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WEEKLY August 15–21, 2020

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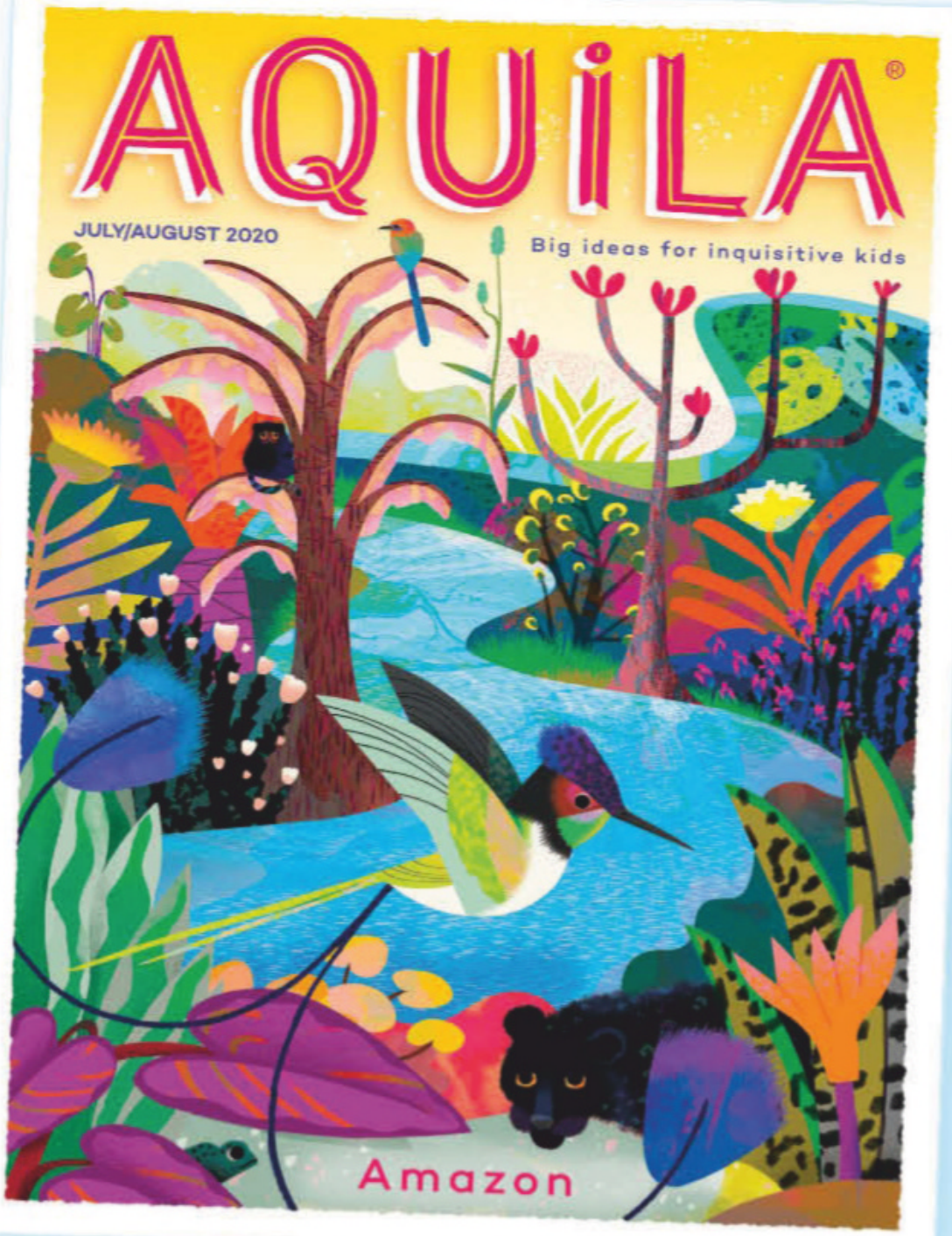

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This week's issue

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Cover image: Dave Fung

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PAULO OLIVEIRA/ALAMY

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FIONA HANSON/AP

Mysteries of life Nobel prize-winner Paul Nurse tries to solve them

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Second wave How the coronavirus pandemic is affecting the world

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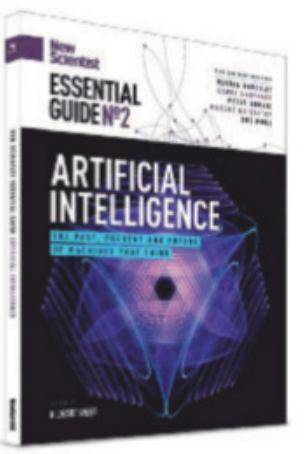

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Global thinking

We need to think globally, not nationalistically to beat the coronavirus

THE covid-19 pandemic has exposed some major fault lines in public trust of science and medicine. From conspiracy theories about 5G phone masts, Chinese bioweapons and Bill Gates to some people's refusal to wear masks even when required to do so, it is clear that a significant minority of people are worryingly resistant to the facts.

These conspiracy theories and their fallout are going to look like very minor skirmishes if and when a covid-19 vaccine becomes available. Already there are worrying signs that many people will refuse to get vaccinated. A survey released last week found that around half of the UK may decide to decline. International polls have found similar levels of anti-vaccine sentiment.

You might be tempted to condemn refuseniks to their fate. But of course, their actions will have consequences for others, too. Vaccines are principally aimed at protecting individuals, but they can also create a social good through herd immunity. That is a lifesaver for people who, for various reasons, cannot be vaccinated .

"'Vaccine nationalism' blighted the response to the 2009 flu pandemic and it looks as if it is rearing its ugly head again"

This is just one reason why clinical trials mustn't be rushed. An unsafe or mediocre vaccine could be worse than none at all.

Scientists also have a duty to build trust in vaccination, and thankfully they already are. A project called CONVINCE has started the hard and thankless task of persuading those worried about vaccines to change their minds.

A vaccine will also widen another fault line that is already running through the body politic: nationalism versus globalism. Last week, the World Health Organization warned about the dangers of rich countries hogging scarce supplies. This "vaccine nationalism" blighted the global response to the 2009 flu pandemic and it looks as if it is rearing its ugly head again.

Once more, the answer must lie in using facts to change minds. We need to convince governments that nationalist responses are bound to fail when it comes to this new coronavirus.

The pandemic is, by definition, a global problem – and it needs a global solution. ▮

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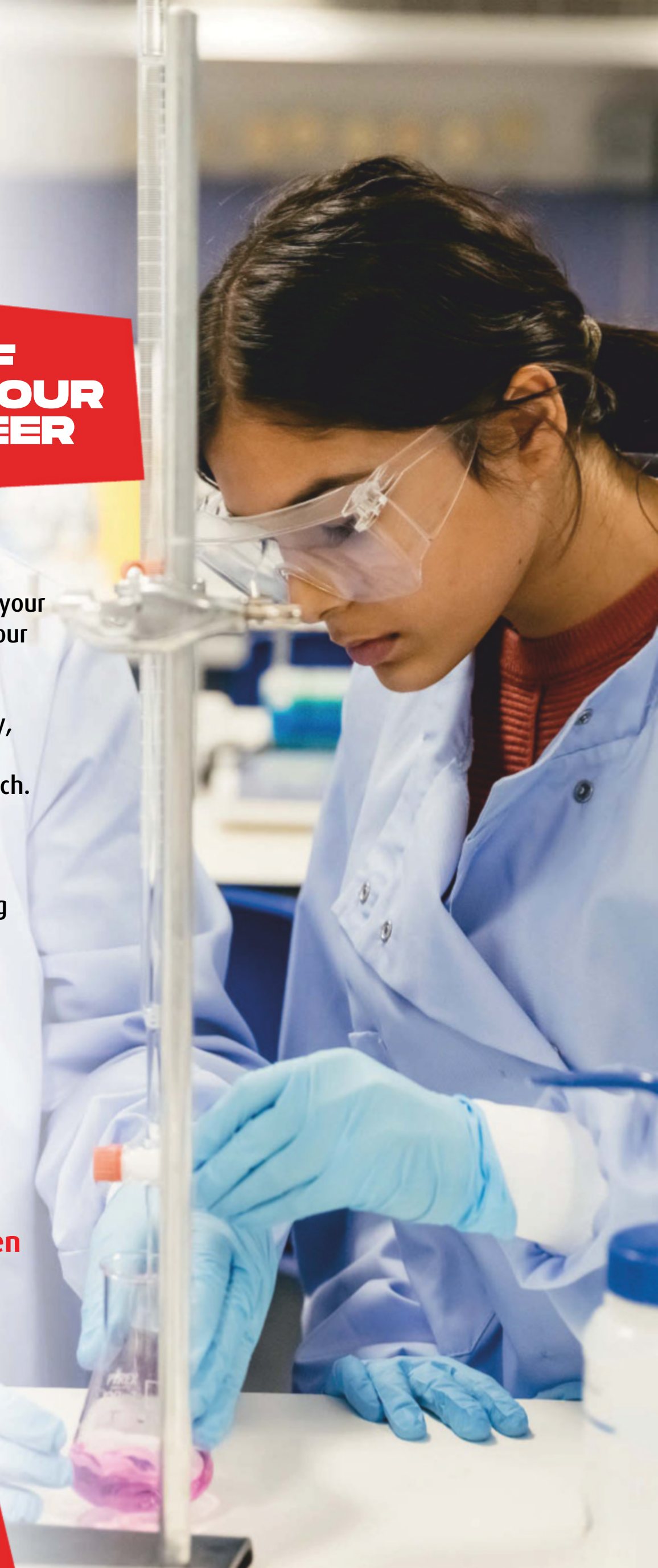

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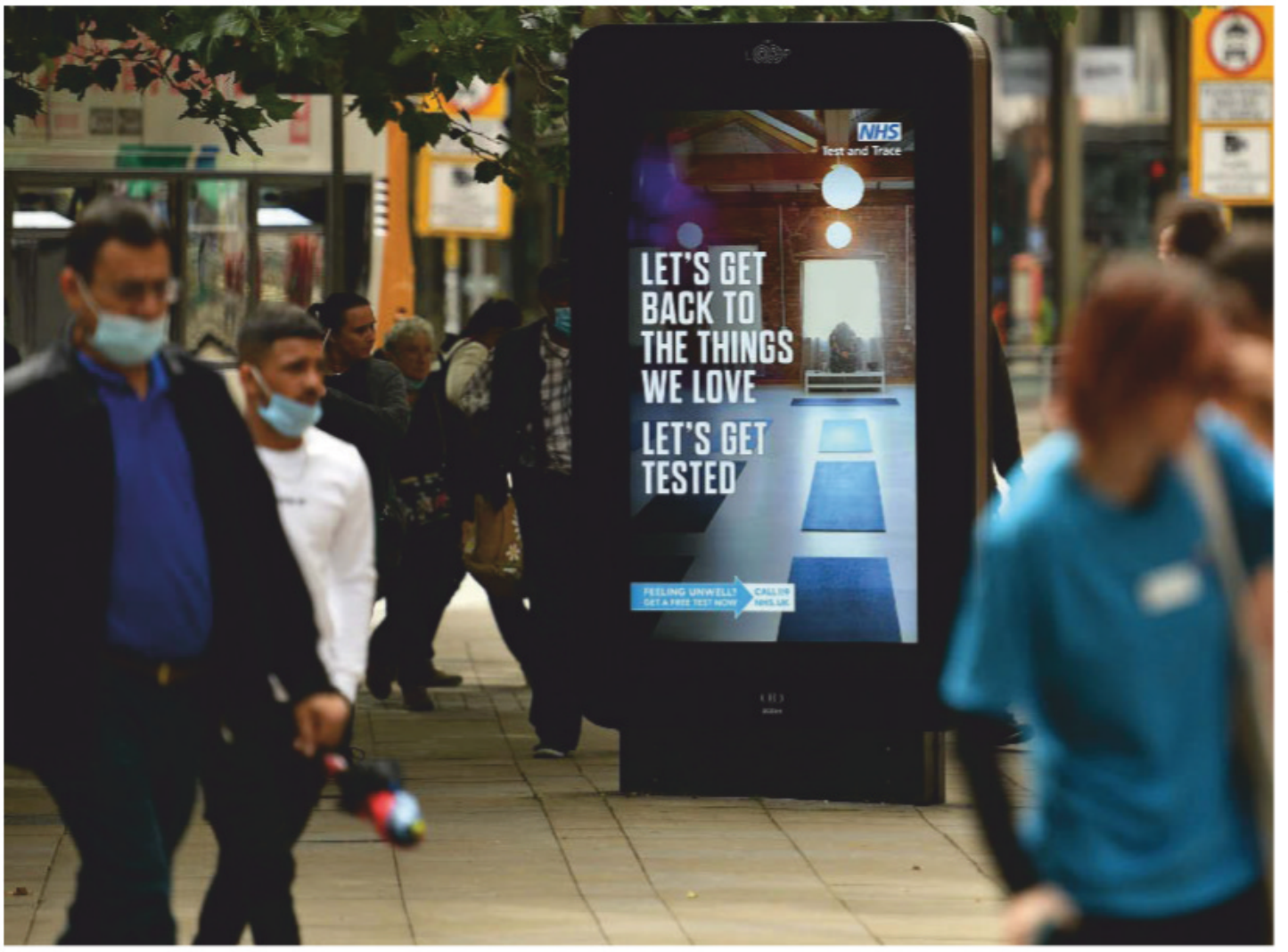


OLI SCARFF/AFP VIA GETTY IMAGES

A billboard in Manchester, UK, promoting testing for covid-19

Rapid tests questioned

Two rapid tests for the coronavirus will be rolled out in the UK, but neither is supported by published data, reports **Jessica Hamzelou**

THE UK government has announced that two 90-minute tests will, between them, provide more than 6 million coronavirus assessments to individuals at care homes and National Health Service hospitals across the UK.

But while the companies behind both tests say they have validated their accuracy, the details haven't been published. "I'd never heard of these two tests," says Jon Deeks at the University of Birmingham, UK, who has been comparing the evidence behind a range of rapid tests to diagnose covid-19.

One of the tests was developed by DnaNudge, a company that offers diet-based shopping advice for customers who share their DNA. The coronavirus test is based on a nasal swab, which is inserted into a disposable palm-sized cartridge. Up to 12 cartridges are then put into a machine the size of a shoebox, where a chemical reaction converts the virus's RNA to DNA and copies it. Chemicals seek out sequences from the coronavirus to signal its presence.

The cartridge system was developed for retail, but it was "very simple" to adapt for the coronavirus, says Chris Toumazou, co-founder and CEO of DnaNudge.

The second test, developed by Oxford Nanopore Technologies, requires a lab or dedicated clean room for processing samples and feeding them into a machine the size of a desktop computer. The machine handles 15,000 samples per day, says a spokesperson for the firm.

The spokesperson wouldn't give the results of trials, or how accurate the test is when compared with standard tests. They told *New Scientist* that accuracy data is being prepared for publication.

Looking at data published before June, Deeks and his colleagues have identified only two rapid tests that have been assessed in independent studies: the Xpert Xpress test developed by Cepheid and Abbott's ID NOW test. The team is due to publish its findings soon, but more research is needed, says Deeks. Most of the tests seem to work well when samples contain a lot of virus, but perform poorly when faced with low viral loads, for example.

When asked why the UK government chose the DnaNudge and Oxford Nanopore tests, a spokesperson for Public Health England (PHE) stressed that it doesn't validate or regulate tests. The spokesperson said PHE would have "been in the room" when the decision was made, but didn't have the final say. They weren't able to comment on the Cepheid or Abbott tests before publication.

"Both tests are promising, but without published results they cannot be properly scrutinised"

Toumazou says that his test has been validated. His team has been testing the diagnostic alongside standard NHS tests at English hospitals for the past two months, he says, and has shared the results with PHE and the UK's Medicines and Healthcare products Regulatory Agency. The MHRA told *New Scientist* that DnaNudge has an exceptional use authorisation, meaning the tests are allowed to be used clinically until October, but didn't comment on the accuracy of the tests. PHE wasn't able to respond to questions about accuracy before publication.

The DnaNudge test's user guide states that it has 97 per cent sensitivity and 100 per cent specificity, meaning that 3 per cent of cases would be missed, and there were no false positive results. These figures are based on a study of 401 nasal swabs, 40 of which were excluded due to invalid results, states the guide.

Both tests are promising, but without detailed, published results they cannot be properly scrutinised by the academic community, says Deeks.

Muhammad Munir at the University of Lancaster, UK, whose team has developed a separate, 30-minute diagnostic test for the coronavirus, agrees. New technologies need to be properly assessed, he says. ▮

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

Ethics

Who gets to have the vaccine?

If a covid-19 vaccine is finally developed, tough decisions await about who should be first in line for the limited initial supply, says **Graham Lawton**

KIRSTY WIGGLESWORTH/AP/SHUTTERSTOCK

IT IS August 2021, and the moment the world has been waiting for has finally arrived. After many false dawns, a vaccine against covid-19 has passed all the tests and is ready to be rolled out.

It has been an arduous journey, but at last vaccine manufacturers around the world are cranking out thousands of doses a day. The end of the pandemic is on the horizon.

But this isn't the end. It isn't even the beginning of the end. There are more than 7.5 billion people in need of vaccination but perhaps only a billion doses available in the first six months of production.

Who gets one? Everyone agrees that front-line healthcare workers must be first in the queue. But who should be next? What is the best way to attain herd immunity? Will people accept the vaccine? And is it possible to stop rich countries from hoarding the supplies?

The answers to these questions depend largely on decisions being made now, in 2020, long before a successful vaccine has been developed. Of course, that day may never arrive. But let us assume that it does. What happens next?

No single approach

Even if a vaccine works, there is no one-size-fits-all vaccination regime. The two newest vaccines to be developed give a flavour of the problem facing epidemiologists. These are the Ebola vaccine Ervebo, approved in November 2019, and a dengue fever vaccine Dengvaxia, approved in 2015.

Consider Ervebo. Before covid-19 stalled its roll-out there was enough time to devise and test containment strategies. These show that the most effective approach is ring vaccination. That means tracking down confirmed cases and vaccinating all of their contacts and all of their contacts' contacts, thus throwing a ring of immunity around the virus.

For Dengvaxia, however, the most effective strategy depends on local circumstances. When the virus is rampant, mass vaccination offers the most protection to the largest number of people. But where transmission rates are lower, it is better to selectively vaccinate adults who have already had the virus. This is because a second bout is more dangerous than the first one due to the way the immune system ratchets up. That also means that vaccinating infants, who are unlikely to have had the virus, can backfire because the vaccine acts like a first bout.

So what works for one disease might be less than optimal for another, because diseases and vaccines are all different. For covid-19, the absence of both a vaccine and full understanding of the disease means that designing a strategy is a very inexact science.

Who will get a vaccine, and when, according to the World Health Organization's strategy

50 million
Healthcare workers – doctors, community health workers, nurses and midwives – are the first priority for vaccinations

600 million
Adults over the age of 65, making up 8 per cent of the global population, are the second priority

1.1 billion
High-risk adults, with conditions such as diabetes, cardiovascular disease, cancer or obesity, are third in the queue

SOURCE: WORLD HEALTH ORGANIZATION

A team led by Emma McBryde at James Cook University in Australia has started modelling possible scenarios, but the results are still under wraps. One thing we can say, however, is that ring vaccination isn't going to work. Ebola is transmitted by contact with bodily fluids, so spreads relatively slowly, whereas covid-19 is a respiratory disease that spreads very rapidly.

Regardless of the specifics, the overwhelming rationale for introducing any new vaccine is to reduce severe illness and mortality. That holds true for covid-19. But there are other considerations, says Nicholas Grassly, a vaccine epidemiologist at Imperial College London who sits on the Strategic Advisory Group of Experts covid-19 vaccine group for the World Health Organization (WHO) but spoke to *New Scientist* in a personal capacity. "Vaccination for covid-19 is not just about health, it is about

A volunteer in London is injected with a trial vaccine against covid-19

the economy and protecting essential services, too," he says. "That is a little bit different from how vaccines are traditionally looked at. So the question is, who should we vaccinate to maximise the health benefits, facilitate a return to productivity and protect health and education services?"

That decision would be more straightforward if vaccine stocks were unlimited. But they won't be, at least not at first; the most ambitious scale-up plan so far is by a vaccine team in Oxford, UK, which says it could produce 2 billion doses within 12 months of approval. It is possible that two doses will be needed per person, so that would only be enough shots for fewer than 1 billion people, allowing for a 15 per cent wastage rate.

"It is quite unlikely that there is going to be enough vaccine for the entire world," says Beate Kampmann, director of the Vaccine Centre at the London School of Hygiene & Tropical Medicine (LSHTM). That means tough choices await.

The hard work has already started. The WHO published a preliminary vaccine allocation plan in June. It prioritises healthcare workers, of which there are about 50 million worldwide. Next are the 600 million adults over the age of 65, and then the 1.1 billion adults over 30 with cardiovascular disease, cancer, diabetes, obesity or respiratory disease.

Individual countries are also formulating plans. In the UK, the Joint Committee on Vaccination and Immunisation held an extraordinary meeting on vaccine prioritisation on 18 June. It started from the premise that the priority is to "save lives and protect the NHS", a familiar slogan to anyone who has been watching the UK response to the pandemic.

To that end, the committee decided that healthcare workers must be the highest priority, followed by care workers. Next in line should be people at increased risk of disease and death from covid-19, which means older people and those with pre-existing conditions. Everybody else will have to wait, although perhaps not as long as people in lower-income countries (see "Vaccine nationalism", page 10).

Herd immunity

The US Centers for Disease Control and Prevention is also exploring the options. Its plan similarly puts 12 million "critical health care and other workers" at the head of the queue, followed by 110 million other health workers and high-risk individuals. The general population – 206 million people – go to the back.

It is notable that none of these plans mention herd immunity, which arises when there are enough immune people in the population to stop a virus from circulating. Despite its somewhat tarnished reputation after "natural" herd immunity was briefly and unscientifically touted as an exit strategy in some countries including the UK, vaccine-induced herd immunity is still our best bet for ending the pandemic and even eradicating the virus. "We are going to need global herd immunity," says Gavin Yamey at the Duke University Global Health Institute in Durham, North Carolina.

There is a reason that vaccine-induced herd immunity hasn't yet been incorporated into planning, says Grassly. It is often taken for granted that mass vaccination covering between 60 and 70 per cent of the population will lead to herd immunity to the coronavirus, but it may not.

Vaccines are designed to protect individuals from severe illness or death, not to induce herd immunity. They sometimes produce it by preventing infection and transmission, but that is a happy accident. The nasal flu vaccine, for example, halts transmission of the virus and can therefore create herd immunity. For this reason, it is principally given to children to prevent them from infecting vulnerable older relatives who are unlikely to respond strongly to a vaccine.

But as yet we don't know whether a covid-19 vaccine will work this way. "If vaccines become available, it will be because they are protective against disease,"

"Vaccination for covid-19 is not just about health, it is about the economy and protecting vital services"

says Grassly. "They may, or may not, also be protective against infection or transmission, but we don't know yet."

If a vaccine does promise herd immunity, it would probably be worth revising the vaccination priorities to take advantage, says Grassly. We know, for example, that some people who don't develop symptoms can still be highly contagious. There are also "superspreaders" who infect many more people than average. The difficulty will lie in identifying who those people are, but it may pay to prioritise vaccination for teachers and those working on public transport or in supermarkets, he says.

There would also be an argument for vaccinating children rather than vulnerable adults. "Healthcare workers should be first, then the intuitive thing is to prioritise the elderly," says Alberto Giubilini of the Uehiro Centre for Practical Ethics at the University of Oxford. "But, paradoxically, the best strategy might be to vaccinate children. Their immune system responds better to vaccines. To reach herd immunity you want to give the vaccine to the people for whom it works best."

