

- 2** Of geometry, classical (9)
- 3** *Homo sapiens* (5)
- 4** James Bond film of 1979, set partly in space (9)
- 5** Unreactive (5)
- 6** Degree; increment (9)
- 7** ___ elk, mammal of the Pleistocene (5)
- 8** Having teeth (7)
- 9** Usual; of distribution, Gaussian (6)
- 15** Metamorphic rock composed mostly of talc (9)
- 17** Climate typical of the middle latitudes (9)
- 18** Country to which monotremes are endemic (9)
- 19** Rotating neutron stars (7)
- 21** λ (6)
- 23** Computer programmer (5)
- 24** Formation of geese in flight (5)
- 26** Long-barrelled firearm (5)

Quick quiz #66

- 1** All maps need only four colours to make sure that no adjacent regions are coloured the same. True or false?
- 2** What did the Canadian company D-Wave Systems claim to have invented the first commercial example of in 2011?
- 3** Where are the Lomonosov ridge, the Mendeleev rise and the Podvodnikov basin?
- 4** "I'm sorry, Dave, I'm afraid I can't do that" is an infamous quote from which movie villain?
- 5** What type of insect is Harvard biologist Edward O. Wilson most famous for studying?

Answers on page 54

Cryptic Crossword #38

Answers

ACROSS **1** Coulomb, **5** Moles, **8** Anomalous, **9** Cam, **10** Parsi, **12** Ecdysis, **13** Nuclear fusion, **15** Cuckold, **17** DPhil, **19** Uni, **20** Libations, **22** Ergot, **23** Ecstasy

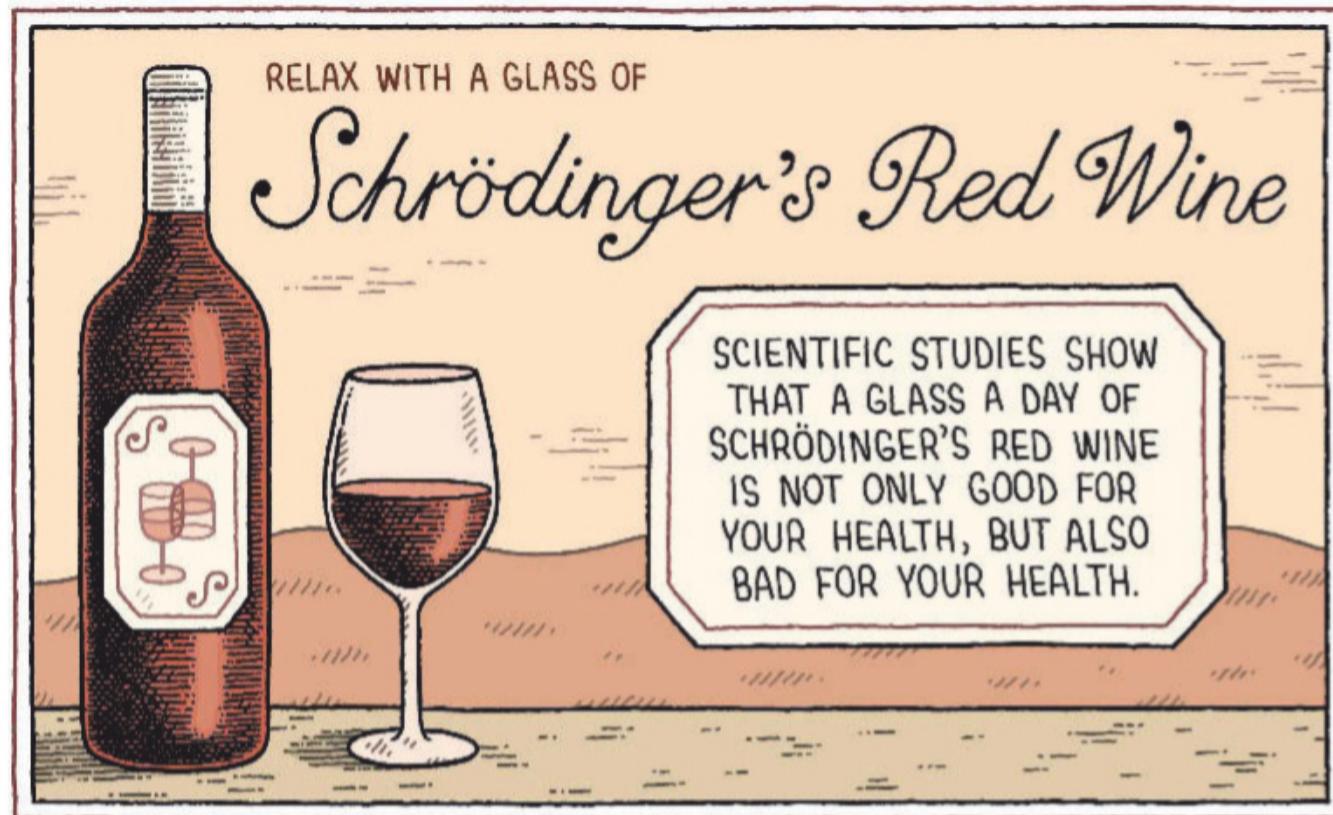
DOWN **1** Clamp, **2** UFO, **3** Opaline, **4** Biodegradable, **5** Mused, **6** Locksmith, **7** Samisen, **11** Recycling, **13** Noctule, **14** Updates, **16** Owlet, **18** Lusty, **21** Oca



