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WEEKLY January 23–29, 2021

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Weekly

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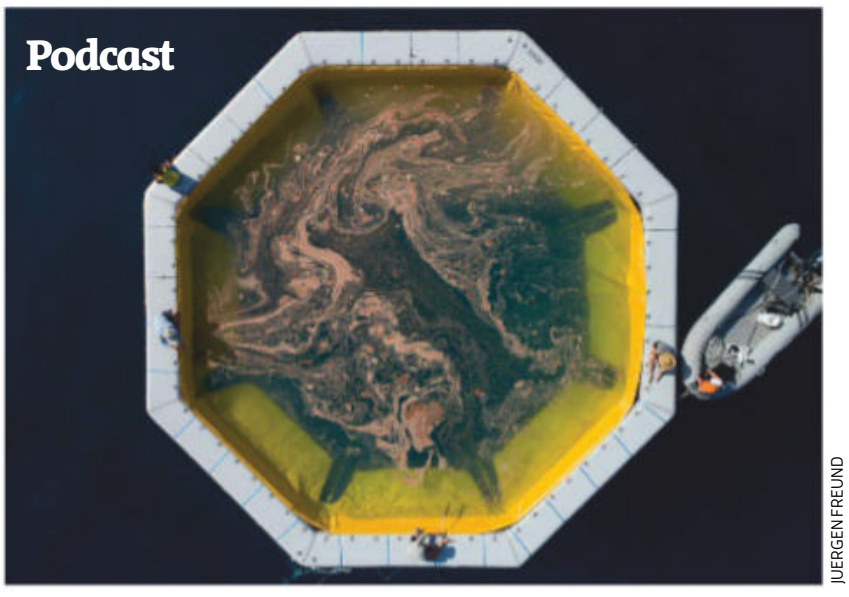

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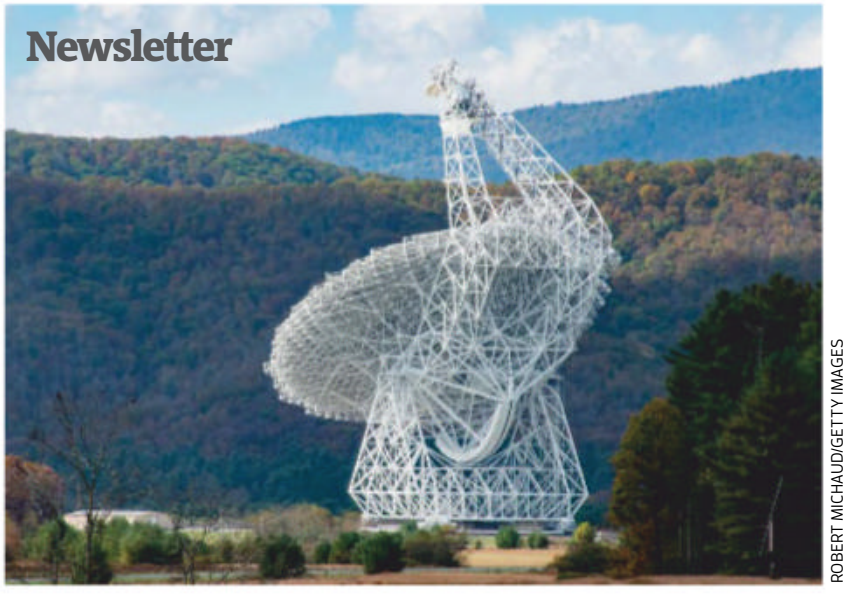

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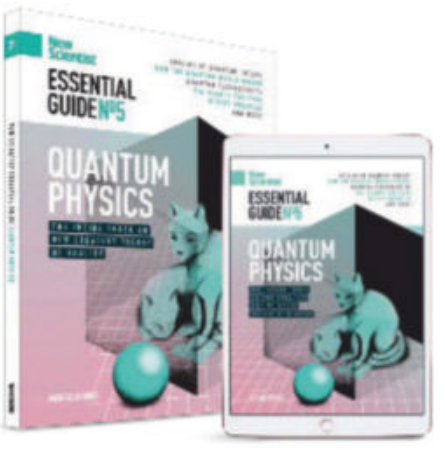

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Covid vaccine dosing, superconductors and coral restoration

Episode 49
New coronavirus variants

Episode 48
Must-know science of 2021: covid, climate and microplastics. Plus culture picks for the new year

Episode 47
Christmas special quiz of the year

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Time to adapt

As the coronavirus mutates, we will need to adjust our approach to it

JUST one month ago, the world was already struggling to contain the spread of the coronavirus. Now the challenge has become even harder. The emergence of new variants with different properties has changed the rules of engagement.