It is even possible that the vaccine might not work ›

In short supply

Even if an effective vaccine is developed, it will take years to produce the estimated 14 billion doses needed to protect the global population. Why so slow?

Making vaccines at scale is a laborious process, with quality control taking up a big share of the resources. The world's largest vaccine manufacturer, the Serum Institute of India, produces about 1.5 billion doses of various vaccines a year, which shows the scale of the challenge.

"Trying to come up with an approach for 7 billion people is an enormous undertaking," says Robin Shattock, who leads the vaccine team at Imperial College London. "Currently the biggest number of vaccines that are made a year is about half a billion doses of polio vaccine. Nobody has made a billion doses of any vaccine globally in any single year."

in older people, in which case the strategy would be to vaccinate the people around them.

Another factor that could scupper herd immunity is what researchers call vaccine hesitancy. According to Heidi Larson, director of the Vaccine Confidence Project at the LSHTM, covid-19 anti-vaccine posts on social media outnumber positive voices by about four to one.

In denial

There are signs that the anti-vaccination misinformation is cutting through. In the UK, for example, Larson's team has been asking samples of more than 2000 people whether they would be willing to be vaccinated. In late March, 80 per cent of people said yes. By the end of May, that had fallen to 67 per cent.

In the US, a poll conducted in May found that 42 per cent of people would definitely get vaccinated against coronavirus, 27 per cent definitely wouldn't and the rest were unsure.

A similar obstacle is the growing number of people who refuse to accept that covid-19 even exists, says Leesa Lin at the LSHTM. "Covid-19 denialism is likely to pose a threat to convincing people to take a vaccine. There is a significant association between perception of the disease risk and vaccine uptake," says Lin.

All told, then, the outlook remains highly uncertain. A vaccine may not even be possible. If it is, there won't be enough to go round, at least at first. Even when there is, it may not induce herd immunity. And even if it does, too few people may choose to take it. The beginning of the end? Not likely. "If this was a 100-metre race, we have only run the first few metres," says Yamey. ▮

Vaccine nationalism

During the flu pandemic of 2009, high-income nations were criticised for hoarding vaccine doses. Will "vaccine nationalism" raise its ugly head again?

Some world leaders seem to have learned the lessons of 2009, says Gavin Yamey at Duke University in Durham, North Carolina. "There is clearly enormous political will that when vaccines are developed, rich countries don't monopolise them," he says. "We've heard world leaders like Emmanuel Macron saying that vaccines should be a 'global public good'. That is significant because underlying it is a realisation, at the very highest levels, that without global herd immunity it's going to be very difficult to bring this pandemic to an end."

The World Health Organization (WHO) covid-19 vaccine prioritisation plan (see main article) emphasises the need for "equitable and fair global allocation", and a global coalition called COVAX is working to ensure that this happens. Countries that sign up then pool resources so that if one vaccine succeeds, all can have it. It is effectively an insurance policy, says Yamey.

At the time of writing, 170 countries with a combined population of 4.5 billion have expressed an intention to sign up, including the UK, Canada, New Zealand and Ireland. The poorest 92 of these countries will get a vaccine for free.

Meanwhile, the teams behind the UK's leading vaccine candidates at the University of Oxford and Imperial College London have pledged to make their vaccines available on a not-for-profit basis.

But the nationalist drumbeat is growing. Neither the US nor China has yet publicly declared an interest in COVAX. And several countries have signed deals with firms to buy disproportionate amounts of vaccine. "It is already obvious that countries that have contributed significantly to the funding of the research will want to have the first pick at the crop," says Beate Kampmann, director of the Vaccine Centre at the London School of Hygiene & Tropical Medicine. For example, the UK government has secured a deal for 100 million doses of the Oxford vaccine, which is 5 per cent of the projected world supply for a country with less than 1 per cent of the global population.

> "Without global herd immunity, it's going to be difficult to bring this pandemic to an end"

The US has signed a deal to buy 350 million doses of the Oxford vaccine, 17.5 per cent of global supply for a country with 4 per cent of its population. US president Donald Trump has also set up an explicitly nationalist vaccine development programme called Operation Warp Speed.

"There is no such thing as a British or Chinese or American vaccine, any vaccine must be a global public good," says Yamey. "The billion-dollar question is, are these deals a threat to the global fair distribution of vaccine? My answer is, they are."

Meanwhile, Russia announced this week that it has become the first country to approve a vaccine. However, according to the WHO, the vaccine, being developed by the Gamaleya Institute in Moscow, is only in early stage trials raising concerns that it is being used before it is known to be safe. ▮ GL

Full protections: a lab technician at work to develop a vaccine against covid-19

AKOS STILLER/BLOOMBERG VIA GETTY IMAGES

Pollution

The plastic pandemic

The coronavirus has led to a resurgence in single-use plastics, but there is still time to reverse course, says **Adam Vaughan**

IT LOOKED as if the tide had turned against single-use plastic last year, with the European Union approving a ban on cutlery, straws and more, New York backing a plastic bag ban and consumer pressure continuing to grow.

Then the coronavirus hit. Hygiene fears and the demand for masks have unleashed a plastic pollution pandemic, while industry lobbyists are pushing to roll back restrictions.

It hasn't been long enough for there to be official data on plastic waste and recycling rates, but there is no shortage of estimates and anecdotes. If every person in the UK used one single-use mask a day for a year, it would create 66,000 tonnes of plastic waste, according to one estimate by a University College London team. *New Scientist* readers have reported masks dumped on beaches, streets and in harbours.

Meanwhile, large parts of the retail and hospitality industry have suspended efforts to cut plastic use. Many coffee chains have stopped accepting reusable cups, pubs in the UK are only serving drinks in plastic, not glass, and more petrol station pumps have been equipped with single-use plastic gloves. Online supermarkets have stopped collecting and recycling plastic bags. The list goes on.

"Members of the public can help by using reusable face masks, and disposing of any single-use masks and gloves carefully, to avoid adding to the plastic pollution that already clogs up our rivers and seas," says Louise Edge at Greenpeace UK.

Governments and local authorities are also going backwards. California dropped its ban on single-use plastic bags for several months, although it has since reinstated it. Other places in the US, from Denver to Minneapolis, have delayed bag bans or fees or lifted existing ones. Italy postponed a plastics tax on bottles, bags and more until 2021. A Norway-backed effort to establish an international treaty on marine plastic pollution has indefinitely postponed its meetings because of covid-19.

ANDREY NEKRASOV/ZUMA WIRE/ALAMY LIVE NEWS

A discarded face mask on the shores of Budva, Montenegro

> **"The plastic industry is cynically using covid-19 as justification for removal of restrictions"**

As this goes on, the plastic industry has grabbed the opportunity to push back against growing restrictions in recent years, arguing that single-use plastic is safer and more hygienic amid a pandemic. "The plastic industry is cynically using covid-19 as justification for removal of restrictions," says Julian Kirby at Friends of the Earth.

The drive might not succeed. Trade bodies in the US, Europe and the UK have written to government and state officials asking for them to promote the supposed benefits of single-use plastics during the pandemic, but haven't yet won policy shifts.

Meanwhile, plastic recycling rates may have fallen. Mushtaq Memon at the United Nations Environment Programme (UNEP) says he has heard reports of a decline due to broken supply chains, lower collections and fear of contaminated plastics. In the UK, 26 per cent of local authorities reported disruption to recycling at the start of April, at the height of lockdown. That figure fell to 18 per cent by late July.

Plastic's resurgence has been sparked by fears over transmission of the coronavirus, but it isn't clear whether these are well-founded. Several papers have found that the virus seems to last longer on plastic than on other materials, including glass and cardboard. Scores of academics signed a statement saying reusable products "can be used safely by employing basic hygiene".

One cause for hope is that people still seem to care about stemming plastic use despite the pandemic. In the UK, 74 per cent of people said covid-19 had made no difference to their plans to cut their use of plastic packaging, market-research firm YouGov found in early April. Similarly, UNEP polling of people in Indonesia, Malaysia, the Philippines, Thailand and Vietnam suggests that concern about plastic pollution remains high.

While some businesses may have taken short-term steps backwards, there is little sign of big players reneging on long-term targets, such as UK supermarket Sainsbury's last year pledging to halve plastic packaging by 2025.

Some campaigners see covid-19 economic recovery plans and changes in consumer behaviour as a chance to clamp down on single-use plastic. "We have to move towards a more circular economy – slowing down the conveyor belt from production to waste, through more recycling, less single use throw-away material, better design and targeted use of materials," says Richard Bailey at the University of Oxford.

Cancer

A cancer puzzle solved?

There may be a simple reason why obesity is linked with tumours

Michael Le Page

PEOPLE who are obese have larger organs and thus more cells, according to CT scans of 750 individuals. This could explain why people who are obese have a higher risk of getting many kinds of cancers.

"While obesity is a complex disease that may affect cancer risk in several other ways, the increase in the size of an organ, and in the number of its cells, must increase the risk of cancer in that organ," states the team, which is led by Cristian Tomasetti at the Johns Hopkins University School of Medicine.

Others say the idea is plausible, but far from proven.

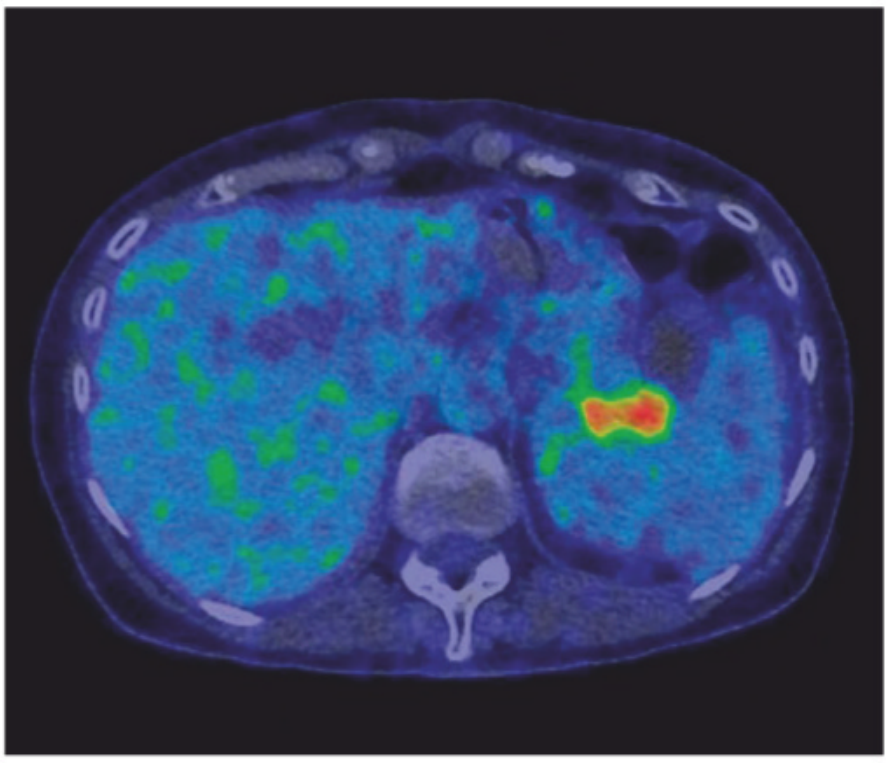
About a fifth of all cancer cases worldwide are attributable to obesity, according to some estimates. But why obesity increases the risk of certain cancer types, such as those of the kidney, remains unclear.

What we do know is that cancers are caused by mutations that disable the mechanisms controlling cell growth. In theory, then, the more cells in any particular organ, the greater the risk of some of those cells becoming cancerous.

Tomasetti and his colleagues used CT scans to measure the volume of the kidneys, pancreas and liver in 750 people. The team found that for every five-point increase in body mass index (BMI), the volumes of kidneys, liver and pancreas increase by 11 per cent.

People with a BMI of about 50 have organs that are between 50 and 100 per cent larger than people with a healthy BMI. "The effect is very large and unexpected," the study states.

Only a very small fraction of these increases is due to an increase in the volume or number of fat cells in these organs, the study says, meaning the increases are mainly due to larger numbers of normal cells.



CENTRE JEAN PERRIN, ISM/SCIENCE PHOTO LIBRARY

Pancreatic cancer on a combined CT and PET scan

What's more, the observed size increases in each organ correspond with the reported increase in cancer risk for that organ (bioRxiv, doi.org/d55z).

"This hypothesis is plausible," says Maria Dalamaga at the National and Kapodistrian University of Athens, Greece, author of a recent review on obesity and cancer. "We already know that tall individuals are more prone to develop cancer." However, the study doesn't control for other factors known to affect the risk of cancer, such as age and sex, she says.

Neil Iyengar at the Memorial Sloan Kettering Cancer Center in New York, whose work suggests obesity increases cancer risk by causing inflammation, is more sceptical. The idea cannot explain why obesity seems to reduce the risk of a few cancer types, he says. "I believe the conclusions are deeply flawed."

In principle, if more cells means a higher cancer risk, large animals like whales and elephants should be riddled with tumours. But they have evolved better mechanisms to protect against cancers, says Joshua Schiffman at the University of Utah.

11%

The increase in liver volume for each five-point BMI increase

"We have shown that elephant cell biology protects against mutation-causing damage better than human cells," he says.

Having more cells is a "very plausible" explanation for why obesity increases cancer risk in people, says Schiffman, although more research is needed to confirm the idea.

Tomasetti declined to discuss his team's findings until the results are published in a peer-reviewed journal. ▮

Artificial Intelligence

Baby-mounted cameras teach AI about the world

Chris Stokel-Walker

THE way that babies learn about and navigate the world could prove to be a good model for training artificial intelligence.

AIs don't learn as efficiently or flexibly as children. To explore why, Brenden Lake and his colleagues at New York University turned to the SAYCam data set, which was published this year. It contains video footage from head-mounted cameras worn by young children for a few hours each week over their first three years of life.

The team fed an AI neural network raw data from SAYCam and asked it to try to work out what it was seeing by identifying what was unchanged and what was different in the video stream over time.

The AI did begin to make sense of the videos. For instance, it was able to recognise that the same object – a cat – popped up repeatedly in the videos. But the AI often did so by extending its attention beyond the cat itself, suggesting it may be relying on contextual cues to identify objects (arxiv.org/abs/2007.16189).

Lake says this suggests the algorithm doesn't recognise objects in the same way as a child, but he argues the findings are still significant. "We have a proof of concept that [visual features] are learnable with enough naturalistic data," he says.

Simone Scardapane at Sapienza University, Italy, says the work offers a "fascinating insight" into how AI algorithms would react when they are fed the kind of messy data children must deal with rather than the heavily engineered data sets they are normally given.

"AI requires a lot of data and labels in order to get to the same levels of performance on a task that kids are good at," says Lake. But if it becomes possible to train them to learn in similar ways to a child, their intuition may well be stronger. ▮

New Scientist
Newsletter

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Adam Vaughan

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Particle physics

The Higgs boson is still behaving, which poses a massive problem

Leah Crane

PHYSICISTS have spotted the Higgs boson performing a new trick, but unfortunately it is one that brings us no closer to understanding the workings of fundamental particles.

Researchers have long hoped to see it doing something surprising, which would help us make progress in figuring out the workings of the universe.

Discovered in 2012 at the CERN lab near Geneva, Switzerland, the Higgs gives all other fundamental particles mass, according to the standard model of particle physics. However, despite the work of thousands of researchers around the world, nobody has been able to figure out exactly how it does that or why some particles are more massive than others.

Some researchers have suggested that particles have different masses because there is more than one type of Higgs boson, with each type coupled to a different range of other particles.

The only way to try to solve that problem is by observing how the Higgs interacts with other particles using the Large Hadron Collider at CERN. For the first time, both of the major research groups that use the collider – the CMS and ATLAS collaborations – have observed the Higgs decaying into two muons, a sort of particle we have never directly seen it interact with before. Members of the two groups presented this work at the virtual International Conference on High Energy Physics.

MAX BRICE/CERN

The CMS detector at CERN is studying the behaviour of the Higgs boson

The problem is, muons are much less massive than the other types of particles we have seen the Higgs interact with, which means the new discovery makes it more likely that there is only one type of Higgs. That behaviour is exactly what we expect from the standard model. Adam Gibson-Even at Valparaiso University in Indiana says it is an instance of "Higgs boson, exactly as ordered".

But this leaves the mystery of why particles have different masses completely unanswered. While the result may not be surprising, says Gibson-Even, it is somewhat frustrating because we know the standard model is incomplete; in addition to not explaining why particles have different masses, it also doesn't account for dark matter or dark energy. Nevertheless, experimental results have been entirely in line with the model.

"It's a problem in the sense that we know that the Higgs boson as-is doesn't explain these things," says CMS researcher Freya Blekman at the Free University of Brussels, Belgium. If the same Higgs interacts with both muons and heavier particles, that closes another avenue to solving the question of mass.

The next step, says Blekman, is to take even more accurate measurements of the Higgs interacting with a range of different particles. Many of these measurements need to be more precise than those that the LHC can provide, which is part of the argument for building a more powerful "Higgs factory" collider, she says.

"This is what particle physics is about – tens of thousands of predictions we have to eliminate"

"We have removed scenarios, but we don't have an explanation yet," says Blekman. "But this is what particle physics is about – we have tens of thousands of predictions and we have to eliminate them." ▮

Insects

Fruit flies have brain cells that sense the way the wind blows

SPECIFIC neurons in fruit flies fire according to wind direction, helping them form a neural map of their surroundings. Algorithms inspired by this may be able to help robots navigate their environment.

Tatsuo Okubo at Harvard Medical School and his colleagues wanted to determine how wind direction was characterised by a fruit fly's brain. While it is well known that wind direction affects the behaviour of insects, no one had yet developed a map of the neurons involved in this phenomenon for any animal.

The researchers initially looked for neurons that corresponded to antennae because they thought these would be the ones affected by wind. "We then found these beautiful ring-shaped neurons that were next to neurons that affect the head direction," says Okubo.

They recorded the firing rate of these ring neurons in a living fruit fly while changing the wind direction of its surroundings.

The team found that wind-sensitive neurons had different preferences for wind direction, firing more if the wind blew from their favoured direction. This led to a fluctuating firing pattern in the overall population of neurons corresponding to wind direction.

Moreover, when these cells were silenced, the fly's head direction neurons reacted as if there were no wind at all, suggesting that wind information directly influences the direction a fruit fly faces (*Neuron*, doi.org/d53j).

It is unclear whether we have such neurons too. "Humans can definitely use wind for long-range navigation like pathfinding, but exactly how they sense it or how that feeds into a navigational circuit – it's still an open question," says Okubo.

These findings could one day be used to give robots an additional method of navigation, he adds.

"This research proves that neurobiology still has a lot to learn from small but sophisticated insect brains," says Ronny Rosner at Newcastle University, UK. "This will be particularly useful if we want to develop the most efficient algorithms for spatial orientation of intelligent machines." ▮

Jason Arunn Murugesu

Fertility

Menopausal and pregnant

A blood plasma treatment may help restore ovaries

Jessica Hamzelou

A WOMAN experiencing menopause has given birth after receiving a blood treatment injected into her ovaries. Three perimenopausal women – those beginning to transition into menopause – have also had babies following the treatment, according to a small pilot study.

Known as platelet-rich plasma, the technique is being developed as a potential fertility treatment by Konstantinos Pantos and his colleagues at the Genesis Athens fertility clinic in Greece.

Around 60 millilitres of blood is taken from the arm and spun in a centrifuge to remove red and white blood cells. The remaining plasma contains platelets, cell fragments that help blood clot and appear to play a role in the regeneration of tissues. This platelet-rich plasma, or PRP, is then injected into both ovaries.

Pantos and his colleagues have been offering PRP as a paid service for the past five years. "We have treated several hundred women," says Pantos. Some want to get pregnant or reduce menopause symptoms, while others want to restore hormone levels to feel younger.

As part of a pilot trial, the team tested the effects of PRP in 30 perimenopausal women and 30 menopausal women between 2017 and 2019. The perimenopausal women were all aged 40 or over and had irregular periods, high levels of hormones that are elevated in menopause or both. The menopausal volunteers were aged between 45 and 55, hadn't had a period for at least a year and also had high hormone levels. None of the women had to pay.

Within three months of receiving PRP, 80 per cent of the perimenopausal women showed improvements in hormone levels and had their periods fall into a regular cycle. Four of the women became pregnant within this three-month window, and three went on to have babies.

Of the 30 menopausal women who received PRP, 13 had their periods restored and experienced significant shifts in their hormone levels. One of these women became pregnant within three months of treatment, and she has since given birth. None of these women had IVF, and they weren't required to be trying to get pregnant to be part of the study.

5%

Lifetime chance of conception with poorly functioning ovaries

Many of the women also reported improvements in their menopause symptoms, says Pantos, who presented the findings at a virtual meeting of the European Society of Human Reproduction and Embryology.

Because PRP wasn't tested against a placebo, it isn't clear if it improves fertility in menopausal women. But the chance of conception in women with poorly functioning ovaries is only around 5 per cent over the course of their lives, says Scott Nelson at the University of Glasgow, UK. "The four cases would be higher than expected," he says.

Richard Anderson at the University of Edinburgh, UK, isn't convinced by the results, though. "It's extremely preliminary," he says. He points out that treatments can look good in pilot studies and then fail in more rigorous trials.

Emre Seli at Yale University also has concerns, but adds that he has seen similarly promising results at his own clinic. "I can't tell you 100 per cent that this is going to be a super useful intervention," says Seli. "But I find it very exciting."

It isn't clear how, if at all, PRP might be working. "There are loads of questions that we still have to answer," says Mara Simopoulou at the University of Athens, Greece, who has been working with Pantos.

Much more research is needed before PRP can be considered as a fertility treatment. Pantos's team is running four randomised, placebo-controlled clinical trials, while Seli is running another two. These studies should clarify whether PRP is any better than a placebo. "It's still research, and it needs to be kept that way until we know more about it," says Pantos.

WILPUNT/GETTY IMAGES

The menopause normally occurs between the age of 45 and 55

Birth story

Aisha's* hopes of having a second child were dashed when she became menopausal aged 38. Aisha, who lives in Dubai, had been having IVF treatment at the time. "Doctors told me I could not have a child anymore," she says.

She opted to pay for an injection of platelet-rich plasma, administered by Konstantinos Pantos and his colleagues at the Genesis Athens fertility clinic in Greece (she wasn't part of the trial discussed in the main story). After treatment, her periods restarted, and levels of a hormone called AMH, which is thought to indicate egg reserve, increased tenfold.

She restarted IVF, but didn't make progress and didn't have any embryos implanted. Six months later, she returned to Athens for a second treatment. "This time I could feel the difference," she says. "I could see it in my looks, and I felt younger." Within a few months, Aisha conceived her daughter without IVF.

*Not her real name

Health

Vaccine for major common cold virus could be in use by 2024

Alice Klein

A VACCINE that protects against one of the main common cold viruses has been shown to be safe and effective in a clinical trial and could be available by 2024.

Respiratory syncytial virus (RSV) is so contagious that more than 90 per cent of people have experienced their first infection by the age of 2. It usually causes cold symptoms but can lead to severe illness in young children and older people. Globally, around 60,000 children under the age of 5 and 14,000 people over the age of 65 die each year after contracting the virus.

Developing vaccines against RSV and other respiratory viruses has been challenging because the respiratory tract, which includes the nostrils and throat, is a surface exposed to the external rather than internal environment, says Kirsten Spann at the Queensland University of Technology in Australia, who wasn't involved in the clinical trial.