Our crosswords are now solvable online
newscientist.com/crosswords

The back pages

Tom Gauld
for New Scientist



Twisteddoodles
for New Scientist



Quick quiz #66 Answers

1 True, although a 1976 proof of the "four colour theorem" has only more recently become widely accepted by mathematicians

2 A quantum computer

3 On the floor of the Arctic Ocean north of Siberia; they are central to Russian claims of how far north its jurisdiction extends

4 The insurgent computer HAL 9000 in the film 2001: A Space Odyssey

5 Ants, especially social ones

Puzzle
set by Chris Maslanka

#74 The twisted wood

On my way through the twisted wood, I bumped into Tweddle and Twaddle. These two are logical, but like to quarrel. When I found them, they were arguing over which of the 12 philosophers living in those parts was the greatest. Was it:
Spotton, Tuorlo or Twee?
Fluffer, Wimby or Mee?
Twitton, Twottie or Hirst?
Schnitzel, Freddie or Wurst?

Clearly, the correct answer had to be one of those 12, so I picked one of the names at random. I whispered the first letter of my nominee in Tweddle's ear and the final letter in Twaddle's ear. They then made the following remarks:

Tweddle: I don't know your choice.

Twaddle: I don't know it either.

Tweddle: I still don't know.

Twaddle: Aha, but now I know it!

Which of the 12 did I chose?

Answer next week

#73 Changing guard

Solution

Perkins will end up facing right, regardless of where the other left-turners were standing. The five soldiers who are initially facing left will "transfer" that leftness to a soldier to their left until there are no more right-facers to transfer this to. The soldiers will end up arranged like this:

L L L L L R R R R R R R R R R

Perkins is eighth from the left, so he will end up facing right.

David Attenborough

One of the finest collections of short fiction on the internet is to be found on Reddit. The website boasts a plethora of pseudo-chat rooms that cater to every conceivable taste, both safe for work and otherwise. One of the most popular is r/Relationships, where people can share details of their personal lives with total strangers for validation and advice.

Yet as stories on r/Relationships have become more baroque – my boyfriend doesn't want anything to do with the dog I adopted during a previous relationship, help me convince my partner not to drop out of law school to start a podcast, etc. – suspicions are growing that many of the posts are made up.

That hasn't stopped software developer Garrett MacGowan from creating an AI rendering of David Attenborough's voice to read out some of the forum's most iconic threads. Feedback was worried that such a melding would tarnish the stature of a beloved icon, but the reverse has happened: in Attenborough's husky whisper, even the internet's worst imaginings take on a dignified hue.

Lean times

Feedback previously reported on a case of nominative determinism that had crept into the pages of *New Scientist*, in which Glasgow researcher Michael Lean was quoted in an article on obesity.

Jon Arch has now written in – with Michael's blessing – to point out that his surname in fact derives from the Gaelic words *Macgillean Dubh*, and so didn't emerge fully formed as an adjective indicating slenderness. "New Scientist might like to reflect on the assumption that all British names are English," they write. A salutary reminder, thank you.

Brain spinning

Continuing on the same theme, Christine Dann points us in the direction of a choice quote from neuroscientist Scott Grafton's



Got a story for Feedback?