That the coronavirus should evolve isn't surprising – this is what viruses do. Scientists have been sequencing the genome of the SARS-CoV-2 virus since it began spreading out of Wuhan in China, recording the mutations that naturally accumulate as more and more people become infected and pass it on.

This virus evolves mercifully slowly. Until recently, the genetic changes we saw were of little consequence to us, but that has begun to change.

Now the virus has picked up mutations that allow it to spread more easily and, in some cases, that could help it evade our immune system (see page 8).

A faster-spreading virus leads to more infections, as has been seen in the UK and several other countries, and thus, inevitably, to more deaths.

"A virus that can evade our immune system has the potential to reinfect people"

An "escape mutant" virus that can evade our immune response, meanwhile, has the potential to reinfect those who have already had covid-19. Such a variant might even lead to the need for tweaks to vaccines or new treatments (see page 10).

The news of these new variants has coincided closely with the widespread and very welcome roll-out of vaccines against covid-19. These vaccines offer us a way out of the pandemic, but we already knew it would be a long road to vaccinating almost the entire adult population of the globe. The recent evolution of the virus shows us just how long and complicated that road could be.

As we try to work out how best to counter these variants, and what tweaks may need to be made to our vaccines, there is really only one thing we know for certain: the only way to stop the virus from evolving is to stop it from spreading. ▮

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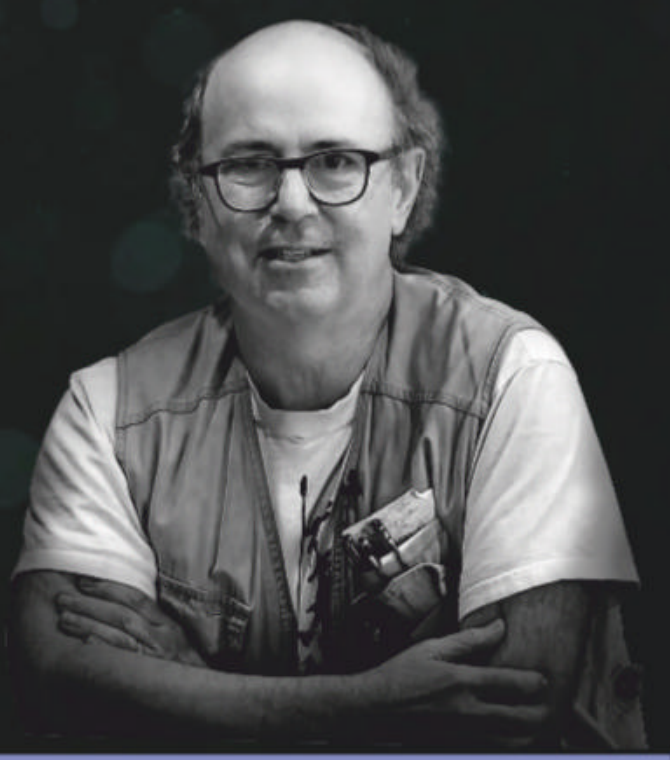

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A street scene near a market in Wuhan, China, this week

The pandemic

Origins of covid-19

The World Health Organization has begun its mission to try to determine the source of the coronavirus, reports **Adam Vaughan**

THE World Health Organization's scientific mission to explore the origins of the coronavirus has only been under way for a few days, but has already been the subject of clashes between the US and China over the investigation's access to people and evidence.

The first of the 13 scientists arrived in Wuhan on 14 January, after visa issues delayed an original 5 January start date.

Led by Peter Ben Embarek at the WHO, the team is currently in quarantine for 14 days in a hotel and talking with Chinese officials, including those at the Chinese Centre for Disease Control.

Members of the mission have said they are having daily covid-19 tests and are being "treated very well".

The polite language contrasts with the verbal sparring between the US and Chinese governments in recent days.

The US state department claimed last weekend that it had reason to believe several staff at the Wuhan Institute of Virology, which has been the subject of debunked claims it was the source of the SARS-CoV-2 virus, had covid-19-like symptoms in autumn 2019.

The US government later called on China to give the WHO team access to samples from the Huanan wildlife market that might have had a role in the outbreak of the virus, as well as to allow interviews with caregivers, former patients and lab workers in Wuhan.

China issued a rebuke on Monday, with *Reuters* reporting that Sun Yang of the China National Health Commission told the board of the WHO: "The virus origin studies are of a scientific nature. It needs coordination, cooperation. We must stop any political pressure."

Such interventions from the US won't assist the scientific mission, says David Heymann at the London School of Hygiene & Tropical Medicine. "I don't think that's helpful at all. They [the WHO team] are the ones that should be making the decisions, and China is a sovereign country."