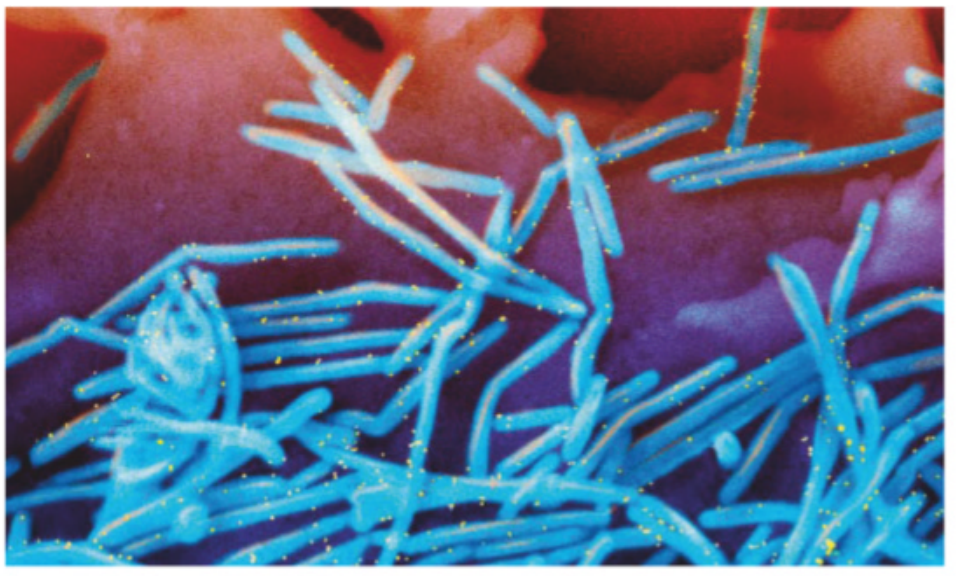
"It's harder for antiviral antibodies in the blood to reach viruses in the respiratory tract, or even know they are there, because there is some physical separation," she says.

This also explains why we can get RSV and other cold viruses over and over again, says Spann.

In recent years, however, there has been rapid progress in finding new ways to boost immunity against respiratory viruses.

Several RSV vaccines are being tested in clinical trials, including one made by German company Bavarian Nordic. Its vaccine is designed to build immunity against RSV by exposing the body to five small fragments of the virus.

Respiratory syncytial virus particles (blue) in human lung cells



NATIONAL INSTITUTE OF ALLERGY AND INFECTIOUS DISEASES/SPL

In a clinical trial involving 420 adults aged 55 and older, a single injection of the vaccine in the upper arm tripled the levels of RSV-fighting antibodies inside the nose and caused no serious side effects.

This immune response lasted for six months – enough to cover a winter cold season – and was restored with a booster shot at 12 months (*The Journal of Infectious Diseases*, doi.org/d556).

The results are promising, but more research is needed to see if the immune response is strong enough to prevent RSV infections, says Spann.

Bavarian Nordic is now planning a bigger clinical trial of its RSV vaccine that is scheduled to begin in 2021 and will involve more than 12,000 adults. If the results are positive, the company hopes to make the vaccine available by 2024. The firm plans to offer the vaccine to children too, but not until it has passed clinical trials involving people in this age range.

Vaccines for other cold viruses are also in development. US company Moderna, one of the leading covid-19 vaccine developers, is working on a vaccine to protect children against human metapneumovirus and parainfluenza viruses.

It is worth vaccinating against as many cold viruses as possible because infections in early life can increase the risk of developing asthma, says Spann. ▮

Archaeology

Poison arrows may have been loosed 70,000 years ago

HUNTER-GATHERERS in Africa may have been using poison-tipped arrows for more than 70,000 years, according to a recent analysis.

This would be the oldest known use of poison arrows in the world, says Marlize Lombard at the University of Johannesburg in South Africa.

In southern Africa, Kalahari San people use poison-tipped arrows to hunt. They often obtain poisons from the intestines of the larvae of *Diamphidia* leaf beetles. It isn't clear when this practice started.

"Direct evidence of truly ancient poisoned-arrow use in the Old World is sparse," says Lombard.

Most of the accepted archaeological evidence comes from the past 8000 years. However, there are hints that southern African peoples used poison arrows long before this point. In April, Lombard's team published a study of a 60,000-year-old bone point. This concluded it was an arrowhead and was coated in a sticky liquid, which may originally have been poison.

In search of more evidence, Lombard has compiled data from 128 known examples, all collected from southern Africa within the past 150 years. She measured the cross-section area of the tip of each arrowhead, which gives an indication of how sharp it is.

She found that poison-tipped arrowheads are distinctive: they are sharp enough to cut, but not sharp enough to go deep, because they only need to get in far enough for the poison to enter the bloodstream.

"Poison-tipped arrowheads are distinctive: sharp enough to cut but not sharp enough to go deep"

Lombard then compiled data from 306 similar bone points from archaeological digs, dated from the past 40,000 years. Many had the same tip cross-sectional area as the modern poisoned arrowheads and may have been used the same way (*Journal of Archaeological Science: Reports*, doi.org/d53k).

She also examined 11 older bone points, up to 80,000 years old. Eight fit the profile of poison-tipped arrowheads, so poison arrows could have a long prehistory. ▮

Michael Marshall

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Climate change

A warning cry from the Arctic

As records tumble, 2020 has already been a terrifyingly bad year for the Arctic – and there is more to come, **Adam Vaughan** reports

"THE conditions we've seen in the Arctic this year have been truly remarkable, and not in a good way," says Michael Meredith, a polar researcher at the British Antarctic Survey.

Even for a region that has warmed twice as fast as the rest of the planet, this year's Arctic fires and ice melt have been extraordinary. The first half of 2020 has seen temperature records tumble in one of the coldest places on Earth.

The symbolic milestone of 100°F was passed in the Siberian town of Verkhoyansk in June, on the way to a record high of 38°C. Longyearbyen in the Norwegian archipelago of Svalbard in the Arctic Ocean hit an all-time high of 21.7°C in July, hotter than Oslo that day. The Svalbard Global Seed Vault, where thousands of crop seeds are stored, was built in this location thanks to its supposedly cool climate.

It hasn't just been hot, but hot for an extended period. The Arctic circle was around 8°C above average for the first half of the year, and 10°C above average in June. Although this has been driven by a natural variation in the weather-affecting jet stream that travels high above the North Atlantic, it would also have been almost impossible without the greenhouse gases we have pumped into the atmosphere. Siberia's heatwave is thought to have been made at least 600 times more likely by climate change. "I think 2020 is a clear window into what is to come," says Meredith.

KJEKOL/GETTY IMAGES/ISTOCKPHOTO

Colourful houses in summer at Longyearbyen in Svalbard, Norway

38°C

Record Arctic temperature, recorded this June

600

Climate change made the Siberian heatwave at least this many times more likely

18

Arctic CO_2 emissions haven't been as high for this many years

Unfrozen north

One big effect has been drastically shrinking sea ice, which polar bears rely on to hunt their prey. Meanwhile, satellite images have brought a daily reminder of fires blazing in northern forests and underground peat, resulting in the region releasing the most carbon dioxide in 18 years. And Russia's worst oil spill in modern times, which began near Norilsk in the Arctic on 29 May, seems to have been due to a container collapsing as the permafrost it sat on thawed in the heat.

The simultaneous nature of these events has researchers worried. Last year saw record fires, while sea ice loss was bad but not unprecedented. This year is different. "It's the confluence of all of them. Each of these as individual events and phenomena are exceptional in their own right," says Carly Phillips at the University of British Columbia in Canada. "The fact they're all occurring simultaneously should raise alarms."

Arctic sea ice, which melts in summer and usually reaches its minimum extent in September before beginning to refreeze, has been on a sharp decline for decades. The 14 smallest extents have occurred in the past 14 years, says Walt Meier at the US National Snow and Ice Data Center (NSIDC).

The melt started unusually early this year. As of 6 August, the ice covered 5.8 million square kilometres, 27 per cent less than the 1980-2010 average. At this rate, 2020 could break the 2012 record for the lowest area of ice ever seen.

Julienne Stroeve, also at the NSIDC, was in the Arctic from December 2019 to March 2020 aboard a ship deliberately stuck in an ice floe to study the region. "The thing that surprised me the most was how dynamic the ice pack was. It was very mobile," she says. "That's probably a result of thinner ice overall."

That thinness is partly due to a weather phenomenon called the

Arctic oscillation, which is strongly positive this year, causing sea ice to drift towards the North Pole. That motion away from the coast of Siberia leads to thinner ice forming. Siberia's heat provides extra stress. Geographically, the ice loss has been uneven this year, with large areas of open water in the Laptev and Barents seas, but ice above north Alaska at average levels.

Fire alarm

On land, this year's Arctic fires have already been more severe than those in 2019, spewing more carbon into the atmosphere in July alone than the 50 megatonnes released in the whole of 2019 – and last year was a record-breaker.

"In July, we saw a real step change," says Mark Parrington at the European Centre for Medium-Range Weather Forecasts in the UK, who has been tracking the blazes by satellite since isolated ones broke out unusually early at the start of May. They have since merged into bigger conflagrations in the Russian republic of Sakha, over a wider area than last year (see map, right).

Millions of hectares of native vegetation have burned in this part of Siberia, releasing carbon and vast quantities of smoke. Firefighting in such a large and remote area is tough. Russian authorities have even tried to bring rainfall by seeding clouds. The hot, dry conditions in Siberia have made trees and vegetation more vulnerable to fire, but the problem goes deeper.

"Not only is the surface layer of fuels drier, now we've got receding permafrost. The deeper soil layers used to be protected by cold, frozen, wet conditions. Now that permafrost is no longer there, allowing fires to penetrate deeper," says Merritt Turetsky at the University of Colorado Boulder. How far down they go is poorly understood.

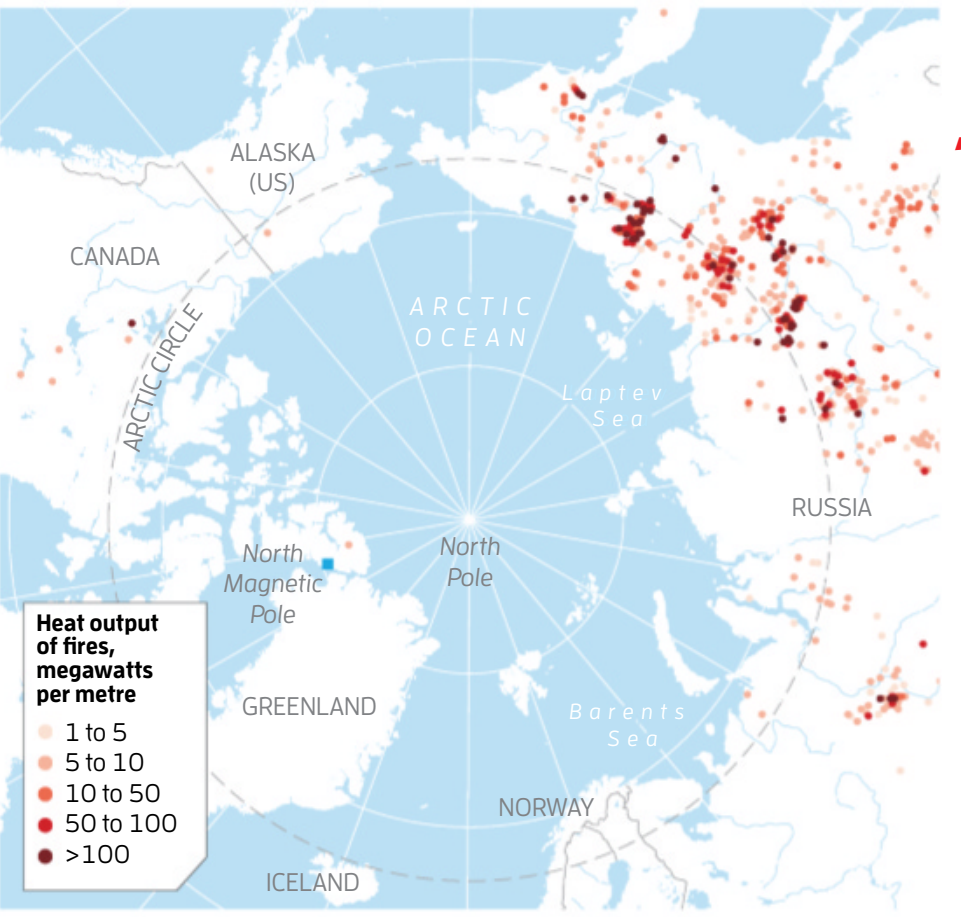
Some of those underground fires might even have been smouldering since last summer, leading them to be dubbed "zombie" fires. Researchers are still divided on how clear-cut the evidence is for such fires. But if field trips and satellite images confirm their existence, that raises the disturbing prospect of a short-term feedback loop where each bad fire year will add to the next one. "If what we speculated about zombie fires is true, then that is an ignition source that will most likely come into play next year," says Parrington.

The smoke from the Russian fires is moving across Alaska, Canada and could eventually reach Greenland, says Parrington. One main pollutant it contains is carbon monoxide, which can stay in the atmosphere for about a month. For the 4 million people living in the Arctic, the effect of the smoke will be one of the most immediate impacts, says Phillips. The air pollution from the fires could even exacerbate respiratory problems in Russia, one of the countries worst hit by covid-19, which attacks the lungs.

YEVGENY SOFRONEYEV/TASS/GETTY IMAGES

Controlled burns in Sakha, Russia, aim to reduce the risk of fires

Fires around the Arctic 1-28 July 2020



SOURCE: COPERNICUS ATMOSPHERE MONITORING SERVICE

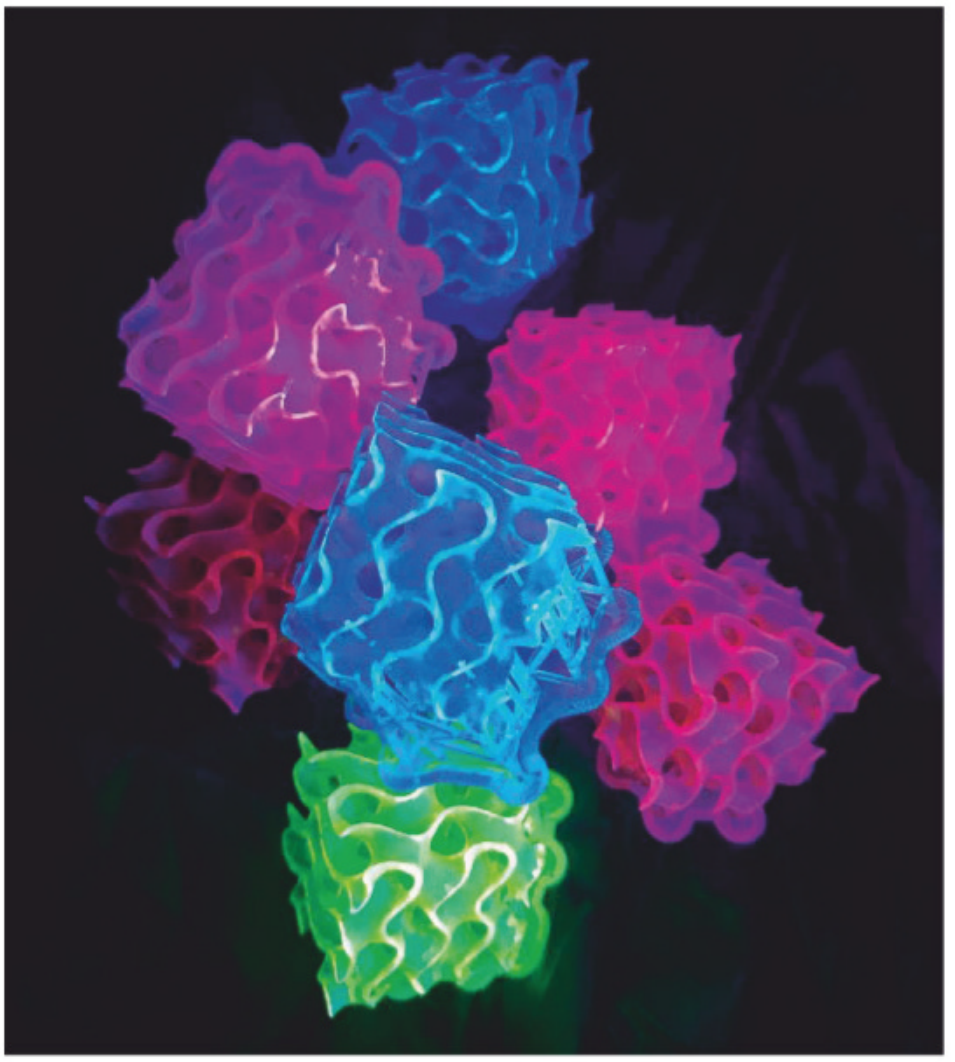
Not all of the Arctic has been sweltering: Alaska and north-west Canada have been unusually wet and cold this year, and a recent study by Turetsky and her colleagues confirmed that Alaska is getting wetter during summers. But in general, 2020 is a disaster year for the Arctic, the fallout from which will be global and play out over the long term.

Warming already appears to have turned the region from a carbon sink to a source of it (see page 38), and the burning of previously protected carbon underground will only accelerate climate change. The alteration in albedo – how much sunlight is reflected back into space – from bright ice turning into dark open water has the same feedback effect.

Climate models have long predicted dramatic shifts in the Arctic, but these are arriving sooner than expected. "To see an individual extreme year of the sort we have, and so soon, is very concerning," says Meredith. "It's as though some of our worst predictions for the future are being played out in front of our eyes."

"Each of these events is exceptional. That they are occurring simultaneously should raise alarms"

There is still time to act, says Turetsky. "To me, this is a warning, a cry from the Arctic. This is our early beacon sign of what's to come in terms of rapid climate change around the world. We can still stave off the worst consequences of climate change, but our window to do that is small." ▮



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Technology

Bright fluorescent materials 3D printed in any shape

FLUORESCENT materials have been created using a new technique, and they can be 3D printed in any shape you want. It may lead to solar panels that are more efficient.

Some 100,000 different dyes are able to fluoresce – or glow under ultraviolet light – because individual molecules in solution are physically distant from each other, says Amar Flood at Indiana University. "But in solids, the particles are closer together and so interfere with each other, which stops them behaving as individuals."

Flood says this means materials made using fluorescent dyes, such as fibres for textiles, aren't as fluorescent as the starting solution, which has been a recognised problem in chemistry for 150 years.

His team has now tried mixing doughnut-shaped molecules called cyanostars with the dyes. The cyanostars are able to hold the positively charged dye molecules apart from each other so they maintain their fluorescent properties, even when they are in a solid state. Brighter individual fluorescent materials exist, but the team's methods promise to make it easier to make fluorescent solids from a large range of dyes.

The technique can be used with any positively charged dye and in conjunction with 3D printing to make solids that glow (*Chem*, doi.org/d56j).

Fluorescent material could improve the efficiency of solar panels by letting them convert infrared rays or low-frequency visible light from the sun into a form that can be captured by solar cells. **Jason Arunn Murugesu**

Life

Zombie microbes extend the limits of life

DEEP-sea microbes can survive on less energy than previously thought necessary for any living thing, potentially changing the definition of life as we know it.

James Bradley at Queen Mary University of London and his colleagues used data from sediment samples collected from beneath the sea floor to determine the rate of energy use by the microorganisms that live there.

Using a model that considered various aspects of the habitat, including the rate at which organic carbon is degraded, the availability of oxygen and the number of microorganisms, Bradley and his team calculated the rate of energy use per microbial cell. The value was 100 times lower than that previously thought to be the limit for life. A few cells survived on less than 10^{-21} watts of power (*Science Advances*, doi.org/d56f).

Previous estimates for the lower energy limit for life have involved growing microorganisms in the lab and starving them of nutrients to determine the limit for survival. But Bradley says these experiments don't fully represent the range of environments that microbes inhabit in the real world, including beneath the sea floor.

Because of their extremely low rate of energy consumption, the microbes – mainly bacteria and archaea – can survive buried for millions of years. "That increases the possibility of places which we can go to search for life on other planets," says Bradley, such as on Mars.

"I don't think that we have a good understanding yet of the mechanisms by which they survive in this incredibly low-energy state for millions of years," says Bradley. "Possibly it's something to do with their ability to reduce their metabolic rate... and to enter into a kind of zombie-like state." **Layal Liverpool**

Solar system

Dirty snowballs cause Jupiter's odd lightning

THE JUNO spacecraft has spotted lightning on Jupiter unlike anything we have seen before, and it may be caused by strange slushy balls of ice and ammonia.

Planetary scientists have long thought that Jupiter's lightning happens in much the same way as Earth's: through liquid water and ice interacting within clouds and building up electric charge. That was supported by seeing lightning coming from a layer of water clouds beneath the cloud tops that we see as Jupiter's "surface".

NASA/JPL-CALTECH/SWRI/MSSS/KEVIN M. GILL

But now, NASA's Juno spacecraft has spotted lightning much higher in the planet's atmosphere, where it is too cold for liquid water. "It's very different from anything that happens on Earth," says Heidi Becker at NASA's Jet Propulsion Laboratory in California, a member of the Juno team.

The team found that this strange lightning could be caused by liquid ammonia acting as an antifreeze. That would create "mushballs" of a slushy ammonia-water mixture surrounded by water ice. The high-altitude lightning could occur when these mushballs collide with ice particles and build up electric charge (*Nature*, doi.org/d55s).

The balls could then drop into Jupiter's interior, explaining why the interior doesn't have as much ammonia gas as we expected. The missing ammonia may be hiding in mushballs. **Leah Crane**

Really brief

SPACEX

Starship blasts off in first test flight

It may look like a water tower, but SpaceX's Starship can fly. The rocket is about 50 metres tall and 9 metres in diameter and is designed to send explorers to the moon, and eventually to Mars. It made its first test flight on 4 August, reaching about 150 metres into the air.

Microcracks dull razor blades

Why do razors go blunt so quickly? Scans with electron microscopes have now revealed that blades have tiny chips in their edges as a result of the process that hardens the steel. When hairs meet the blade at a point where there is a crack, the crack grows, dulling the blade (*Science*, DOI: 10.1126/science.aba9490).

Sun's magnetic field mapped

We now have the first map of the magnetic field of the outer layer of the sun, the corona, to help predict solar flares that could threaten Earth. The field strength is between 1 and 4 gauss, which is more than 10 times weaker than a typical refrigerator magnet (*Science*, DOI: 10.1126/science.abb4462).

Palaeontology

Long-necked reptile was a marine hunter

A BAFFLING extinct animal was actually a marine reptile that may have used its extremely long neck to ambush prey.

Fossils of *Tanystropheus* were identified more than 100 years ago, but the animal's true nature has long been a mystery. It lived around 242 million years ago, in the Triassic period when the first dinosaurs were emerging.

Tanystropheus was a reptile. Its most striking feature was its neck, which was three times the length of its body. Fossil remains of it fall into two groups: large specimens up to 6 metres long and small ones of up to 1.5 metres. But questions remained.

"Is it terrestrial or is it marine? Are those juveniles and adults, or are they two different species?" says Olivier Rieppel at the Field Museum of Natural History in Chicago.

His team re-examined a broken skull from a large specimen and was able to CT scan the individual bones and digitally reposition them to reconstruct the skull, revealing crucial details.

The skull is unmistakably that of a marine animal, says Rieppel. For instance, its nostrils are on the top of the snout, to allow it to breathe when it surfaced (*Current Biology*, doi.org/d55t).

Meanwhile, the bones of the small specimens showed multiple growth rings, indicating they belonged to adults, not juveniles. This means the large and small fossils are actually different species, says Rieppel.