Send it to feedback@newscientist.com or
New Scientist, 25 Bedford Street, London WC2E 9ES
Consideration of items sent in the post will be delayed

book *Physical Intelligence*: "Henry Head was the lead editor of the journal *Brain*, not to be confused with Lord Brain, who later became head of *Brain* and wrote an admiring essay on Head published in *Brain*."

Dip in standards

A recurring bug in the Feedback bed is the misuse of acronymy by scientists who ought to know better. The suggested appellation for these was astronyms, owing to their high incidence among astrophysicists, but subsequent readers have written in to assure us that all branches of science are equally guilty.

Really? You expect us to believe that? Well, then how do you explain a paper recently uploaded to the arXiv preprint server that parses the phrase "Morphological Analysis Yielding separated

Objects iN Near infrAred usIng Sources Estimation" as MAYONNAISE. Only an astrophysicist could come up with that one. And no, that wasn't intended as a condiment.

Neat pun

Feedback's attention has been drawn in recent weeks to a number of journal articles with noteworthy punning titles. This week's entry is a paper in the *American Journal of Respiratory Cell and Molecular Biology* on the use of interleukin-6 (IL-6) receptor antagonists as a possible treatment for covid-19. In the paper, Tanner Hedrick, Brian Murray, Robert Hagan and Jason Mock reflect on the undue attention such treatments have received and the need for greater care in promoting new therapies. The title? "Clean-up on IL-6".

Western central time

Questions continue to swirl around Kanye West's campaign to become president of the US. Is he really running? If so, why? And, crucially, will he have to redefine time to win?

In order to be on the ballot in Wisconsin, West was required to turn in his nomination paperwork by 5 pm on 4 August. According to documents cited in the *Milwaukee Journal Sentinel*, however, his campaign actually filed it 14 seconds late, meaning that his name won't appear as an option for Wisconsin voters.

Rather than admit defeat and move on, the West campaign opted to challenge the decision. On what grounds, you might ask? Well, says lawyer Michael Curran, the 59 seconds immediately following the start of the new hour continue to belong to the previous one. In his own words: "For the average observer, arriving before 5.01 pm is arriving 'not later' than 5 pm." To be filed later than 5 pm, he argues, it would therefore have to be submitted at 1 minute past.

It is an ingenious line of reasoning. Hopefully, our editor will see the light when it comes to Feedback's own filing deadline.

PC Waddle

What is black and white and red all over? A penguin that has just been stopped by the police. That, at least, is our takeaway from a story in *The Independent* about an incident in Nottinghamshire, UK. Police officers apparently found a runaway Humboldt penguin "plodding up a village street" and escorted it home (to a nearby farm, apparently, rather than Chile).

When asked about the bizarre story, a local inspector said officers had been trained to deal with "a variety of incidents with complex demands". Feedback would love to know more about this apparent penguin-stopping training. Do flippercuffs even exist? ■

This is Gilead Amit's last Feedback

Small torque

How do food packaging companies decide how tight to make the lids on jars? Has this increased over time or am I just getting older?

Jackie Jones

Brighton, East Sussex, UK

One reason that food jar lids are so tight is the vacuum in the jar.

If I am making jam or chutney, I put the hot mixture into the jar, filling it to within about 5 or 8 millimetres of the top. I then put the lid on and tighten it by hand. At this stage, I can easily take the lid off again.

As it cools, the air in the space above the conserve contracts, forcing the safety button on the lid to drop. This forms a tight seal that makes the lid harder to remove. It is this seal that prevents the food going off and is essential to give it a long shelf life.

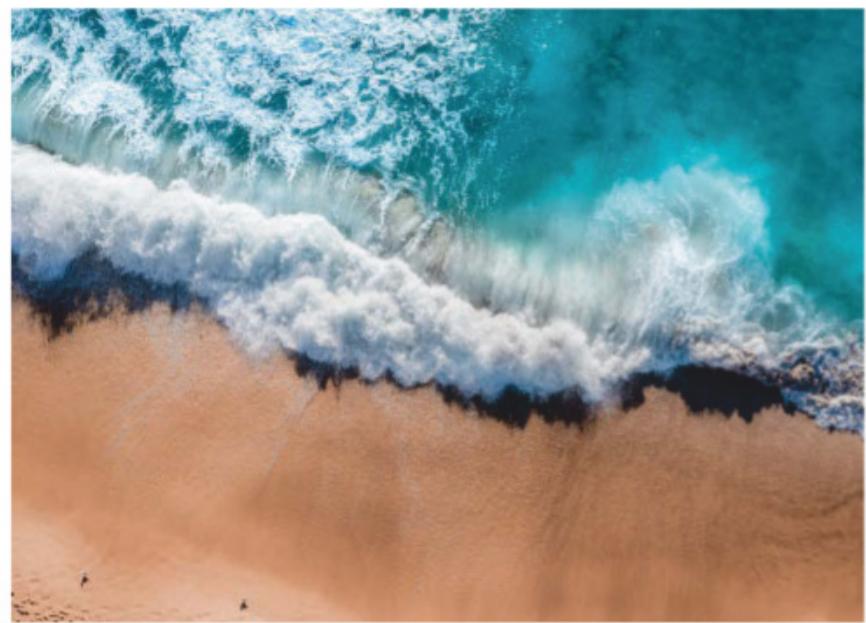
This would apply to most food packaging where it is put into jars while hot, whether in a factory or at home. As to whether lids have got tighter, it probably depends on the factory in question. I remember my mother having problems undoing jars, so isn't just a recent occurrence and it might have an age-related aspect.