Although the WHO team is currently quarantined, on its release Heymann says one of the most important things it can achieve is to form good face-to face relationships with Chinese scientists and officials, to lay out a research agenda for the future.

"The polite language of the WHO team contrasts with the verbal sparring between the US and China"

That is the first step to stopping future pandemics, he says.

The mission will probably struggle to pinpoint the origins of the coronavirus, a goal that may never be achieved, says Heymann. "I think it's very difficult to find an animal source of an outbreak like this. It just takes one [spillover] event. Looking for that single event is like looking for a needle in a haystack," he adds.

The WHO has also acknowledged the scale of the challenge. Michael Ryan at the WHO, speaking at a press conference on 15 January, said: "It is a difficult task to fully establish the origins. Sometimes it can take two or three or four attempts."

The investigation into the genesis of the pandemic comes as China battles with a renewed outbreak of covid-19 cases, with clusters in the province of Hebei. The country has recorded more than 200 daily cases in recent days.

The spike, while minor compared with some of the increases seen in Europe, comes ahead of the start of the Chinese new year on 12 February, when millions of people usually travel across the country to take part in celebrations, raising the risk of transmission.

Heymann says the WHO team is likely to want to complete its research before then, to avoid any unnecessary risk. ▮

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

Mutant variants

The coronavirus evolves

Several new viral variants pose added threats – how worried should we be?

Graham Lawton

THE rise and spread of new variants of the coronavirus are seen as ushering in a dangerous new phase of the covid-19 pandemic. But from the virus's perspective, nothing has changed. It is just doing what comes naturally to viruses: evolving.

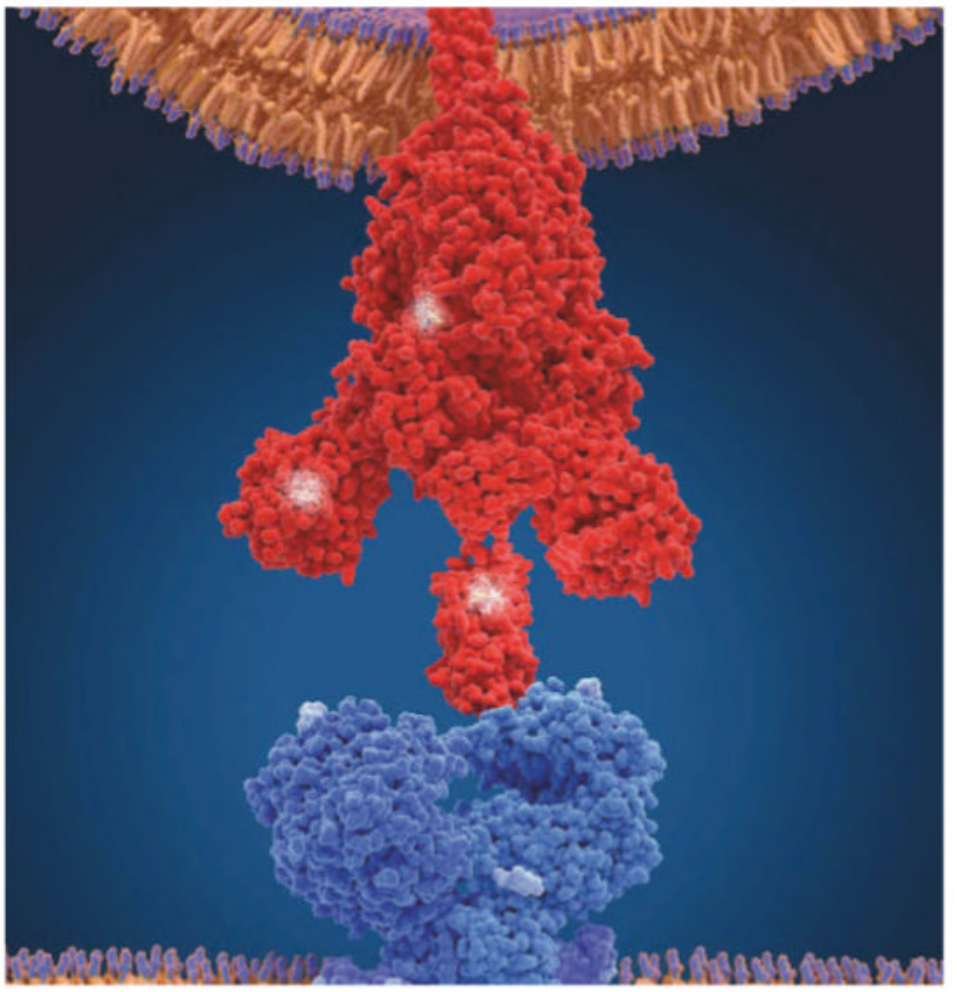
It is now well-established that SARS-CoV-2 is a coronavirus with a large and unusually stable RNA genome, but that doesn't mean it doesn't change at all. Unlike most other RNA viruses, which are among the most mutation-prone biological entities in the world, SARS-CoV-2's genome changes very slowly. This is largely because it has a proofreading function that is efficient at eliminating errors during replication, a major source of the genetic variation that we call evolution.