The two species were probably able to coexist because they ate different foods. **Michael Marshall**

Environment

CONNIE KERR/GETTY IMAGES

Humans help disease-carrying animals thrive

WE ARE changing the world in a way that favours animals that carry more diseases. This includes bats, the source of the coronavirus.

"Some species are doing better and they are disproportionately likely to be those that transmit diseases to people," says Rory Gibb at University College London.

His team used data from a global project looking at how ecosystems change in disturbed areas, such as land cleared for farming, compared with undisturbed areas nearby.

Combining these findings with data on what diseases animals carry, and whether they can infect people, the team discovered that small, fast-lived animals such as rodents, songbirds and bats tend to become more abundant after people move in. These animals also carry more diseases compared with larger, longer-lived species that have declined or disappeared (*Nature*, doi.org/gg66c6).

One explanation for why short-lived animals harbour more diseases is that they invest more in reproducing at the cost of immune defences, making them more vulnerable to pathogens, says Gibb.

A flip side of this could be that disease risk might be cut if ecosystems are restored.
Michael Le Page

Learning

In-ear gadget aids language learning

A DEVICE that stimulates a nerve leading to the brain can help you learn unfamiliar sounds in a new language.

Vagus nerve stimulation has been used for more than 20 years to treat conditions like epilepsy, but it usually involves surgery to implant electrodes by the nerve in the neck. Matthew Leonard at the University of California, San Francisco, and his colleagues have developed an earbud-like electrode that can stimulate part of the vagus nerve without the need for an implant.

His team tested the in-ear device in 36 English-speaking people, stimulating their nerves imperceptibly sometimes while they tried to identify sounds in Mandarin – a language they didn't know. Twelve of the volunteers didn't receive any stimulation.

Synchronising stimulation with hearing speech sounds seemed to enhance learning (*Science of Learning*, doi.org/d55v). "Just a small amount of stimulation over a very short time period gave us a relatively large bump in learning," says Leonard.

Although only tested with tones from Mandarin, Leonard says the approach could be applied to any language. **LL**

New Scientist
Newsletter

Launchpad

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Leah Crane

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Views

Comment

Protecting genetic data

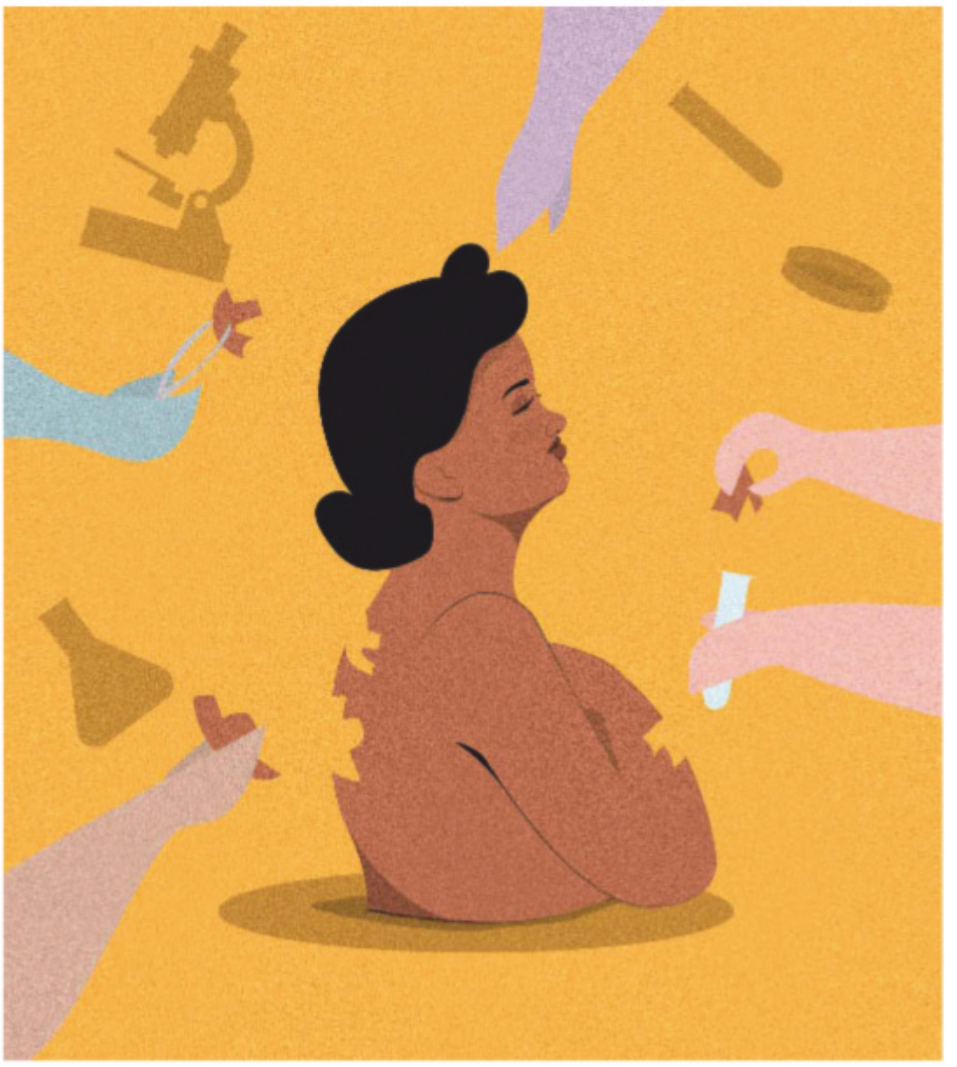
Henrietta Lacks's cells were used for research without her consent. We still have much to learn from her story, says **Maninder Ahluwalia**

THIS month is the 100th anniversary of the birth of Henrietta Lacks, commonly referred to as "the mother of modern medicine". Her cells have been used in experiments in laboratories around the world but were cultivated without her consent. Eventually, her story led to the rewriting of the rules around ethics in healthcare. As the dawn of an era of personalised medicine begins, the lessons from her story are more important than ever.

Lacks, an African American tobacco farmer from Virginia, was diagnosed with an aggressive form of cervical cancer in 1951. Her doctor at Johns Hopkins Hospital in Maryland obtained a biopsy from her cervix for diagnosis and treatment. A small part of her tissue was taken to the tissue culture laboratory without Lacks's knowledge or consent – a common practice at the time.

Nobody had yet been able to keep human cells alive for a long period of time outside the body. However, George Gey, who was head of the tissue culture laboratory, found that Lacks's cells survived and replicated. Nearly seven decades later, these so-called HeLa cells have now lived more than twice as long outside Lacks's body than inside.

Lacks died a few months after her cancer diagnosis, but her cells continue to be used for research. They have been vital to studying diseases, including covid-19, as well as for developing vaccines and IVF, to name a few examples. They have also become the foundation of a multibillion-dollar industry. There are more than 17,000 patents involving HeLa cells.



MICHELLE D'URBANO

Gey supplied the cells to scientists nationally and internationally without making a profit himself, though he gave no credit to Lacks. Her family weren't even aware of the existence of the cells until 1973, when researchers at Johns Hopkins approached her children for blood samples to learn more about the HeLa cells.

Their mother's cells had become a major boon to medical science and Lacks and her family didn't receive any compensation or recognition. Lacks's story came to wider public attention in 2010 with the publishing of Rebecca Skloot's book *The Immortal Life of Henrietta Lacks*.

However, the controversy didn't end there. In 2013, the European Molecular Biology Laboratory in Heidelberg, Germany, published the HeLa genome without the consent of the Lacks family, which could have revealed private genetic information about her descendants.

Eventually, a compromise was reached called the HeLa Genome Data Use agreement. Now, two members of the Lacks family sit on the US National Institutes of Health working group that grants permission to access HeLa sequence information.

This sort of agreement should be a blueprint for other genetic data. We are moving towards personalised medicine becoming the norm, in which treatments are tailored to people's genetics. This approach has the potential to greatly improve how we treat disease, but it also relies on researchers having access to large amounts of genetic data from different samples. With that come issues around privacy and consent, for both the individual and their family. In every case, there needs to be communication and transparency between researchers and donors.

Lacks's compelling case was a turning point in the field of bioethics. Most countries now have specific rules and laws around informed consent and privacy to help protect patients. That is a testament to the many ways in which Lacks has transformed modern medicine.

Maninder Ahluwalia is a lecturer in biomedical sciences at Cardiff Metropolitan University, UK

Field notes from space-time

What does dark matter even do? Understanding what this baffling substance gets up to may help us to finally understand it, writes **Chanda Prescod-Weinstein**

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

Chanda's week

What I'm reading
I'm usually critical of books that I call "Jane Austen fanfic", but I think Molly Greeley's The Clergyman's Wife *is a great look at Charlotte Lucas in the years after* Pride and Prejudice. *I am learning a lot.*

What I'm watching
Like everyone else who is cool, I'm catching Star Trek: Lower Decks.

What I'm working on
Learning new computation techniques to make it easier to compare simulations of dark matter with observational data.

This column appears monthly. Up next week: Graham Lawton

WHAT'S the matter with dark matter? Its name, for one thing.

Dark matter is so-called because of the idea that it is like being in a room without a light on. But actually, we know the universe is filled with light even with lots of dark matter in it. We see evidence of this very often – directly from the sun during the day and reflecting off the moon at night. On a clear night we can see stars too. With sensitive instruments, we can also detect the cosmic microwave background radiation that pervades all of space-time.

The universe isn't like a room without a light on. It is much more like a giant room with billions of lights spread out all over the place.

Light goes right through dark matter – it is transparent. So transparent matter or clear matter would be a better name. However, we are in the dark about what exactly dark matter is.

We know it interacts with gravity just like the matter we can see (like people and planets) and we know it moves slowly. What we don't know is how to write down an equation that describes its quantum nature and therefore its relationship (or lack thereof) with the standard model of particle physics. Knowing so little about dark matter is a fairly strange predicament because we have been able to work out that it comprises most of the matter in the universe. Normal matter only makes up about 20 per cent.

The fact that we know dark matter exists is a lovely detective story, one I have touched on in a previous column (18 May 2019, p26). The first compelling evidence for dark matter came from Vera Rubin using a device made by Kent Ford. She measured the speeds of stars as they rotated around the centres of their home galaxies. Using these speeds, she calculated how massive the stars are. Adding up all of those masses, she was able to get a total mass for the galaxy. This was greater than the mass calculated using the amount of light the stars radiate. This discrepancy indicated the presence of matter that we couldn't see, something which had been hypothesised for a century.

There is now extensive evidence from other observations that there is a lot of this subluminal matter, as Nobel Laureate Jim Peebles calls it in his new book, *Cosmology's Century: An inside history of our modern understanding of the universe*.

These observations include strong gravitational lensing,

"Knowing so little about dark matter is a strange predicament because we have worked out that it comprises most of the matter in the universe"

in which dark matter between us and a distant galaxy is so massive that it bends space-time and makes it act like a funhouse mirror, warping the galaxy's light. It is incredibly difficult to explain such observations with alternative models. Dark matter, despite the mystery over what it actually is, is the simplest explanation we have.

It is easy to think this mystery is merely one of fundamentals: what particle is it made of? But not knowing this has a domino effect on other areas of astrophysics too.

For example, my recent work has focused heavily on trying to understand how large galaxies form, how their satellite galaxies form and the relationship of central galaxies and their satellites to dark matter halos – giant collections of dark matter – which envelop them. This turns out to be difficult to understand, partly because we can't see dark matter, but also because we don't know what details to put into our computers to help us simulate how galaxies and their halos form.

In my column of May 2019, I also wrote that my preferred dark matter candidate is the axion, a hypothetical particle that helps solve a problem in the standard model of particle physics, and I promise I haven't abandoned it.

Instead, I have thrown myself into the question of how the relationship between galaxies and their halos evolve if dark matter is made out of axions. Of particular interest is the unusual behaviour that axions seem to display.

There is good reason to believe that, unlike many other dark matter candidates, axions can go into exotic quantum states known as Bose-Einstein condensates. In this state, all of the particles act as one, creating a macroscopic quantum wave. This trait of axions would lead to different galactic centres than ones expected from other dark matter candidates.

Questions about axion Bose-Einstein condensates remain. For example, how the condensate state forms depends on what forces are at work. In a paper I am working on, my colleagues and I calculated the timescale for condensate formation depending on such factors.

We found that if we ignore gravity, it takes 10 million times longer! We now feel confident that gravity plays an important role in getting axions into this condensate state, which will help us model the evolution of galaxy halos made out of these particles. These models can be compared with data, and if they match, this will mean that studying what dark matter does can provide a hint about what dark matter is. ▮

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The hidden dark matter of our food, NASA's new search for life on Mars and smallpox in the American civil war

Episode 25
Coronavirus effects on children, and on other diseases, changing the way you sit could add years to your life and supercrops for a climate-changed world

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Editor's pick

Observations on the call for covid-19 slimming

25 July, p 16

From Jackie Jones, Brighton, East Sussex, UK

Over the past nine months, I have had major surgery and proton beam therapy. I have also lost 17 per cent of my body weight. I am pleased about this, as it h as taken me from an overweight BMI into the normal range. I have been trying to achieve this for years with no luck, given the difficulties stated in your article on reducing weight – recommended to mitigate the risks of covid-19.

This time it was easy: I had no interest in food. There was no revulsion or dislike, but I found eating as interesting as watching paint dry. I mentioned this to my dietitian who commented that this is common after trauma and prescribed me supplements to mix with milk, which I dutifully took. I am now back to near normal eating.

If this is so common and there was no physical reason for me not to eat, it seems that it must be something to do with brain connections linked to the feeling of hunger and interest in eating. Could this be explored to help the fight against obesity?

From John Davnall, Manchester, UK

In answering the question "Why are we getting heavier", one possible answer was missed. We expend energy just to maintain our body temperature. In the UK, this is usually to keep warm. With improvements in home heating, this demand on our bodies' energy consumption has been reduced.

Have the habits of how much we eat kept pace with the need to eat less because of this?

Why a second wave of coronavirus might be dire

Letters, 18 July

From Gerben Wierda, Heerlen, The Netherlands

Christine Duffill argues that a second wave of coronavirus might not be as bad as the first. Not because people that have fought it off will be immune, but because they have fought it off easily the first time, so will do so again.

Sadly, this isn't at all certain. When people get infected with very little virus, they normally don't get seriously ill and may not get ill at all. This is probably due to the fact that as soon as a virus enters the body, the race is on between the growth of the pathogen and the growth of the immune reaction. If someone is infected with very few virus particles, the immune system is likely to get ahead in that race.

A second infection won't automatically be fought off as easily. It will depend on how much virus a person is exposed to. If it is a lot, the immune system will be overwhelmed, possibly allowing exponential growth of the virus.

Shout about it: ways to combat superspreading

8 August, p 10

From Iain Murdoch, Marton, Warwickshire, UK

You list people being indoors and in close proximity as factors in coronavirus "superspreading" events. A further factor is another typical behaviour at social events: the raising of voices at close quarters to make yourself heard.

To stay safe, as the noise of conversation rises in a room, leave, and certainly don't go near the life and soul of the party.

It may be worth thinking about limiting numbers, as when fewer people gather, say up to four or five, conversation can be carried out in quiet tones and from a distance of more than 1 metre.

Background music can add to the problem. Perhaps social events could be limited to 60 decibels, including music.

Don't forget those who oppose nuclear power

25 July, p 42

From Geoff Russell, Adelaide, South Australia

Adam Vaughan's interview with Friederike Otto discusses climate change litigation. Obvious targets are coal companies, but other people have suggested that those in the litigation cross hairs might include a variety of environmental groups, specifically those opposed to nuclear power.

I suggest we would still have a climate problem if nuclear power had taken off earlier, but it would be much smaller and we would have better tools to fight it. We would also be better placed to tackle the other big climate and environment vandal, which is usually dismissed with a nervous, embarrassed laugh: the meat industry. We would have cleaner air and less mining too.

So, yes, roll out the lawyers if they can help, but don't forget to include a myriad of green groups and parties on the charge sheet.

Aliens may favour other megaprojects

18 July, p 15

From Chris Eve, Lynton, Devon, UK

You report that searching for "Star Tugs", machines capable of moving a sun, could be a new way to find alien civilisations. Given the low likelihood of having to dodge a supernova, the example given for ET doing this, perhaps we would do better to seek signs of other, similar technologies.

For example, civilisations may have developed the means to move a sister planet's orbit into the habitable zone or to change the orbit of their own world to avoid a star's expansion.

Such projects could involve a cascade of planned changes to the movement of a series of objects of increasing mass, set in train by an initial nudge. These could use gravity, impacts and vast motors.

In the same vein, intense electromagnetic fields generated by a spinning magnetic object have interesting possibilities for planetary-scale engineering. They could attract, repel, change the spin axis or alter the day length of an iron-rich planet.

AI probably won't save us from ourselves

18 July, p 34

From John Hastings, Whittlesey, Cambridgeshire, UK

Max Tegmark says "we can use [AI] to solve the climate crisis, to lift everybody from poverty".

We already know how to deal with the climate crisis and how to lift everybody from poverty. What we lack is the collective personal, national and international will to do it. This is due to human greed, short-termism and selfishness.

Will AI really solve these problems of human nature? Personally, I doubt it.

Calling foul on new theory for demise of pirate ship

11 July, p 17

From John Stawpert, London, UK

It is suggested that the pirate Blackbeard may have crashed his ship on purpose. Rather than being used for plugging holes, isn't it more likely that the lead sheets on the Queen Anne's Revenge were antifouling sheathing?

This use of lead to repel barnacles and so on had already been developed, and marine growth on hulls is a perennial problem in the region where Blackbeard operated the ship and on its routes prior to this.

Reducing drag from growth through the use of such a system would significantly speed up a ship, an obvious benefit to pirates attacking merchant ships and avoiding the Royal Navy.

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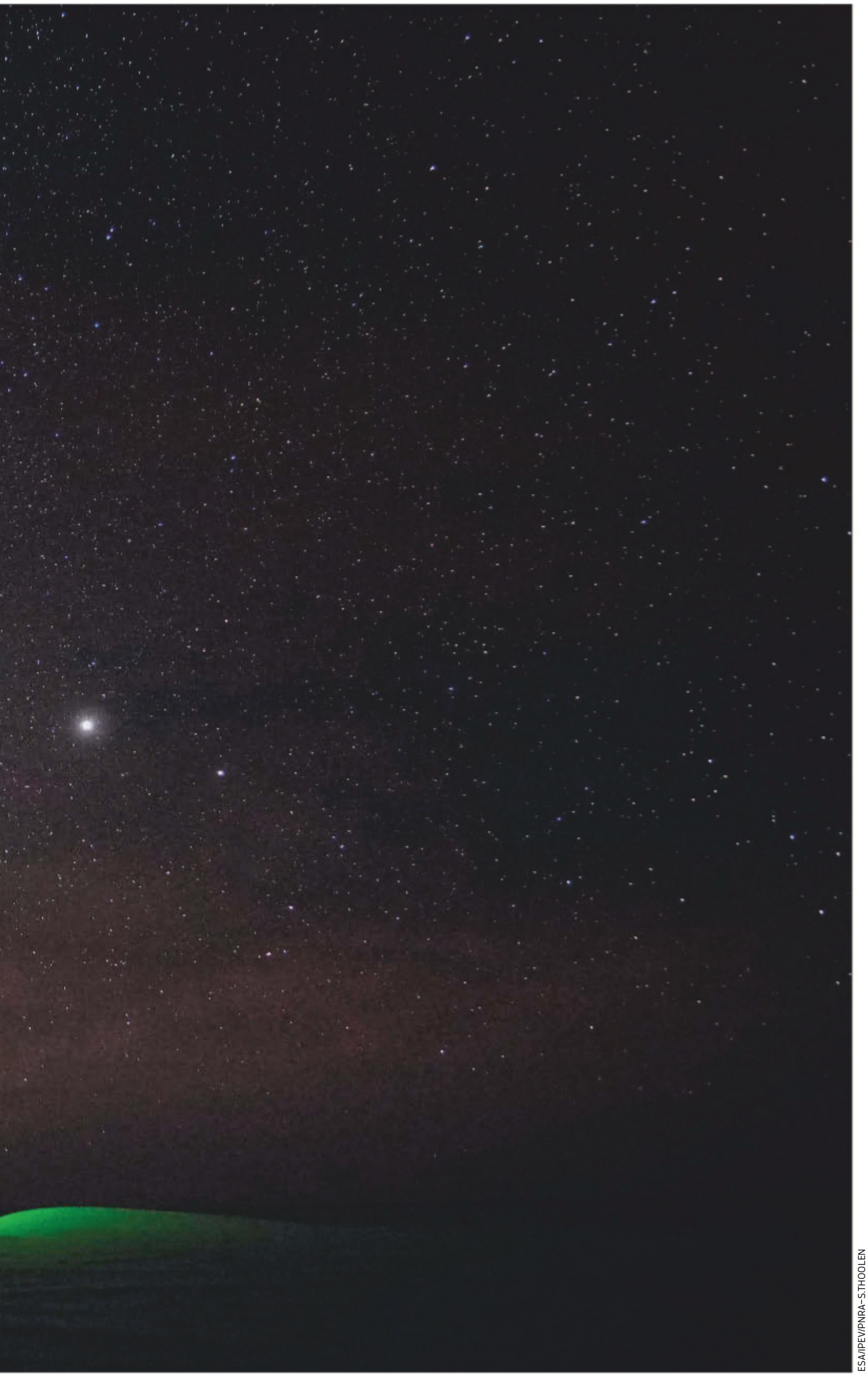


ESA/IPEV/PNRA–S.THOOLEN

Green lantern

Photo European Space Agency

PIERCING through the winter sky, this green light looks like part of a dazzling natural phenomenon. In fact, the strikingly clear single beam is from a laser fired at the European Space Agency's research station in Antarctica to probe atmospheric conditions, including the impact of pollutants.

The pulsed laser is part of the Concordia station's Light Detection and Ranging (LIDAR) instruments, and it is emitted for 60 seconds every 5 minutes during winter there. LIDAR works like radar, but uses reflected light rather than radio waves to sense. Researchers at what is the world's most remote research station use it to probe our atmosphere's boundary layer, which extends from the ground to around 1 kilometre up.

The instrument directs the laser within this section and uses scattered light to measure the likes of temperature, cloud formation and aerosol particles.