Mike Follows

Sutton Coldfield, West Midlands, UK

Lids may be harder to unscrew because of the increased use of safety seals, which rely on a partial vacuum inside the jar. There is a "button" of flexible metal in the centre of the lid that can either be raised or depressed.

Hot food is placed into the jar and the lid closed. As the contents cool, the pressure of the air left inside the jar falls and the metal on the lid pops downwards. The greater atmospheric pressure outside the jar keeps the metal button depressed and makes it more difficult to open the jar. I find it easiest to break the seal with the gentle use of a bottle opener, treating the lid as an oversized bottle cap.



MOHAMED KHAKI/EYEEM/GETTY IMAGES

This week's new questions

Brain pain Do the different causes of headaches create pain in different parts of the skull? *Pauline Fothergill, Pocklington, East Riding of Yorkshire, UK*

Wayward waves If waves are caused by wind action on the sea surface, then why do they always appear to roll towards a beach? *Andrew Sidwell, Nottingham, UK*

Friction can also play a role. Because I am right-handed, I find it easier to close a jar – which has a right-handed screw thread – than to open it, and I can use stronger muscles.

Opening a jar demands that static as well as kinetic friction has to be overcome, which can increase if food becomes trapped in the thread, and I am using weaker muscles to turn the lid anti-clockwise. Right-handers will instinctively swap to their left hand to try to unscrew a recalcitrant lid, in order to use stronger muscles.

Dog legs

I attached my activity tracker to my dog. Even though she has very little legs, her step count was almost exactly the same as mine. What is going on?

Anthony Woodward

Portland, Oregon, US

A Fitbit doesn't have a smart camera watching your feet striding along. It has an accelerometer that detects

change in velocity in all three spatial axes.

A first algorithm analyses the accelerometer outputs and attempts to determine which are attributable to walking or running. It isn't foolproof. The algorithm can be deceived by shaking your wrist up or down, or by driving over a bumpy road.

Data points attributed to walking or running are then subjected to an algorithm that also includes the personal information supplied by the Fitbit owner, including age, gender, height, weight and where the owner wears the Fitbit.

Unless the questioner reprogrammed her Fitbit before attaching it to her dog's leg, the algorithm will calculate the number of steps as if the Fitbit were about 3 feet not 3 inches above the ground.

Why do waves always seem to roll towards a beach?

The estimated step count isn't completely accurate. In one study, a wrist Fitbit overestimated the distance walked at a slow speed but underestimated the distance walked at a fast speed. Fitbit is one of the more studied activity trackers, but other devices presumably function similarly.

William Harwin

University of Reading, UK

Early mechanical pedometers tried to count steps. To drive the counter, they used something called a mass-spring-damper mechanism, in which the mass resonated approximately in line with the speed of walking.

Modern fitness apps do much the same, but the mass is tiny and contained in an accelerometer, and the app will use a digital filter to remove signals that aren't much like steps.

The step count, or distance covered, is calculated based on the average level of the resulting signal.

Although this works when you are walking, the device also counts other activities, such as cooking and bell-ringing, as walking and adds these to your step count.

In the case of the dog, her movements will be faster but smaller when she is running alongside you, so the average size of her acceleration may be higher than yours.

Added to that, the digital filter will still respond if your dog is bouncing up and down at twice your rate, so it isn't unlikely that these two factors combine to give the appearance that your dog is taking the same number of steps as you, even though this is clearly not the case. ■

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