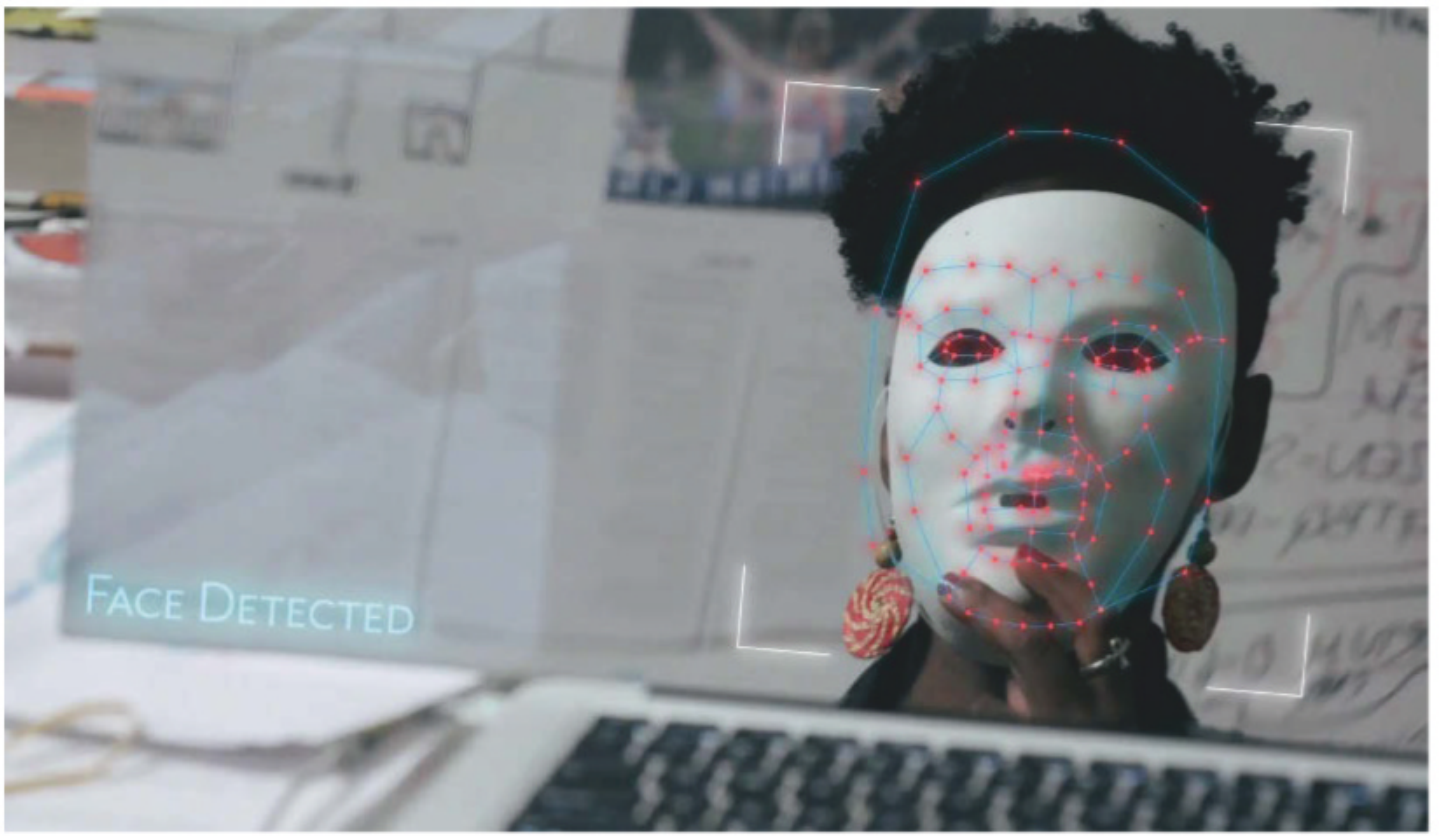
While greenhouse gases warm the planet, chlorofluorocarbons – long-lived chemicals that came from sources such as spray cans – degrade the ozone layer, which helps protect the surface from UV radiation. Both effects, mostly human created, influence the atmospheric boundary layer and contribute to climate change at the surface. The conditions in Antarctica make the boundary layer easier to study.

ESA released this picture as its human space flight and robotic explorations image of the week.

Gege Li

Bias in the machines

Computers are worse at recognising women and people of colour than white men, and algorithmic bias doesn't stop there, finds **Vijaysree Venkatraman**



7TH EMPIRE MEDIA

Face-recognition AI could only "see" Joy Buolamwini when she wore a white mask

Film

Coded Bias

Shalini Kantayya

Ongoing film festival screenings

IN HER first semester as a graduate student at the MIT Media Lab, Joy Buolamwini encountered a peculiar problem. Commercial face-recognition software, which detected her light-skinned classmates just fine, couldn't "see" her face. Until, that is, she donned a white plastic mask in frustration.

Coded Bias is a timely, thought-provoking documentary from director Shalini Kantayya. It follows Buolamwini's journey to uncover racial and sexist bias in face-recognition software and other artificial intelligence systems. Such technology is increasingly used to make important decisions, but many of the algorithms are a black box.

"I hope this will be a kind of *Inconvenient Truth* of algorithmic justice, a film that explains the science and ethics around an issue of critical importance to the future of humanity," Kantayya told *New Scientist*.

The documentary, which premiered at the Sundance Film Festival earlier this year, sees a band of articulate scientists, scholars and authors do most of the talking. This cast primarily consists of women of colour, which is fitting because studies, including those by Buolamwini, reveal that face-recognition systems have much lower accuracy rates when identifying female and darker-skinned faces compared with white, male faces.

Recently, there has been a backlash against face recognition. IBM, Amazon and Microsoft have all halted or restricted sales of their technology. US cities, notably Boston and San Francisco, have banned government use of face recognition, recognising problems of racial bias.

People seem to have different experiences with the technology. The documentary shows a bemused pedestrian in London being fined for partially covering his face while passing a police surveillance van. On the streets of Hangzhou, China, we meet a skateboarder who says she appreciates face recognition's convenience as it is used to grant her entry to train stations and her residential complex.

"If an AI suspects you are a gambler, you could be presented with ads for discount fares to Las Vegas"

The film also explores how decision-making algorithms can be susceptible to bias. In 2014, for example, Amazon developed an experimental tool for screening job applications for technology roles. The tool, which wasn't designed to be sexist, discounted résumés that mentioned women's colleges or groups, picking up on the gender imbalance in résumés submitted to the company. The tool was never used to evaluate actual job candidates.

AI systems can also build up a picture of people as they browse the internet, as the documentary investigates. They can suss out things we don't disclose, says Zeynep Tufekci at the University of North Carolina at Chapel Hill in the film. Individuals can then be targeted by online advertisers. For instance, if an AI system suspects you are a compulsive gambler, you could be presented with discount fares to Las Vegas, she says.

In the European Union, the General Data Protection Regulation goes some way to giving people better control over their personal data, but there is no equivalent regulation in the US.

"Data protection is the unfinished work of the civil rights movement," said Kantayya. The film argues that society should hold the makers of AI software accountable. It advocates a regulatory body to protect the public from its harms and biases.

At the end of the film, Buolamwini testifies in front of the US Congress to press the case for regulation. She wants people to support equity, transparency and accountability in the use of AI that governs our lives. She has now founded a group called the Algorithmic Justice League, which tries to highlight these issues.

Kantayya said she was inspired to make *Coded Bias* by Buolamwini and other brilliant and badass mathematicians and scientists. It is an eye-opening account of the dangers of invasive surveillance and bias in AI. ▮

Vijaysree Venkatraman is a science journalist in Boston, Massachusetts

Mind-altering perspectives

Superliminal messes with your head and perception of space, but the trick wears thin too quickly, says **Jacob Aron**

Game

Superliminal

Pillow Castle

Multiple consoles

I HAVE been having strange dreams recently. This may be due to the ongoing coronavirus pandemic – a survey in March found that people in the UK have been getting more sleep due to lockdown measures, and more sleep can have an effect on your dreams.

Or it might be that I have been playing *Superliminal*, a first-person game designed to mess with your head and your perception of space. It takes place entirely in dreams, with the unnamed character you play as participating in an experimental form of therapy called Somnasculpt administered by a Dr Glenn Pierce.

The story here is pretty light. As you pass through the game, you hear messages from Pierce and the AI that is running the dream therapy, with both getting increasingly agitated as you become lost in the dreamscape, but that is about it. The plot is essentially a set-up for very clever forced perspective and other optical illusions.

This is demonstrated early in the game, when you pick up a chess piece from a table. Place it down again and it has changed in size to match your perspective. If that sounds confusing, think about the classic tourist photo of people pretending to support the leaning tower of Pisa, and imagine you could actually shrink it down to hold it up for real. You can repeat the trick over and over, making objects tiny or gigantic.

You use this ability to pass through a series of surreal puzzle rooms, placing objects on pressure plates or making a wedge of cheese large enough to use as a ramp to a high door. Later levels add complications, such as needing to stand in a specific spot to transform an image stretched across a wall into an object you can pick up.

Developer Pillow Castle loves to mess with you, changing the "rules" of the game just as you

> "I actually ran out of the way, worrying that I was about to be squished by a giant chess piece"

have figured out how something works. But, ultimately, the forced perspective wears thin. Many of the game's puzzles can be solved by picking up an object, holding it in the air and watching a larger version fall to the ground with a thud. This is fun the first few times – I actually ran out of the way, worrying that I was about to be squished by a giant chess piece – but it doesn't offer enough variety.

The game is obviously inspired by *Portal*, a 2007 release that kicked off the first-person puzzle genre, in which you also navigate a series of rooms while listening to an AI, in that case, the malevolent GLaDOS, which berates you at every turn. Rather than forced perspective, you use a "portal gun" to solve puzzles. This allows you to connect two surfaces via a wormhole through which you and objects can pass.

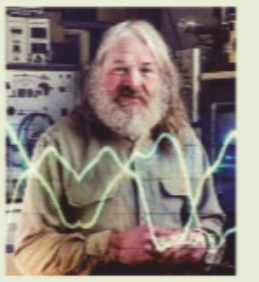
In later levels, *Superliminal* introduces its own version of portals in the form of linked doorways that can be resized, making you grow or shrink as you pass through them. It is a fun idea, but in practice I found it very fiddly. My struggles to line up the doors in the way I wanted left me pining for *Portal*'s elegance.

It is perhaps unfair to compare *Superliminal* to one of the greatest games of all time, but it doesn't help itself by aping *Portal* so closely. The game does at least have a more optimistic tone than *Portal*'s cynicism, ending with a positive message that some people may find to be a genuinely useful takeaway from the experience. ▮

PILLOW CASTLE GAMES

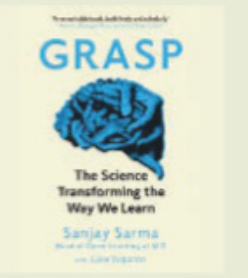
Superliminal has a creative relationship with perspective

Don't miss



Watch

John Was Trying to Contact Aliens tells the story of John Shepherd, who spent 30 years trying to contact extraterrestrials by broadcasting music millions of kilometres into space. On Netflix from 20 August.



Read

Grasp: The science transforming the way we learn sees Sanjay Sarma, head of open learning at MIT, join fellow researcher Luke Yoquinto to explain how scientific findings in wildly different fields are transforming the way we learn and teach.

Visit

Driverless: who is in control? is an excellent exhibition about autonomous vehicles at London's Science Museum. The museum reopens on 19 August, and is extending this show until January 2021.

NETFLIX; ROBORACE

Missed connections

The coronavirus pandemic may be dismantling your social network without you realising. **David Robson** investigates how to fight back

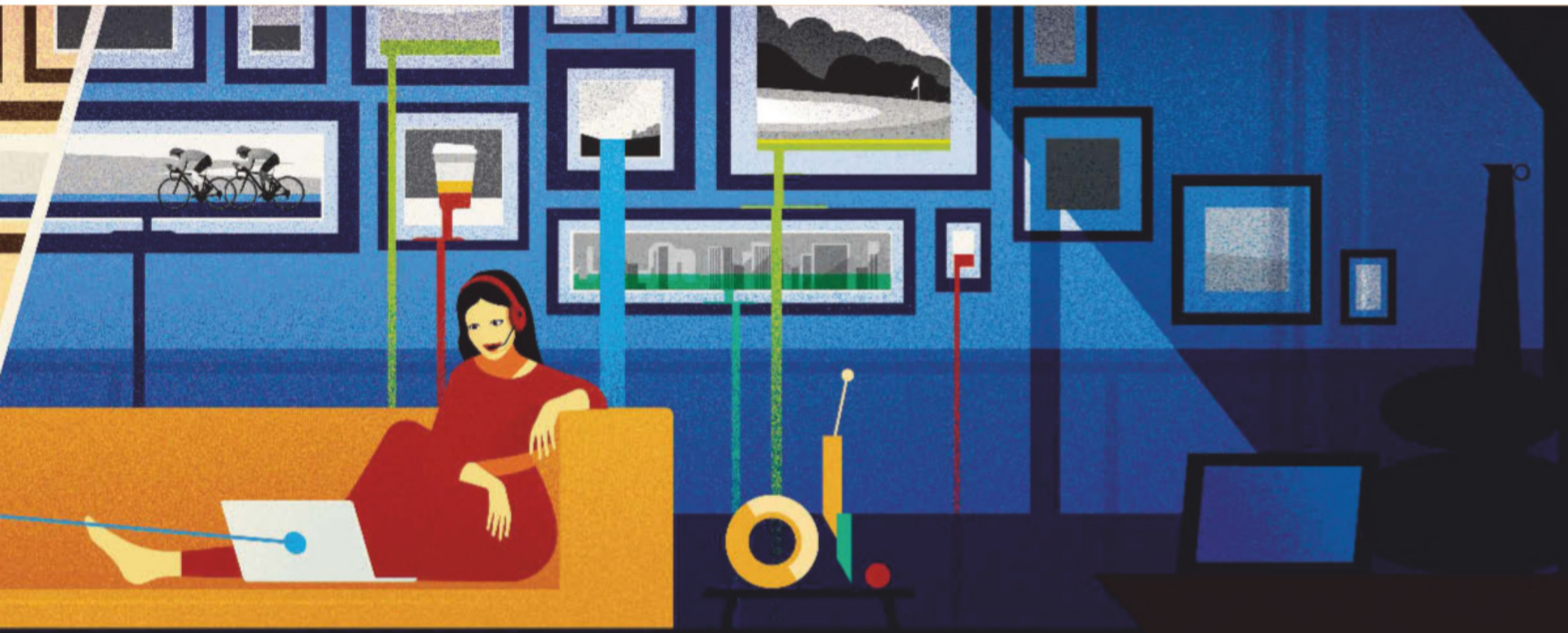
AT THE beginning of the UK lockdown, I woke each morning with a feeling of impending doom. I was scared about covid-19, of course, but also worried about isolation. How would I cope without seeing friends and family? How could I perform my job as a journalist if I couldn't meet people?

These weren't baseless fears. In recent decades, a raft of research has shown that individuals with richer social worlds tend to have better mental well-being and lower stress, and to perform better at work. Missing out on our interactions with friends, colleagues and even shopkeepers can have a surprisingly powerful impact on our health.

WhatsApp conversations and Zoom "parties" have helped me to maintain a sense of connection, but these tools can't replace aspects of interaction – like social touches and impromptu chats by the water cooler – that can boost mood and strengthen relationships.

Microsoft CEO Satya Nadella suggested as much in a recent interview with *The New York Times*. Although he felt the shift to digital interactions was going relatively smoothly, he wondered if we were burning through the

TOM PEAKE



"social capital" built up over years. He suspected that social bonds might start to evaporate. "What I miss is when you walk into a physical meeting, you are talking to the person that is next to you, you're able to connect with them for the two minutes before and after," he said.

As many of us continue to work remotely, the long-term effects of social distancing could be serious. What can science tell us about social capital and its resilience? And how can we mitigate any ill effects?

First, some definitions. When people like Nadella talk about social capital, they are describing "the various connections that an individual might have that provide them with some kind of resource", says Vanessa Parks at the University of Mississippi. For sociologists and psychologists, this can include emotional support, important information learned through the grapevine or practical help, such as a lift to the hospital or cooperation at work. Having high social capital isn't just a matter of being popular and well-liked, though. As well as having a dense web of connections that includes close friends and more distant acquaintances, people with more social capital tend to be more engaged in building their community.

"A wealth of studies have shown that high 'social capital' enhances our quality of life"

There are various ways to measure social capital. Scientists may ask people to estimate the number and strength of the links in their social network, count their direct participation in community events or use questionnaires that examine their general feeling of trust in the people around them.

Over the past 20 years, a wealth of studies have confirmed that social capital makes a huge difference to our quality of life. People with high social capital may both perform better at work and find it easier to land a new job, for instance, thanks to the greater possibility of constructive collaborations.

Social capital can also soothe our stresses and help us live more healthily, leading to a lower risk of mental illness and physical disease, and a longer lifespan. One famous meta-analysis, by Julianne Holt-Lunstad at Brigham Young University in Utah, found that a lack of social connection presents as large a risk to our health as obesity or smoking up to 15 cigarettes a day. ›

Is this remotely working?

In the 1980s, advances in personal computing and the expansion of the internet led more and more entrepreneurs and futurists to dream that it would soon be commonplace for people with office jobs to work remotely from home. By the 1990s, this seemed all but inevitable. In 1993, management guru Peter Drucker wrote: "It is now infinitely easier, cheaper and faster to do what the 19th century could not do: move information, and with it office work, to where the people are. The tools to do so are already here: the telephone, two-way video, electronic mail, the fax machine, the personal computer, the modem, and so on."

By 2019, however, fewer than 5 per cent of UK employees regularly worked from home. With the emergence of covid-19, that is now around 45 per cent.

What took us so long? Despite Drucker's enthusiasm, in the early 90s, working over a dial-up connection would have taken an age and reliable two-way video was still some way off. But with fast broadband, the connectivity required for many jobs has been available for at least a decade, meaning that the inertia must be social as well as technological.

The biggest fear, reduced productivity, has proven to be unfounded. Studies consistently show that output increases when workers are at home. Concerns over team bonding may have more substance. Remote communication misses some of the essential elements that lead to a deeper sense of connection (see main story), and that could be problematic when you are negotiating deals or establishing a new collaboration. The relative success of new ways of working in the pandemic would certainly suggest that we can get by with less face time, however – even if it would be unwise to scrap it entirely.

Perhaps, then, it was simply a fear of the new, the so-called "status quo bias", that has held us back. Sometimes it takes a crisis to shake us into radical change.

HOLLIE FERNANDO/GETTY IMAGES

"Seeing even just vague acquaintances can have a surprisingly big impact on our happiness"

There is no doubt that technology has helped to preserve some of these essential links amid the pandemic. "It's not like our social bonds have disappeared because of covid-19," says Parks. But a close look at the psychological literature suggests there may be three distinct ways that our social capital is nevertheless leaking away.

The first is the loss of "shared experience". Although straightforward one-on-one conversations may be our primary means of maintaining a friendship, much of our time is also spent in joint activities such as cooking and eating, playing football or golf. The act of doing the same things at the same time appears to create a bond that is independent of the words spoken.

Samuel Roberts at Liverpool John Moores University and Robin Dunbar at the University of Oxford, both in the UK, followed a group of students during their final year of school and first year of university, and questioned them about their feelings of emotional closeness to different members of their social network throughout this period. They found that the frequency of communication – either face-to-

The subtle ways we share touch in person can release mood-boosting endorphins

face conversations or phone calls and email – was more important for keeping female friendships alive. But for men, it was the continuation of shared activities that better predicted feelings of emotional closeness during the transition. Many of our current interactions – Zoom and Skype calls – are relatively weak shared experiences, and may fail to preserve a profound sense of connection in the long- term. Given Roberts and Dunbar's findings, it is possible that men will find it especially hard to maintain their social relationships during lockdowns.

The second element to consider is our non-verbal communication, such as physical touch. Various studies have found that non-sexual physical touch – rubbing someone's arm if they are sad, say – triggers profound neurological and physiological changes, including the release of endorphins. These painkilling compounds can produce a natural high that helps create a sense of bonhomie and goodwill. Social touch also appears to buffer our responses to stress, reducing the release of the hormone cortisol and calming our heart rate following an unpleasant experience like public speaking.

Interestingly, we don't seem to get these benefits from other types of support. People hearing kind, encouraging words, for example, recover from stress more slowly than those who get a hug from their partners, suggesting that the sense of physical closeness may be one of the most important ways that social capital benefits health. Ongoing research at University College London and Royal Holloway, University of London, shows that many people are now missing this vital source of comfort. "The deprivation of intimate touch during covid-19 is associated with worse psychological well-being, including feelings of loneliness, anxiety, less emotional tolerance for social isolation and poorer mental health in general," says Mariana von Mohr, who is working on this research.

Are you there?

Most of our relationships aren't touchy-feely, of course. But due to the delays, interruptions and slight awkwardness of remote conversations, we may also be lacking spontaneous laughter, which, like touch, is a kind of social grooming known to trigger endorphins and encourage bonding. "My hypothesis would be that when people are face to face, they laugh more than when they're on the phone or when they're on a video chat," says Roberts. With work colleagues, in particular, it may be hard to share an informal joke from the opposite ends of an internet connection.

Third, and perhaps most surprising, we may be missing our "weak ties". These are vague acquaintances and fleeting interactions, say with a barista or the distant colleague queuing next to us at the coffee machine. "You might have a sort of mutual recognition, but you wouldn't necessarily know their name," says Gillian Sandstrom at the University of Essex in the UK – so they aren't the kind of person you would now arrange to catch up with on Zoom. Before the pandemic, people had an average of between 11 and 16 of these interactions on a typical day. Their importance to our well-being and work success shouldn't be underestimated.

In a series of studies published six years ago, Sandstrom and Elizabeth Dunn at the University of British Columbia in Canada asked students to count the number of interactions with strong ties and weak ties over the course of their day. They found that both were important independent predictors of subjective well-being and a sense of belonging. In other words, someone with many close friends would be happier still if they had lots of vague acquaintances. And even a small effort to build on those interactions can pay great dividends. When participants were encouraged to make small talk to a stranger, for example, they reported a 17 per cent increase in a measure of happiness.

These apparently inconsequential ties may also be essential for successful ›

ALISTAIR BERG/GETTY IMAGES

In December 2019, Zoom had 10 million daily meeting participants. By April 2020, it had about 300 million

STEVE PFOST/NEWSDAY RM VIA GETTY IMAGES

A hug is a far more potent source of comfort than soothing words

collaborations. Consider an experiment by Bernardo Monechi at the Sony Computer Science Laboratories in Paris: a few years ago, he set up an installation at the Palazzo delle Esposizioni, a museum in Rome, with an almost limitless supply of Lego and three platforms for visitors to build sculptures on. Participants were given an RFID tag, which tracked how they interacted with each other as they worked. Some of the constructions were built by groups who already knew each other and interacted very closely, but Monechi found that the most impressive and elaborate structures were created by those with a large number of weak ties.

Monechi points out that groups of people who are close often share a similar background and outlook, while relative strangers may bring fresh ideas and different perspectives. He estimates that the optimal ratio of strong to weak ties is about 50:50. The results fit with historical analyses of scientists' and artists' networks, finding that the most productive collaborations are often forged between people of different experiences and backgrounds. Without a queue in the canteen or a backroom chat at a work conference, it is now far harder to strike up these kinds of fruitful conversations.

Sandstrom describes many of our current efforts as "social snacking" that creates a relatively superficial sense of connection without necessarily providing the nourishment we need. "You can keep snacking, but at some point you're going to feel unsatisfied if you never have a full meal," she says.

So what should we be doing instead? Given the importance of shared experiences, we might change how we interact with our existing friends. Whether meeting virtually or physically, we need to turn it into a joint activity that will help to cement our bonds. If you used to go to the cinema together, for example, you might arrange to watch the same film at the same time and then catch up through video chat afterwards.

Replacing the comfort of physical touch, while social distancing, will be much harder to correct, but von Mohr believes we might be able to enjoy some of the benefits vicariously. An ongoing study of hers has found that simply watching videos of people holding hands or stroking cats and dogs has helped to reduce some people's anxiety during the crisis. "It suggests that vicarious touch can work as an important substitute for actual touch during the pandemic," she says.

While we may be unable to easily forge new weak ties, we could attempt to make the most of the chance encounters we do have, whether striking up a conversation with someone we see regularly in the park, reaching out to a colleague whose work you have admired from afar or perhaps sending out an open invitation for a video conference with people who work in the same field. Although you may be nervous about their reaction, Sandstrom's research suggests that most people respond very well to an attempt to build new bridges – and you will feel much better afterwards.

From our closest friends to our most distant acquaintances, there has never been more reason to recognise the importance of the people around us, and our need to cherish those relationships – and that is a lesson that will be well worth remembering long after the threat of covid-19 has passed. ▮

Contagious ideas

While social capital is generally considered to be a force for good, it can be a double-edged sword, as Francesca Borgonovi at University College London recently found in an analysis of covid-19 infections.

Looking at data from the US, she and her colleagues discovered that the disease initially spread much faster in counties with the highest levels of social capital, judged using measures such as the number of local community groups.

The effect didn't seem to last, however, because the areas with the highest levels of social capital were also the quickest to adopt social distancing measures.

This may be due to people with higher social capital tending to have more trust in others and a respect for reciprocal behaviour. "So you try to protect not just yourself and your immediate family, but also the others within your community," says Borgonovi.

David Robson is the author of *The Intelligence Trap: Revolutionise your thinking and make wiser decisions*. His website is davidrobson.me

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SATURATION POINT

Will tropical forests continue to soak up carbon dioxide, slowing the pace of climate change? ***Daniel Grossman*** *joined the scientists trying to find out. Photographs by* ***Dado Galdieri***

A CLANK like a monk's gong rang out as the researchers marched single file up a forested flank of the Rincón de la Vieja, an active volcano in north-west Costa Rica. When they stopped alongside the giant buttressed roots of a strangler fig tree, graduate student Nel Rodriguez Sepulveda of Michigan Technological University held up a small steel chamber, the source of the sound. Katie Nelson, a fellow grad student, tapped her tablet and a machine strapped to Rodriguez-Sepulveda's back began to buzz, noisily sucking air from the steel chamber through a hose. After a few minutes, Nelson glanced at her screen. "It's elevated!" she whooped.

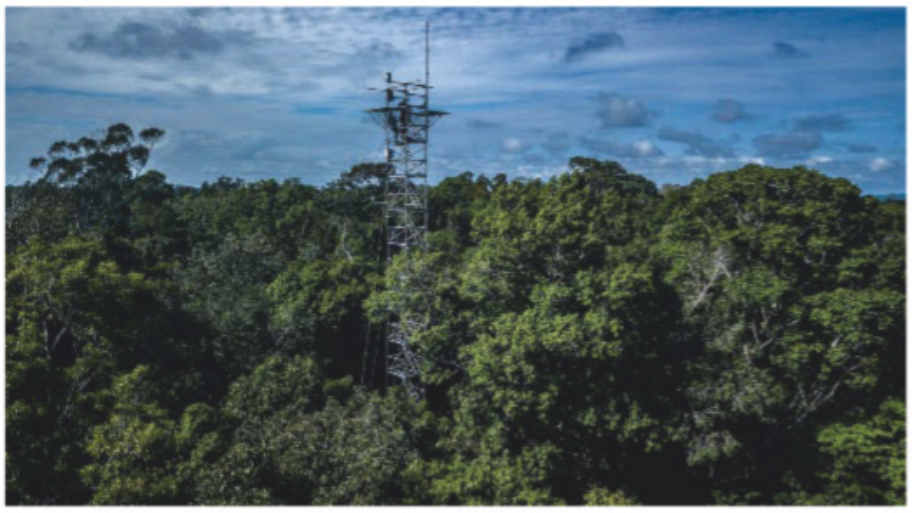
I had joined the scientists on a hunt for a notorious gas that seeps imperceptibly from fissures in the volcanic bedrock. They had come to map the places where it is more highly concentrated in the air than normal, in preparation for an experiment that could finally solve a mystery with profound consequences for the fate of our planet: whether tropical forests will continue to soak up large amounts of carbon dioxide, crucially slowing the pace of climate change.

We have always assumed as much. But increasingly we aren't so sure, raising the prospect that global warming could unexpectedly accelerate. Now the race is on to find out how rising temperatures will affect the ability of tropical forests to lock up CO_2, a question with urgent policy implications. Which is why the natural laboratory provided by the volcano is so important. "It could be a game changer," says Josh Fisher, an ecologist at NASA's Jet Propulsion Laboratory in California, who led the expedition.

As worrisome as rising seas, intensifying storms and more frequent heatwaves are, climate change could already be a lot worse. Since the industrial revolution began, only about half of all the CO_2 released from chimneys and exhaust pipes has remained aloft in the atmosphere. The balance has been soaked up by the oceans and by plants on land, both living and dead. These natural carbon sinks have played an indispensable role in slowing the accumulation of CO_2 in the atmosphere and so moderating global warming.

Opposite page: jungle in the shadow of Rincón de la Vieja, a volcano in north-west Costa Rica that is often obscured by clouds Above: Scientists working on the volcano's slopes survey trees and measure concentrations of carbon dioxide, which seeps from cracks in the volcanic bedrock, in preparation for an unique experiment

Carbon absorption on land is particularly crucial. It is the larger of Earth's two sinks and the one generally thought to be most in danger of abating in the coming decades. Combined, the world's terrestrial plants absorb some 12 gigatonnes of CO_2 every year, equivalent to nearly a third of global emissions from burning fossil fuel. This is all thanks to photosynthesis, the process by which water and CO_2 is converted to oxygen and organic compounds such as sugars and cellulose. Grasslands, peat bogs and forests of all stripes contribute to the stockpile of locked-away carbon (see "The other carbon sinks", page 42). However, various lines of evidence suggest that tropical forests could be the single largest terrestrial carbon sink, with one influential study calculating that they absorb as much carbon as boreal forests and mid-latitude temperate forests combined. ›



DANIEL GROSSMAN

Left: measuring tree trunks in the Congo basin. Above and right: an experiment in the Amazon in which air rich in carbon dioxide is pumped into chambers to see how plants react as concentrations of the greenhouse gas rise

The problem is that equatorial jungles could also be uniquely vulnerable. Steeply rising temperatures and drought are forecast to create more inhospitable conditions in the coming years. Most predictions, including the latest report from the Intergovernmental Panel on Climate Change, assume that the land sink will continue to robustly stockpile CO_2, buffering its build-up in the air. But if tropical forests decline, will this sink hold up?

It is vital we find out because if the answer is no, we are vastly underestimating the rate of warming. Forecasts of the future of the land sink are "highly uncertain", says Richard Betts, who leads research on climate impacts at the UK Met Office. But in an analysis published in April, Betts wrote that if the land sink fails, temperatures at the end of this century could be nearly 2°C warmer than most predictions suggest.

Recent studies report troubling evidence of tropical forest decline. One from March was based on surveys of carbon uptake in the world's two great tropical forests, the Amazon and the Congo. Hacking their way through thick jungle to find plots marked out years before, an international team coordinated by Simon Lewis at the University of Leeds, UK, were able to measure the girth of nearly 140,000 trees in 11 African countries. Calculating the mass of carbon in each tree and comparing the figures with measurements taken in previous decades and a database of 200,000 Amazonian trees, the researchers found that intact tropical forests in both regions seem to be absorbing less carbon than they once did.

The decline appears to be happening faster in the Amazon, where intact forest absorbed 30 per cent less CO_2 in the 2000s than it had 10 years earlier. That led the team to a grim conclusion: even the parts of the Amazon not devastated by logging are likely to turn from a carbon sink into a carbon source by 2035. That suggests that we may not be able to rely on tropical forests to keep soaking up carbon after all.

But the science isn't entirely settled. Jungles are extremely heterogeneous, so it's possible Lewis's field team studied a biased sample. The 244 survey plots covered a total area smaller than New York's Central Park, a

minuscule fraction of the Congo forest, which is twice the size of France, Spain and Germany combined. "That's a lot of extrapolation," says Scott Denning, a climate scientist at Colorado State University. The decline in carbon uptake found on these plots may not be replicated everywhere else, so "you have to be appropriately sceptical".

There is a glimmer of hope that higher CO_2 levels will instead help tropical forests to continue soaking up carbon, even as other conditions deteriorate. The concept, known as carbon fertilisation, makes sense in principle: add more of one crucial ingredient to the photosynthetic recipe, and you can expect improved growth. Commercial greenhouse operators have long piped in the gas to boost the growth of certain crops. The trouble is that the extent to which it works in the jungle, with so many other factors influencing forest health, is hard to establish.

It isn't that people haven't tried. Richard Norby at Oak Ridge National Laboratory in Tennessee has run several experiments studying carbon fertilisation in full-size trees in natural conditions. As early as the 1990s, he erected a ring of towers around a plot slightly larger than the centre circle of a football field in an old sweet gum plantation near his office and proceeded to pump in CO_2-enriched air through pipes hanging above the plot. Sure enough, the trees grew faster – at first. But they eventually slowed when the soil ran low on nitrogen, more of which appears to be required for those trees to benefit from extra CO_2.

Scientists have since run similar studies, dubbed free-air CO_2 enrichment, or FACE, experiments elsewhere in the US, Europe and Australia. Sometimes the extra CO_2 helps. Sometimes it doesn't. But no such experiment has ever been conducted in a tropical forest – which is critical, says Norby, because every ecosystem has its own quirks.

David Lapola is among those trying to change that. A biologist at the University of Campinas in Brazil, Lapola has spent the best part of a decade setting up a FACE experiment on a jungle plot 90 kilometres north of Manaus, the Amazon's largest city. When I visited last year, workers trudged back and forth under a dense canopy hauling long, rigid panels of clear plastic mounted in aluminium frames. They were assembling the pieces into eight roofless chambers, each the size of a small garden shed.

Lapola was getting set to start supplying the chambers with CO_2-enhanced air. He later told me that, although some plants do seem to grow better with extra CO2, provisional results "do not seem to show much of a difference between enriched and control chambers". This suggests carbon fertilisation might not take up the slack. Norby says that may be because the soil at the site, as in much of the Amazon, is deficient in phosphorus, another essential plant nutrient.

But results from this experiment are far from definitive. Lapola is the first to admit that huge, unenclosed plots are superior. His small chambers let in normal light and rain, but beyond that the conditions inside them are highly artificial. For instance, the plastic walls block out wind and restrict access to birds, insects and rodents. Worse, they are only big enough for short plants – and Lapola says full-size trees in bigger plots could behave very differently. ›

THE OTHER CARBON SINKS

Researchers on Rincón de la Vieja, searching for areas where carbon dioxide level are roughly what we can expect everywhere by 2050

Ecosystems that absorb more carbon than they release are known as carbon sinks because they effectively store greenhouse gases, reducing their levels in the atmosphere. If we are to stand any chance of keeping global warming to 1.5°C above pre-industrial levels, the target set by the Paris climate deal, or even the more realistic 2°C target, we are going to need them. This is why scientists are so concerned about the fate of the world's tropical forests, one of our biggest carbon sponges (see main story). But these jungles aren't the only possible natural carbon sink that researchers have been investigating.

Grasslands soak up a lot of carbon dioxide via photosynthesis. But they don't end up storing much because their dead stems and fronds often decay quickly, returning carbon to the air. Peatlands, which include some grasslands, but also forests and tundra, lock up huge amounts of carbon in their soil. This is because they are uniquely rich in dead and decaying plant matter. In fact, peatlands store 20 per cent of the carbon in all the world's soil, or as much as all the world's above-ground vegetation, despite covering just 3 per cent of Earth's surface. Yet it is important to recognise that peatlands don't remove much CO_2 from the atmosphere every year. Their vast stocks have accumulated over hundreds or thousands of years.

Most of the CO_2 plants soak up from the air – some 12 gigatonnes per year – is absorbed in forests, which cover 30 per cent of Earth's land. That's roughly a third of the annual emissions we create by burning fossil fuels. For years, many scientists thought that tropical jungle absorbed more carbon than any other forests. But recent studies suggest that climate change is causing carbon uptake of tropical woodlands to be outstripped by forests elsewhere.

Take boreal forests, for example. These don't grow as voraciously as tropical forests, limiting how much carbon they can absorb per square kilometre. But they still have a vast potential because they're so large. And they might benefit from carbon fertilisation, a process by which additional carbon in the atmosphere boosts growth. What's more, temperatures are rising faster in the Arctic than anywhere else, and that is making it possible for boreal forests to expand into once inhospitable tundra.

No one is suggesting we should stop protecting tropical forests. But as we seek to avoid runaway climate change, scientists are increasingly urging us to pay attention to other terrestrial carbon sinks.

The problem comes down to money. Running an open-air experiment here would require thousands of tonnes of CO_2 each year, at a cost of several hundred thousand dollars. That's a big part of the reason Lapola and his collaborators, including Norby, have never managed to fund such an experiment in the rainforest.

Now, though, after getting some results from chamber experiments, the researchers have attracted interest from government agencies in Brazil and Europe to fund the construction of a full-scale, open-air fertilisation trial. It will involve six large, circular plots, three of which will be bathed in air fed from 35-metre-tall towers and spiked with CO_2 to simulate concentrations expected in the mid-century. Betts has been waiting for such an experiment for years. "It would be a huge bonus," he says.

In the meantime, our best bet to find answers is the experiment on Rincón de la Vieja in Costa Rica. When I joined the researchers there earlier this year, they

were mapping CO_2 hotspots. Being heavier than air, as it seeps from the volcano's bowels, this gas hugs the ground and flows into valleys, creating a patchwork of areas with high and normal concentrations of the gas. That is the theory anyway. Few researchers have ever surveyed CO_2 concentrations on slopes of volcanoes, and nobody has enlisted a volcano to study carbon fertilisation in a tropical forest.

Fiona Soper, an ecologist at McGill University in Canada, applies the same simple techniques that Lewis used in the Congo basin to study Rincón de la Vieja's jungle. While Rodriguez Sepulveda and her colleague Nelson sampled the air, Soper and her team identified and measured trees inside a 10-metre-diameter circle. Working with another team elsewhere on the volcano, they logged 1000 trees in 60 plots. Meanwhile, the gas sampling team detected CO_2 levels ranging from just over 400 parts per million – the current global average in Earth's atmosphere – all the way up beyond 600 ppm, an amount that we might find across the planet by late this century if today's emissions continue unchecked.

Fisher says that if carbon fertilisation is at work at Rincón de la Vieja, there will be more carbon stored in patches of forest with higher CO_2 concentrations. Soper, now back in her lab, didn't discover evidence of that. But then this trip was always a dry run for a more intensive survey later. And even then, she says, it will probably require sampling many more trees to detect carbon fertilisation. To get the sort of data required, Fisher hopes NASA will fund a vastly expanded research campaign, including ground surveys of many more plots and low-level flights by some of the agency's best drones.

But David Schimel, another NASA biologist, is optimistic that the project could produce a breakthrough. Rincón de la Vieja is "an unexpected and wonderful window for seeing what happens in forests that have experienced high CO_2 for centuries", he says. In a best-case scenario, the volcano research could complement Lapola's new Amazon experiment to give us a first real glimpse of how tropical forests' capacity to absorb carbon will fare in our future atmosphere.

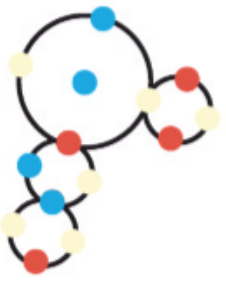
One thing is for sure: we need to know how this plays out, because we're relying on Earth's natural carbon sinks to buy us time while we reduce carbon emissions to net zero and maybe even suck it out of the air with carbon-capture technologies. "We're going to need every little bit of help that mother nature will give us," says Schimel. "We need to know what we can count on." ▮

Daniel Grossman (left) is a reporter based in Massachussetts. Dado Galdieri is a photographer based in Rio de Janeiro, Brazil.
This article was produced in partnership with the Pulitzer Center on Crisis Reporting

KOTRYNA ZUKAUSKAITE

Electric chemistry

We have discovered a smart, green way to choreograph the dance of atoms. **Gege Li** investigates



IT ISN'T long after waking each day that we meet the handiwork of chemists. The flavourings in toothpaste, scents in shower gel, polyester in clothes – all have been created through the breaking and making of chemical bonds. The same goes for nearly all the materials on which the modern world relies.

It isn't easy work. Take remdesivir, the antiviral drug that could help us treat covid-19. To make it, chemists begin with a small molecule called alanine and add a further 64 atoms to it over the course of 25 separate chemical reactions. Whew.

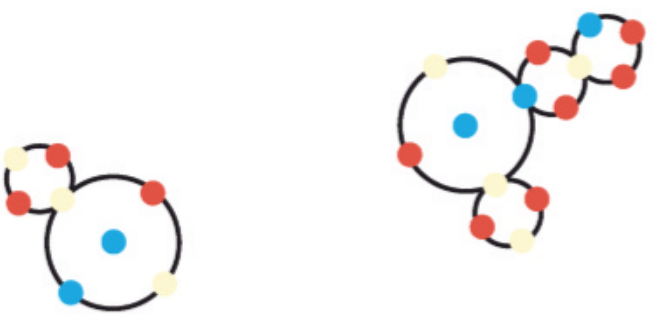
Making such molecular marvels isn't just taxing, it can also be a grubby affair. Synthetic chemists spend most of their time amid pastes, powders and bubbling solutions: it is a messy and often smelly craft.

But perhaps there is a way to make it simpler and cleaner. More and more chemists are experimenting with a new tool of subtle power: the electric field. Not only does it promise to help us control the jiggling of atoms more precisely, but in a world where green credentials are important, it could also make chemical synthesis a lot less damaging to the environment. If this works, chemistry will be transformed.

To see why this new tool is so promising, we need to consider the thing that matters most in any reaction – the flow of electrons. We think of electrons as negatively charged particles that swirl between the positively charged atomic nuclei in a molecule, gluing the atoms together. The job of the synthetic chemist is to cajole this electron glue into flowing from one place to another, and so rearrange and extend the atomic scaffolding to form exciting new substances. To aid this, chemists often pay attention to the polarity of the molecules involved, the overall distribution of positive and negative charge within them. Understand and manipulate this, and you can guide where the glue goes.

Reactions come in many flavours, but often have just a few components. Typically, there is a chemical dissolved in a liquid together with one or more other substances that will join to or change the starting material in some fashion. Then, crucially, there is often a catalyst. These additives make a reaction go faster without being used up themselves in the process. Without them, chemistry can be so sluggish as to be impracticable.

Wonderful as catalysts are, they make life difficult in the lab. They must be made or purified from raw materials, which takes time and often requires energy-intensive processes that belch out carbon dioxide. When the reaction is finished, they must be carefully separated from the product. You must isolate and recycle valuable catalyst and, anyway, you don't want any of it contaminating whatever you have made. All of this is messy, painstaking work. ›



If we could avoid having to rely on this kind of catalyst, it would be a huge advantage. There are a few old tricks chemists can use to attempt to do this. Heating a reaction usually speeds it up, but as tools go, this is a bit of a sledgehammer that can create undesirable side reactions. Particular wavelengths of light can also kick-start reactions, but only a select few.

Sason Shaik at the Hebrew University of Jerusalem in Israel has been wondering for decades if there might not be a much better trick. As a student in the 1970s, he came across a reaction that used a high concentration of salt as a very effective catalyst. Salts in solution conduct electricity and it struck Shaik that perhaps it was the electric field that was doing the business.

That makes some sense in principle. An electric field is effectively a space in which the electric charge goes from positive at one end to negative at the other. If you could apply an electric field to a molecule, then you might conceivably persuade its electron glue to flow more readily. Flip the orientation of the field and maybe the electrons would flow the other way. Shaik thought that applying an external electric field might speed up a chemical reaction and enable you to decide exactly what it produces. "These are the effects that every chemist would like to control," he says.

"Heating a reaction can speed it up, but it is a bit of a sledgehammer"

Shaik first tried the idea using computer simulations – and it seemed to work. In 2009, he looked at a stalwart of chemical synthesis, the Diels-Alder reaction, in which two strings of carbon atoms form a ring. He showed that electric fields could quicken the reaction and affect the form of ring produced.

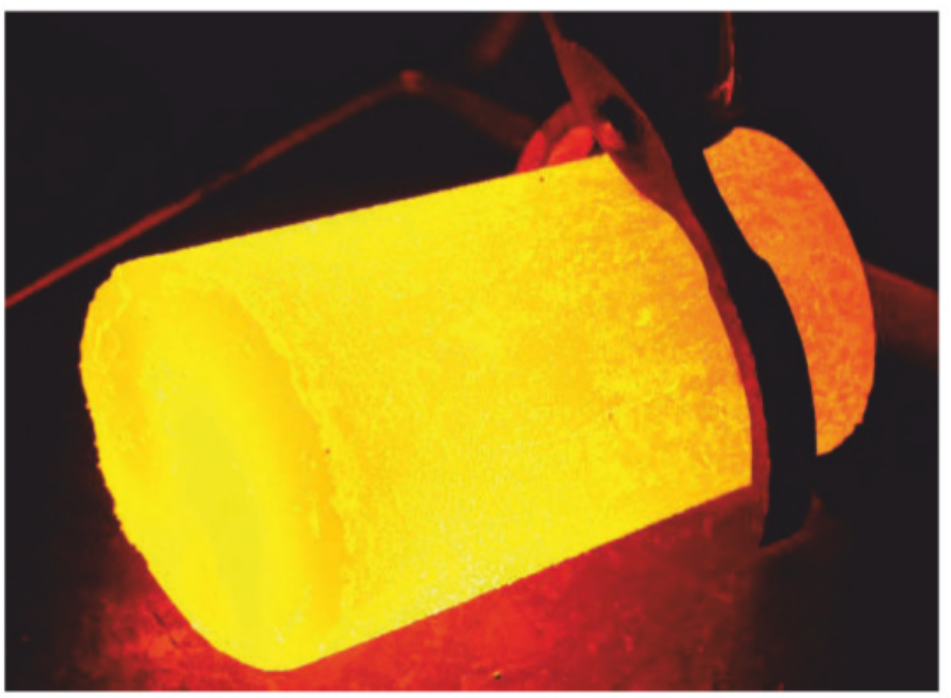
Despite this success, it seemed like little more than a theoretical nicety. In Shaik's simulations, the alignment between electric field and molecule was crucial to success. In the chaotic reality of a round-bottomed flask, molecules in solution are tumbling around at all angles, meaning that any external electric field would only line up with a fraction of them at any time. For years, it seemed Shaik's dream catalyst was just that.

However, there is one way to get molecules to lie still: stick them to a surface. In 2016, that is how Michelle Coote at the Australian National University in Canberra managed to test Shaik's Diels-Alder modelling for real. Working with Nadim Darwish, now at Curtin University in Perth, Australia, Coote and her team fixed a molecule of one substance to a metal surface, and a molecule of a substance they wanted it to react with to the tip of a special type of microscope. In this way, the two molecules were brought together in a controlled fashion in the presence of an electric field. When the field's voltage was increased, the molecules snapped together more quickly. "It was totally consistent with what you'd expect if an electrical field was catalysing this reaction," says Coote.

This proved to be a watershed moment. "It really broke the ice," says Shaik. "Many chemists started seeing that these ideas derived from theory were not just a daydream, but something that creative chemists could do in the lab." One of them is Ayan Datta at the Indian Association for the Cultivation of Science in Kolkata, who has begun exploring whether a wider range of reactions can be catalysed by electric fields. He recently simulated their effects on a reaction that is widely used in all sorts of synthetic chemistry. Applying the field lowered the energy needed to get the reaction going so much that it would happen at least twice as fast.

Still, none of this optimism gets around the impracticality of the method. In Coote's work, the microscope tip worked on one molecule at a time. If we wanted to make a single gram of a typical-sized drug molecule in this way, we would have to work our way through 10^{21} molecules, which, at a rate of one per second, would take more than a trillion years. We need a better way of making these fields spark into action.

Several years ago, Matthew Kanan at



SPUTNIK/SCIENCE PHOTO LIBRARY

Expensive metals like palladium are often used as catalysts

ANNA IVANOVA/ALAMY

Electric catalysis could make industrial processes greener

Stanford University in California created a small device in which a solution of chemicals flows continuously along a thin channel that passes through an electric field between two electrodes. He reported that this boosted the rate of reaction and that flipping the polarity of the field changed the product of that reaction. This suggested a much better method than Coote's use of a microscope. But Kanan hasn't pursued the idea and says there are still "substantial technical challenges".

Coote hasn't given up. Over the past few years, she has been exploring another way to harness electric fields in grand style – this time using a phenomenon most of us have experienced: static electricity. As you will know if you have ever rubbed a balloon against fabric and then held it to your hair, static electricity builds up when certain materials rub together and electrons are transferred from one to the other, creating an electric field.

Coote and her colleague Simone Ciampi, also at Curtin University, have been experimenting with this hair-raising stuff for a while. They take thin sheets of plastic, up to 1 metre across, and charge them by rubbing them together for a few seconds. They then put the sheets on a system of rollers that dips them through half-litre containers of reacting solution. In unpublished experiments, the pair have shown that these charged surfaces can catalyse reactions that involve the transfer of an electron from one molecule to another.

It is early days, but Ciampi says the method could "undoubtedly" be scaled up to industrial-sized reactors. It could also be made easier and more effective, perhaps by using not sheets, but rods, with one end of each dipped in the solution, the other rubbed to charge it up continuously. Another idea is to drip solutions onto the plastic sheets so they spread out and get more sustained contact with the static electric field.

All this suggests the problem with getting individual tumbling molecules to align with the electric field isn't the showstopper we once thought, according to Ciampi. This is because, first, some of the molecules will be randomly aligned with the field anyway, and the larger the statically charged surface and the longer you leave it, the more molecules that will apply to. Second, we are starting to find that, as the molecules approach the charged surface, they tend to align themselves with it anyway.

If electric catalysis does become a mainstream tool in chemistry, its green credentials will be most welcome. That is certainly why Datta is primarily interested. Regular catalysts are often metals – expensive and sometimes poisonous – that have to be carefully removed from reaction mixtures and ultimately disposed of. With an electric field, none of that is needed. "The good thing is you can just switch the field off," says Datta. "It's a much more clean and green way to do reactions."

Shaik is also hoping electric fields could provide solutions to truly knotty chemical problems, such as how to break down certain types of plastic for recycling. "Right now, it's a mess, there are no good methods," he says.

For her part, Coote is optimistic about the future role of electric fields in chemistry. Because all molecules have some degree of electric polarity, "catalysing reactions with electric fields is something that could be done for anything", she says. It may be several years before we get to that point, but in the meantime, electric fields might just make the work of the chemist a little less messy. ▮

Gege Li is a science journalist based in London. She tweets as @YGegeLi

No more damned lies...

Statistical literacy is more important than ever in the covid crisis, statistician **David Spiegelhalter** told the audience at a recent *New Scientist* event – but that means turning yourself into a data detective

THERE IS a quote from Nate Silver about statistics which I think is very nice: "The numbers have no way of speaking for themselves. We speak for them, we imbue them with meaning." You can't just collect some data and it'll tell you the answer. There is an art to trying to extract information, knowledge and understanding from data, and even in choosing what data to collect. It's something we've all been dealing with over the past few months with covid-19: can we believe these numbers? What do they mean?

Now if this were a live audience, I'd be asking how many people have done stats courses. If people put their hand up, I'd ask how many people actually enjoyed them, and most of the hands would go down. That makes me upset. I love statistics, I think it's great. But it has tended to be taught in the past as a series of formulae and tests and regression and things like that.

My book *The Art of Statistics* takes a very different approach. It spends a lot of time on problem solving, on things like: what are you trying to do? Is this data suitable for what you're trying to answer? What can we conclude from it? It's amazing how far you can get without ever doing any fancy statistical methods or using probability theory or the sample distribution of the sample mean and all this sort of stuff we all had to endure – and which I've always taught, of course.

The key is what is called the "data cycle". You don't start off with data, you start off with a problem. You plan how are you going to try to answer it. Is there any data, and what might we collect? Then you collect data and wrangle it and manage it and clean it up. Only then do you come to the analysis. That's normally the only thing that is taught in stats courses, but it's only a small part of the whole cycle.

It's followed by the communication, drawing the appropriate conclusions, putting the message out. And there always you have to start again. Because as we're going to see again and again, how you do an analysis just leads to more questions.

I find the data cycle an immensely powerful way to structure the use of data to solve problems. How many sexual partners have people had? Is it worth me taking statins? Who was the luckiest person on the *Titanic*? What's the probability that the skeleton found in that Leicester car park really was Richard the Third? Why do old men have big ears? I mean, these really important questions for the future of humanity.

Many of these issues I've actually been working on. An example I use in the book is that of the doctor Harold Shipman. He murdered at least 215 of his patients, and probably considerably more, over 24 years working in the Hyde suburb of Manchester. I worked on the Shipman inquiry as one of the statisticians who were asked to look at the data and answer various questions. The first question really was, what was happening?

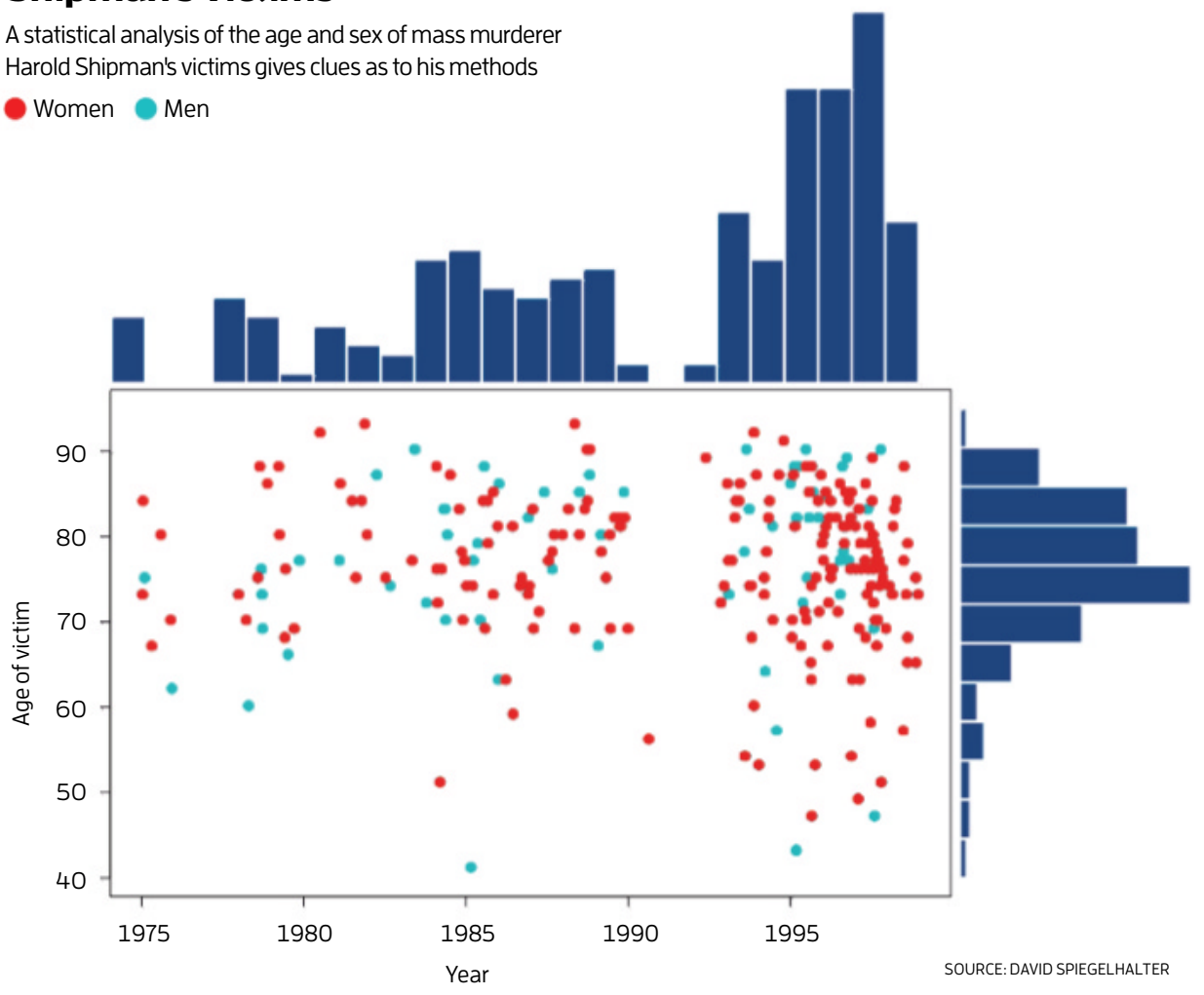
So here's a graphic (right) that just shows the pattern of his murders: the red dots are women, the blue are men. The histograms at the top and on the left show the distribution of the years of the killings and the age of the victims. So just from this data alone, the ages and sex of the victims and the dates of their deaths, what can we conclude?

Is he mainly killing old people? Yes, but it looks like more near the end, some of his victims were much younger. And do you notice that gap of a year – did he go on holiday? No, up to then he had been working in a joint practice, and tt's thought that he suspected that he was being suspected. After that, he set up his own single-handed practice,

MICROSTOCKHUB/ISTOCK PHOTO

Shipman's victims

A statistical analysis of the age and sex of mass murderer Harold Shipman's victims gives clues as to his methods



SOURCE: DAVID SPIEGELHALTER

and after that there's no sort of control over him. By the time he was arrested, he was murdering people at a huge rate, quite extraordinary. We don't know why: he never spoke, and then committed suicide in prison.

So this data just generates more questions. What was Shipman doing? What system was he using? How was he killing people? The general practitioner Richard Baker went and looked at all the death certificates that Shipman had signed, and those his colleagues had as well. It was a massive data collection exercise, but the analysis was completely trivial. It hits you between the eyes. The times of day when his colleagues' patients had died were spread pretty uniformly over 24 hours, but Shipman's victims were dying around two or three in the afternoon. We think that is when he did home visits, visiting elderly people on their own and giving them a huge dose of morphine. They would die in front of him peacefully. It's chilling.

Again, it generates more questions. All the families wanted to know, could he have been caught earlier? Now this is tricky. Those of you who have suffered statistics courses will know that to test a hypothesis, you have to set up a null hypothesis. A null hypothesis is boring: in this case, that there's nothing wrong with Shipman at all. How soon could we have rejected that hypothesis – how soon could we have detected something strange was going on?

So you work out how many deaths you expected to occur over time with different sex and age groups if things were normal. You can compare that with the observed number, subtract the one from the other and you get excess mortality. The reality is a bit more complex and you actually use a slightly different statistical measure. But in Shipman's case you can say that, based on female deaths alone, by 1985, after only about 40 deaths, we could have been very confident something was strange. Of course nobody did do that at the time; it was no one's job to do that.

The other interesting thing is that when they tried this method out on 1000 other doctors around the country, they found a few who were even worse than Shipman. It turned out that these were enormously generous and responsible, kind, caring doctors, who were just living in places with a lot of elderly people and allowing them to die peacefully at home. That's the difference between correlation and causation: we could conclude that these doctors are statistically odd, but not why. We have to be enormously cautious. That data does not speak for itself. ›

The covid mortality spike

So let's look at coronavirus. We can look at the data for deaths in England and Wales, as in the diagram (right). The blue is the deaths happening with covid not mentioned on the death certificate, and the red is deaths with covid mentioned. The base line is the five-year average of deaths for the same period. We can see a massive spike starting at the end of March, but we can see that now, even allowing for continuing covid deaths, there are fewer deaths than normal. Is it just continuing the pattern of lower deaths that we observed early in the year, when we had a milder flu season than normal? Or is this the first sign of what's called mortality displacement, in which deaths of frail elderly people that would have occurred later in the year have been brought forward?

And there are other fascinating patterns going on when you look closer. For example, we know that young men between 20 and 24 had lower mortality than usual over the lockdown period, at one point 30 per cent down, even including a few covid deaths. We don't know the details, but we can probably guess it might have to do with fewer car accidents and maybe less going out getting drunk.

Displaced deaths

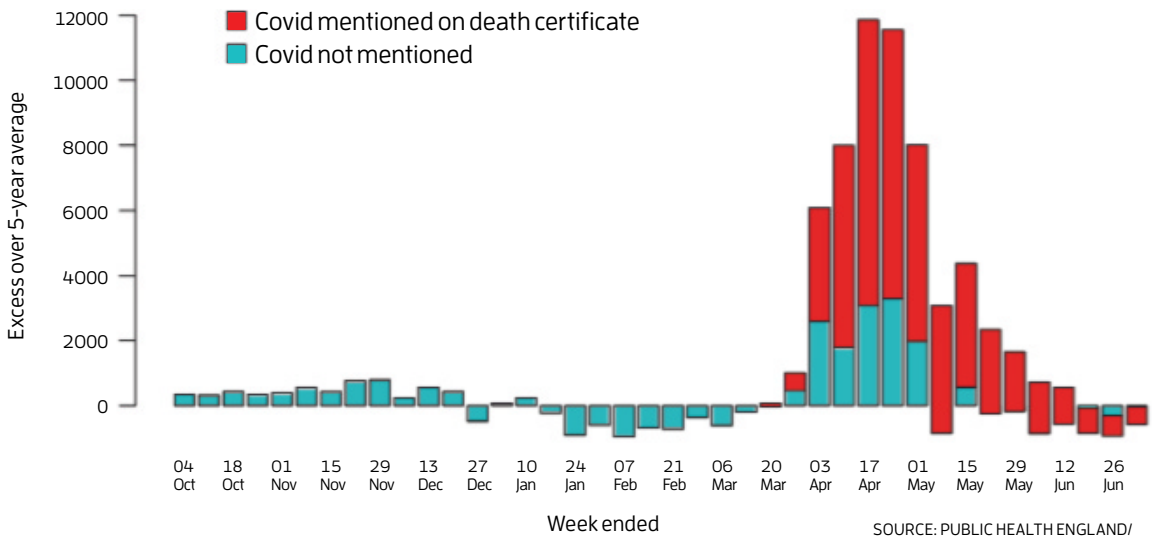
But let's go deeper: let's look at the place in which people are dying (diagram, middle right). Let's look at care homes. There's been a big spike in deaths in care homes, but with a lot of non-covid deaths. It's thought many of these could be covid deaths, especially of elderly people with dementia, just not labelled as such on the death certificate. It's very difficult to make a definite diagnosis in these cases, and doctors have been unwilling to put it on the certificate.

When we look at hospitals, we can see this big rise starting in the middle of March. This is when they emptied the hospitals and sent people back home without testing whether they had covid, or sent people back to care homes. It's been strongly suggested that that was one of the causes of the rise in deaths in care homes, along with the staff moving between different institutions.

But there is also a dip in non-covid deaths in hospitals. There's been a huge reduction in attendance in hospitals of people with heart symptoms, with strokes and so on. Where have these people been dying? Well, they've been dying at home. It's extraordinary. There has been an enormous number of extra

Covid-19 mortality over time

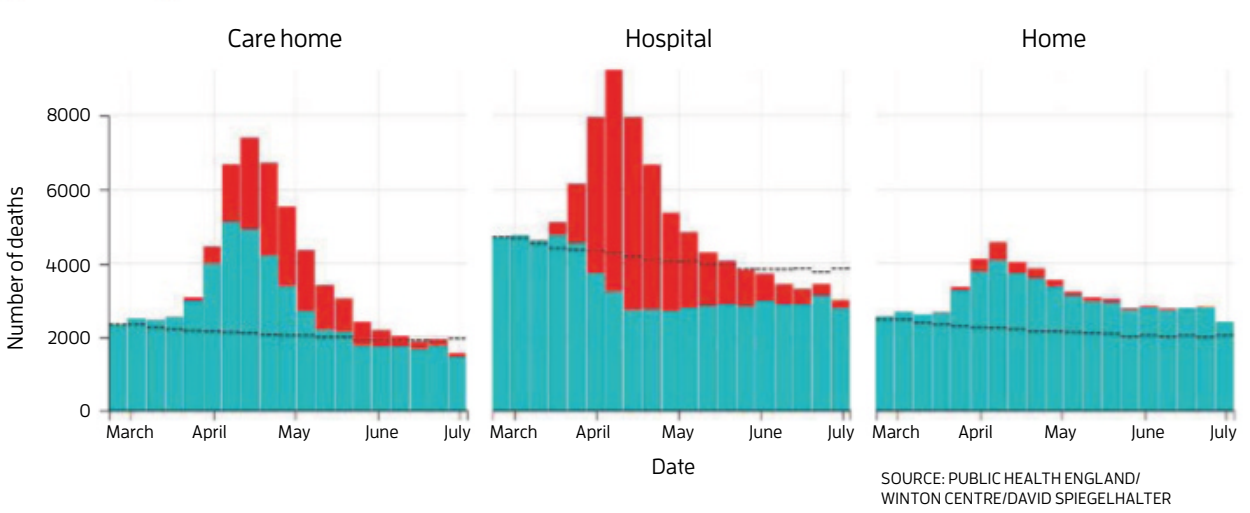
After a huge spike beginning in late March, deaths in England and Wales have recovered to below the five-year average, even counting deaths from covid-19. Data is death registration data from the UK Office of National Statistics, and does not necessarily show week of death owing to reporting delays



SOURCE: PUBLIC HEALTH ENGLAND/ WINTON CENTRE/DAVID SPIEGELHALTER

Where have the deaths occurred?

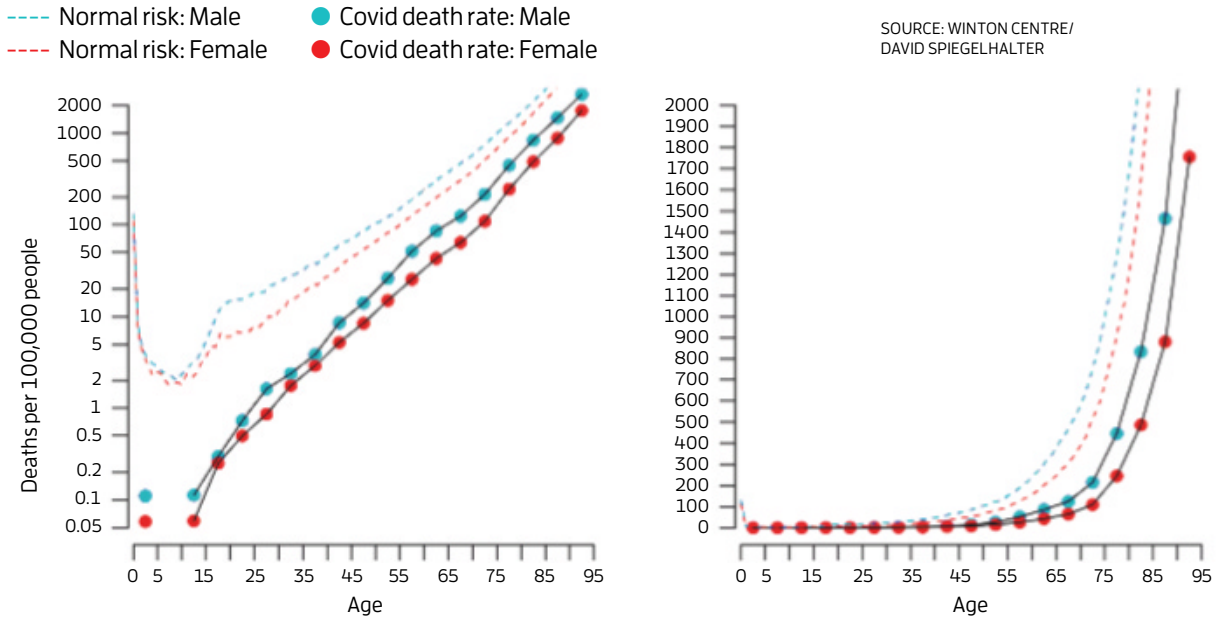
Looking at place of death, whether care home, hospital or private home, shows a distinct displacement effect, with many more non-covid deaths occurring at home



SOURCE: PUBLIC HEALTH ENGLAND/ WINTON CENTRE/DAVID SPIEGELHALTER

The covid-19 age profile

The population mortality rate expresses the risk of catching covid-19 and dying from it. Men have roughly double the risk of women of the same age, while the risk increases exponentially with age, with a 10,000-fold variation in risk across all ages (Deaths registered in England and Wales 7 March - 26 June 2020)



SOURCE: WINTON CENTRE/ DAVID SPIEGELHALTER

Sniffing out the dodgy stats

In response to an audience question, David Spiegelhalter gave his tips for not being blinded by numbers

There are tricks, but it's not a simple thing. A lot of it is feeling, what I call "sniffing the number". My first question is always "why am I hearing this number?": to be sceptical about the motivations of the people telling you the number. Are they trying to make it big or small? Are they trying to persuade me, rather than inform me? Almost always they're trying to persuade.

That leads to subsidiary questions. What am I not being told about? Can I believe this number? Where does it come from? Does it actually represent what I think it represents? It's a bit like judging fake news. You often can't tell from the claim itself; you have to look outside and see what other people are saying about it, do what's called horizontal searching. That's a very basic skill that you can teach people. It's being taught in US schools now to show people how not be taken in by fake websites.

deaths at home, some 15,000 over the period we're looking at – and that's still happening. As we speak, there's still a deficit of non-covid deaths in hospital and an excess in the home.

Again, that just raises more questions. We don't know the quality of these deaths. Most people would prefer to die at home; dying in hospital in this current crisis has not been a good thing. But maybe some of these people might have lived longer, had they gone to hospital. So this just raises more questions, as we go round and round that data cycle.

Coronavirus and age

Let's look now not just at the death rates, but the chance of someone in the population catching covid-19 and then dying (diagram below left). I think this is almost the most staggering bit of analysis I've ever done. In England and Wales, there is a completely exponentially increasing risk of catching it and dying from it for the different age groups. It increases by about 12 to 13 per cent for each year older you are, and so doubles for every five to six years. That means that someone who is 20 years older has got 10 times the risk: compared to a 25-year-old, a 45-year-old has ten times the risk, a 65-year-old 100 times, an 85-year- old 1000 times. Draw a straight line on the logarithmic scale representing exponentially increased risk (left graph) and it just carries on across the age range all the way from essentially five to 95. I've never seen anything like that, it is quite extraordinary.

For school kids, five- to 14-year-olds, of 7 million in England and Wales, just three have died – a 1 in 2.5 million risk. Meanwhile, 138 have died of other causes over the period of the epidemic. So this is both a staggeringly low risk, and very low compared to the normal risk. But for people over 90, more than 2 per cent, one in 50, have died with covid. That represents about a one-third increase over the normal risk they would have had over this period.

The media have not been great always in covering this. The "risk of dying from coronavirus" is a very misused phrase. I've been talking about what's called the population fatality rate, the chance of getting it and then dying. There's another risk, which is if you get it, you die – the infection fatality rate. It's very easy to mix those up.

That happened when the UK Office for National Statistics did a very good report on risks for ethnic minorities. That's an incredibly important issue. All the risks that were discussed are the risks of catching it and dying, and that includes the increased risk of catching it that many ethnic minority communities clearly have, because of their jobs, or perhaps because of deprivation, overcrowding and poor working conditions. However, some reports had it that ethnic minorities were 90 per cent more likely to die if they became seriously ill with covid-19. That's not true.

We've done lots of experiments at the Winton Centre, and we find that people have got a complete misapprehension about covid risk. Many people say, if I catch it, it's 50/50 whether I die or not. People are very anxious. They really think if I get it, this is a very high-risk situation. It is for some people, but for most people, it isn't, even if you catch it.

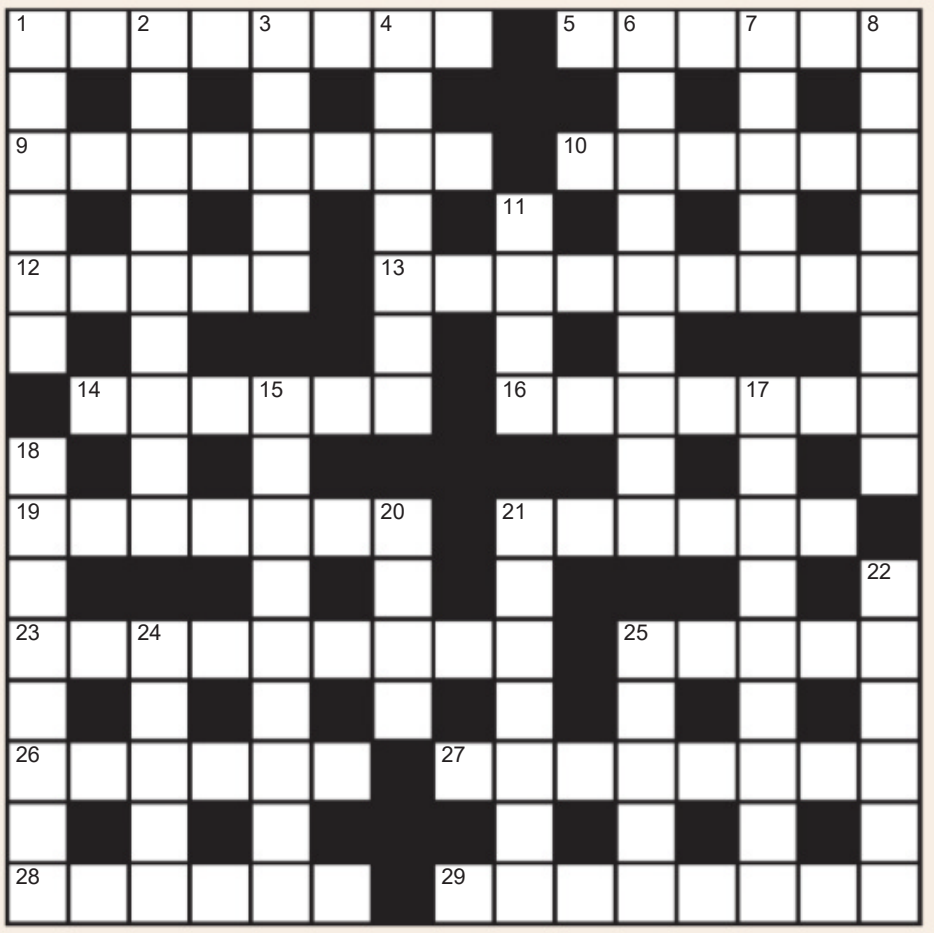
You can look at the actuarial risk of dying in a given year. I produced a graph back in March, before we'd had almost any deaths in the UK at all, saying that the risks if you get the virus are very similar to the risks that are there anyway for dying in the subsequent year. That means that if you get the virus it roughly doubles your chance of dying this year. I'd still argue that that's roughly true. But I originally expressed this by saying the risks from covid were about the same as dying this year, which was very bad communication, as some people interpreted it meaning the death rate from the virus didn't add to normal risk.

For a statistician, this has been quite a stressful time. It's been great, but it's been hard work, and I've got things wrong. But a lot of what we've seen is what I call number theatre, a lot of numbers put out there to impress people. This is not trustworthy use of statistics. People delivering the statistics should be proper professionals who know what they're talking about, and they should treat the public with respect.

Data literacy is a vital skill in modern life. This covid crisis that made this even clearer: not just in the ability to manipulate data, but also to critique the numbers we are told. ▮

David Spiegelhalter is Winton Professor of the Public Understanding of Risk in the Statistical Laboratory at the University of Cambridge, UK, and author of *The Art of Statistics*, out now. This is an edited version of a talk he gave at a *New Scientist* event on 23 July 2020

Quick crossword #64 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

1 Compound of As (8)
5 Unit of distance equal to 31 trillion kilometres (6)
9 Sensory mammalian hairs (8)
10 ___ action at a distance, Einstein's term for quantum entanglement (6)
12 Innovation processes (abbrev.) (1,3,1)
13 Hormone that inhibits pain (9)
14 French civil engineer; programming language (6)
16 Relating to tin (7)
19 Young cats, rabbits or rats (7)
21 Smallest number with six divisors (6)
23 Units of precipitation (9)
25 Message received! (5)
26 Internal; within a building (6)
27 Inflammation of synovial fluid sacs (8)
28 Helical spring toy invented in 1943 (6)
29 Retain; protect (8)

DOWN

1 Online marketing software (6)
2 Natural philosopher, formerly (9)
3 ___ mole rat, eusocial mammal in the genus *Heterocephalus* (5)
4 Gerald ___, conservationist and writer (7)
6 Artificial sweetener (9)
7 Slow-moving arboreal mammal (5)
8 Preservation of human bodies by freezing (8)
11 Probabilities (4)
15 Data collection outside a laboratory setting (9)
17 Person responsible for establishing position and direction (9)
18 Small rocky islands (8)
20 Form of industrial air pollution (4)
21 Tortoise genus; Roman military formation (7)
22 Marine fish that might be a humphead or a yellowtail (6)
24 Large lemur, also called a babakoto (5)
25 Increases (5)

Quick quiz #64

1 The structure of which substance allegedly came to chemist August Kekulé during a dream of a snake biting its tail?

2 What might you measure using a Wheatstone bridge?

3 What form of pneumonia, usually caused by contaminated water, was first identified in an outbreak at a Philadelphia hotel in 1976?

4 What geological era, noted for an explosion in invertebrate life and named after a Welsh Celtic tribe, was sandwiched between the Cambrian and Silurian eras?

5 Io, Europa, Ganymede... what's missing?

Answers on page 54

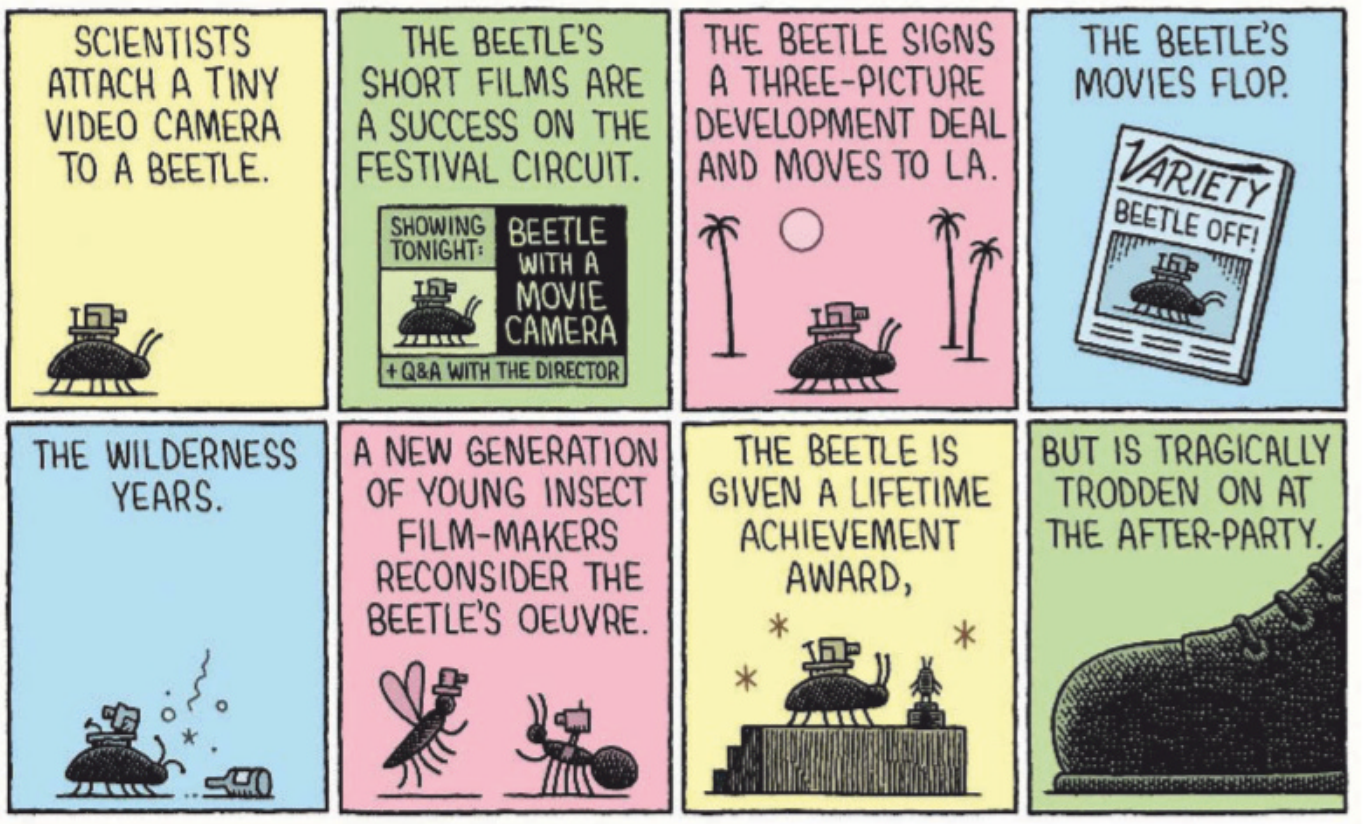
Cryptic Crossword #37 *Answers*

ACROSS 1 Bucolic, **5** Pipes, **8** Republics, **9** Ova, **10** Nadir, **12** Isotope, **13** Alpha particle, **15** Antwerp, **17** Resin, **19** Edo, **20** Slide rule, **22** Rigel, **23** Tetanus

DOWN 1 Boron, **2** Cap, **3** Liberia, **4** Critical point, **5** Pesto, **6** Proboscis, **7** Scalene, **11** Diphthong, **13** Amateur, **14** Torment, **16** Easel, **18** Needs, **21** Urn

The back pages

Tom Gauld
for New Scientist



Twisteddoodles
for New Scientist

Quick quiz #64
Answers

1 Benzene. With the chemical formula C_6H_6, this constituent of crude oil has a central ring of six carbon atoms

2 Electrical resistance

3 Legionnaires' disease, so called because the outbreak occurred at a convention of the American Legion

4 The Ordovician, which ran from 485.4 to 443.8 million years ago

5 Callisto, to complete the list of the four "Galilean" moons of Jupiter first observed in 1610

Puzzle
set by Chris Maslanka

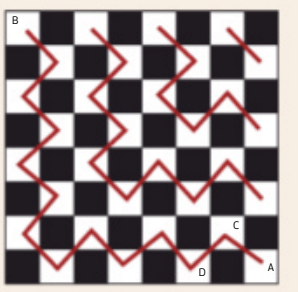
#72 A long lane

The mathematician Professor Numero lives at number 13 Long Lane, the same road as his good friend Professor Lemma, who is at number 156. The friends like that their house numbers when multiplied together are exactly divisible by the two numbers added together. However, Numero has always had his eye on number 28, which he thinks is "perfect". "If only Lemma could also move so that our houses still had the same mathematical relationship," says Numero. Bearing in mind that Long Lane lives up to its name, what is the biggest house number that Lemma could move to?

Answer next week

#71 White lines

Solution



It requires a minimum of four lines to link all white squares. The two white corners (A and B) must be start/end points because they touch only one other white square. Start at A and your first move is to C. The edge square D will be stranded unless the line from C goes into D. The same logic follows around all edge squares which gets you to B. This covers 14 white squares and effectively reduces the problem to a new one with a 6x6 chess board. The same procedure with a new line reduces the board to 4x4. A third line gives a 2x2 board. The final two squares are then covered by a fourth line.

Blackout drinking

Nobody can deny that for those in the right place at the right time, solar eclipses are awe-inspiring displays of nature's majesty. Getting to that right place at that right time, however, is often easier said than done.

Most of the eclipses that Feedback can remember were obscured either by cloudy skies, excessive concern for retinal integrity or by being in the wrong country. Sometimes, possibly, all three at once.

That's why NASA's Jet Propulsion Laboratory ambassador Tony Rice (@rtphokie on Twitter) is getting his plans for the 2023 annular and 2024 total eclipse lined up early.

Observing that the paths of the two eclipses intersected at a spot in Vanderpool, Texas, he dug a little deeper and discovered that the location almost exactly matched that of the Lost Maples Winery – an ideal oasis to wait out Earth's troubles while enjoying the very best that astronomy has to offer.

"Just pointing this out, for planning purposes," Rice tweeted. Feedback will see you there.

JOSIE FORD

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

Honk honk

Depending on your interest in such matters, you may or may not have come across *Untitled Goose Game*, the sleeper video game hit of 2019. The premise is simple enough to explain.

To quote the game itself: "It's a lovely morning in the village, and you are a horrible goose."

Over the course of various situations, the player is urged to control a malevolent goose as it causes small but keenly felt irritation to a broad range of local residents.

Feedback was reminded of the game when we read a story in the *Mail Online* about an electrician who lost his job after accidentally loudly playing the sound of pornography during a council meeting in Worcester, UK.

Modesty forbids us from going too deeply into the details, but suffice it to say that the man in question claimed that the noises originated from a video of a honking goose.

"Council bosses launched an investigation," reports *Mail Online*, "but found that no members of staff said it sounded anything like a goose."

Classic horrible goose behaviour there: making sounds that sound nothing like a goose in order to get somebody into trouble. Disgraceful.

Viva Las Vagus

Feedback is always partial to a good pun. Though let's be honest, we aren't averse to a bad pun now and again either, so long as it ups the word count and keeps our editor unhappy.

Which is why we are grateful to those colleagues of ours who sent through a recently published article in the *Journal of Physiology* all about the functioning of the vagal system and the cranial nerve that gives it its name.

If you would like to find out more about it yourself, look up "What happens in vagus, no longer stays in vagus" by Jordan B. Lee, Lucas J. Omazic and Muhammad Kathia.

Rossy posse

Another week, another chance for some nominative determinism. Come on, we cry, like a desperate parent dragging their child away from their mobile phone for a chance to spend some quality time together. It'll be fun! Promise!

It's off to Scotland this time, where football team Ross County has acquired a new player: goalkeeper Ross Doohan, on loan from Celtic. So far, so mildly mirthful. But, as @G4rve points out on Twitter, this isn't the only goalkeeping Ross County Ross.

Doohan looks set to share the space between the uprights with Rosses Laidlaw and Munro – a 100 per cent Ross rate at the number 1 position.

As if that wasn't enough, they will be joined by midfielder Ross Draper and striker Ross Stewart. Never mind their on-pitch exploits – as far as Feedback's concerned, that roster's going to take some beating.

Where there's a weed

We couldn't get through this week's Feedback without casting an eye over recent appointments in the world of gardening.

Why, you ask? Because we know our readers. If we didn't stop to mention the fact that the new president of the Royal Horticultural Society is Keith Weed, our inbox would undergo some sort of rupture.

The story, as reported in *The Times*, is a veritable raised bed of nominative determinism. "My dad was a Weed but my mother was a Hedges," he said.

What's more, runs the story, "two years ago the organisation discovered that one in eight of its staff had a name associated with nature, the outdoors or horticulture, such as Heather, Berry, Moss, Gardiner or Shears, and various permutations of Rose".

It's hardly surprising to Feedback that the gardening world is such a hotbed of appropriate names: our readers have been pointing this out to us for decades.

Just this week, for example, Peter Slessenger writes in to namecheck Gerard Clover, who is head of plant health at the Royal Horticultural Society, and Dorothy Giacomin points out Guy Shrubsole, a trees campaigner at Friends of the Earth, as well as her old plant sciences lecturer at King's College London: Pete Moore.

Written by Gilead Amit

Looking back

Why hasn't evolution given us eyes in the back of our head or rear-view mirrors?

John Woodgate
Rayleigh, Essex, UK
There are at least two reasons. Eyes are biologically expensive things to make and rear-view eyes don't fit well into the very primitive body plan that mammals inherited. Even mammals for whom rear vision is a prime survival trait, such as rabbits, have only side-facing eyes, with sight to the rear being peripheral, but sufficient to provide an alert.

Humans, and probably some other mammals, do have another adapted sense to compensate. In the 1960s, the world of audio was introduced to "dummy-head recordings", using two microphones placed where the ears would be in a dummy head to capture sound. This creates a 3D stereo experience for listeners using headphones. One particular demonstration recording finished with a whisper close to the back of the head, which caused the listener to react as if to a severe threat.

More nuanced experiments showed that sounds behind the head were noticed by a listener more than sounds to the front, especially if a listener was in a dark room. So our ears can compensate for the lack of rear-facing vision.

You can look at it another way. Rear vision is useful only if potential threats are visible. During human evolution, that was most often not the case.

It is also notable that spiders, which tend to have many eyes, only have them facing forwards.

Jonathan Wallace
Newcastle upon Tyne, UK
There are various aspects to this question. First, it supposes evolution works towards particular goals in a planned way, but that isn't the case.

Genetic mutations arise randomly and are then subject to selection pressures that can allow them to become more widespread within the gene pool if they are beneficial or eliminate them if they aren't.

So one answer is that if a mutation leading to a particular trait, such as rear-facing eyes, doesn't happen in the first place, the trait won't evolve, however advantageous it might seem.

A second factor is that most traits, especially complex ones such as vision, don't spring fully formed into a gene pool, but develop over generations from pre-existing traits and structures.

In the case of vertebrate limbs, for example, we can see how an extraordinary variety of forms and functions have developed from the same basic structure.

What we don't see, though, is vertebrates evolving extra pairs of limbs such that they can have wings and arms for example. It would seem that it is relatively easy for an existing structure to be adapted to new uses, but harder to create entirely new structures.

It may therefore be that the architecture of our central nervous system has simply not lent itself to the evolution of an extra pair of eyes in the back of our head.

Having said this, it is evident that having the ability to spot potential predators creeping up behind us is likely to be beneficial. There are other species that have evolved this ability by moving the position of their eyes relative to the rest of their skull.

Many birds have their eyes positioned towards the side of their skull, allowing them a very wide angle of vision and, in the case of some birds such as the woodcock, they are positioned so they can actually achieve 360-degree vision.

There is a cost to this, though, in terms of loss of binocular vision. Species, such as owls, whose predatory lifestyle requires accurate judging of distances tend to have forward-facing eyes.

This reflects another factor, which is that there may be costs and benefits to any given trait, and for it to evolve, the benefits have to outweigh the costs on average.

Finally, there is often more than one potential "solution" to a given problem. In many species, including most primates, the answer to maintaining 360-degree awareness of surrounding hazards is to rely on many eyes.

Social behaviour is common in the animal kingdom and one reason for this is that there is safety in numbers. You might be looking the wrong way when a leopard approaches, but if your herdmates raise the alarm this is as effective as having eyes in the back of your head.

ROBERT HARDING/ALAMY

How did people who settled the Arctic deal with a lack of sunshine?

This week's new questions

Sundown **How did people in the Arctic in the distant past deal with no sun in winter and weak sun the rest of the year? Did a food provide vitamin D?** ***Sieglinde Kundisch,*** *Abisko, Sweden*

Different views **What exactly occurs in the eyes to make some people short-sighted and others long-sighted?** ***Reece Baptista,*** *London, UK*

On the nail

Germs must accumulate under our nails, especially from the garden, but we don't seem to get infections under them. Is there some kind of natural antibacterial there?

Henrietta Sushames
Wellington, New Zealand
Pathogens under our nails seldom cause nail-bed infections because the nail bed has skin joining it to the nail which fends them off.

Breaking that skin barrier predisposes to infection. This might occur if you chew the sides of your fingernails. Other areas of our bodies rife with bacteria and viruses include our mouth, nose and bowel, but, again, these are protected to a degree by the membranes lining these parts.

When pathogens get to a bit of the body where they can access less protected tissue, for example when we swallow food that is contaminated with campylobacter or norovirus, we get infections more easily. ▮

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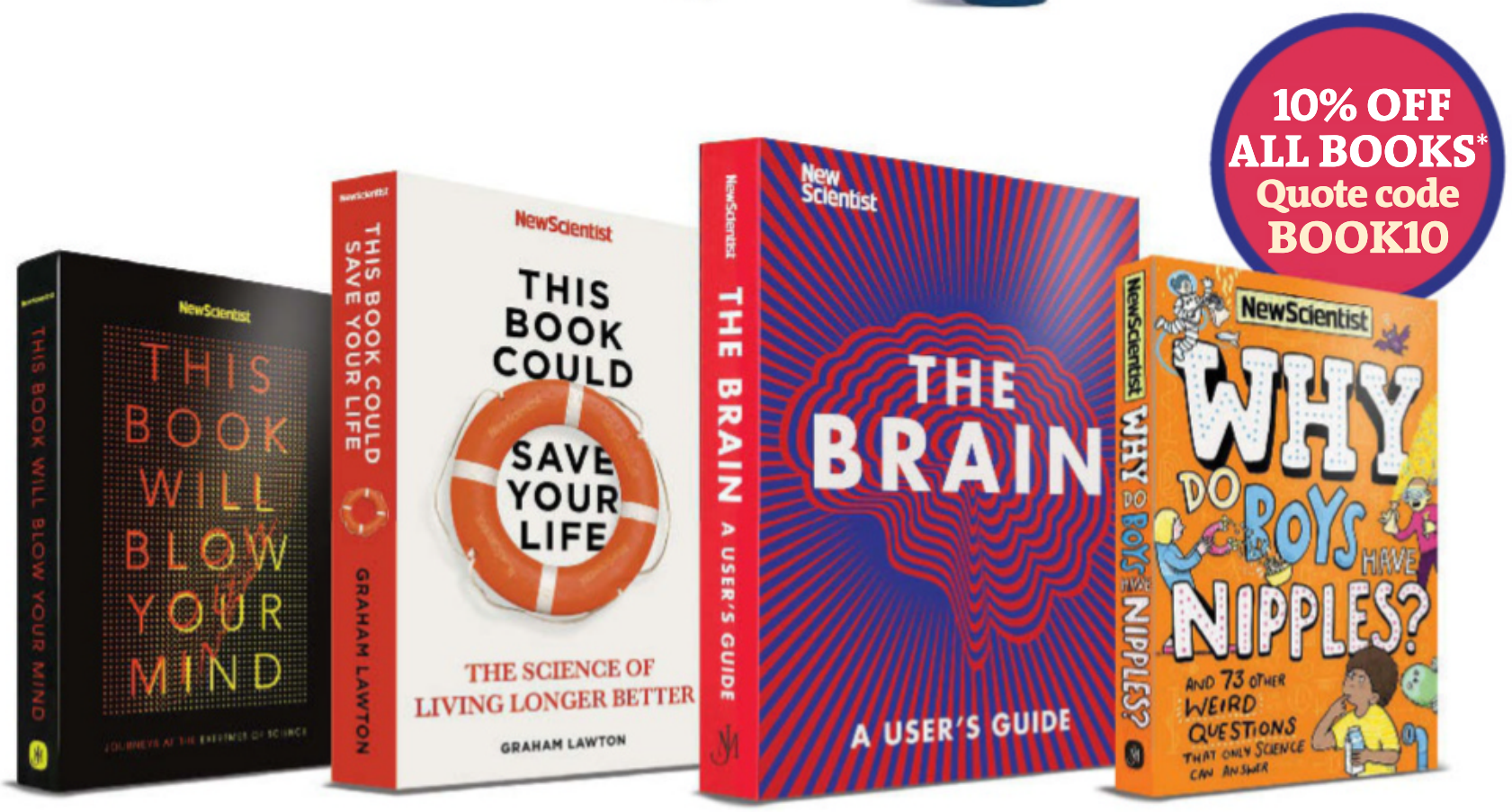

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