"There's not masses of evolution occurring, this is a very slow-evolving virus," says David Robertson at the MRC-University of Glasgow Centre for Virus Research in the UK.

A project called Nextstrain, based at the Fred Hutchinson Cancer Research Center in Seattle, compiles all published viral genome sequences and plots them on a family tree. This shows the original virus, called Wuhan-Hu-1, diverging steadily as it spread around the world.

The virus's average mutation rate remains low and steady at about two mutations per lineage per month, but over time this has given rise to thousands of different lineages. For example, there are more than 4000 different versions of the spike protein that the virus uses to break into host cells and which is the target of most vaccines.

Intriguingly, most of the mutations seem to be induced by the human immune system rather than by RNA replication errors.



JUAN GAERTNER/SCIENCE PHOTO LIBRARY

Illustration of the B.1.1.7 coronavirus variant's spike protein (red)

4000

Number of virus variants with different versions of the spike protein for breaking into host cells

10,000

Estimated number of coronavirus genomes sequenced every week in the UK

One arm of our innate immune system is a generalised antiviral weapon that introduces random errors into viral genomes in a bid to neutralise them. It doesn't always succeed.

Most of the surviving mutations are of no medical significance. Up until now, the virus has been circulating unhindered in a large host population with little immunity, and hence has encountered minimal resistance, or selection pressure as evolutionary biologists call it. The evolution that has occurred is therefore mostly just random genetic drift rather than being the virus adapting.

But not entirely. In May 2020, a new variant with a mutation called D614G started circulating. It seems to be slightly more transmissible than the original virus because of an alteration to its spike protein. About 90 per cent of the viruses now circulating worldwide carry this mutation.

More recently, three other mutants, known as the UK, South African and Brazilian variants, have also started spreading rapidly. All are also thought to have mutations that make them more transmissible, and some might be able to outsmart parts

"We are rolling out vaccines to high-risk groups. We may well see a rapid rise in mutations as a result"

of the immune system, although they don't seem to be more deadly.

The sudden appearance of these three new variants doesn't suggest that the virus has upped its mutation rate, says Sudhir Kumar at Temple University in Pennsylvania. They are an inevitable product of time and lots of transmission events between people. Under such circumstances, new variants are bound to arise by chance. Highly transmissible ones have a biological advantage and so will outcompete their more sluggish rivals.

More variants are inevitable. "As the virus mutates, this story will keep repeating itself," says Sharon Peacock, head of the COVID-19 Genomics UK Consortium. The big worry is the emergence of "escape mutations" that enable the virus to dodge the immune system or render vaccines or drugs useless (see page 10).

Such an escape becomes even more likely as we begin to exert selection pressure on the virus in the form of vaccines, natural immunity and drugs. Mutants that can evade these interventions could slip through the net and start circulating wildly, potentially pushing us back towards square one in our efforts to beat the pandemic.

"We are now rolling out vaccination to high-risk groups and this is going to provide a very strong selection pressure," says Emma Thomson at the University of Glasgow. "We may well see a rapid rise in mutations as a result."

We will also have to keep an eye out for viruses that can evade natural immunity, she says. Virologists have already discovered variants that are able to partially evade antibodies.

These are a wake-up call. Even though the UK variant, known as B.1.1.7, doesn't seem to have an escape mutation, the fact that its spike protein is 17 mutations away from the original is "a little bit terrifying", says Robertson.

"It is a concern that a large number of spike mutations are found in the same strain," says Kumar.

One potential danger that we can probably stop worrying about is recombination, which occurs when two related coronaviruses mash their genomes together to create a hybrid. Two studies scouring thousands of viral genomes have found no evidence that this has occurred.

But escape mutation is a real and present danger. A recent case study highlights what could happen once we put the virus under heavy selection pressure. In May 2020, an immunocompromised patient was admitted to a UK hospital with covid-19. He died of the disease in August. Over the 101-day course of his illness, a team led by Ravindra Gupta at the University of Cambridge repeatedly sampled and sequenced viruses from the patient's respiratory tract.

The virus strikes back

The patient was given infusions of an antiviral therapy called convalescent plasma – an antibody-rich blood extract from another person infected with the virus.

Days later, Gupta's team saw a dramatic rise in a mutant version of the coronavirus and later confirmed that it had partially escaped the therapeutic effects of the plasma. This mutant virus eventually killed the patient.

We mustn't draw too many conclusions from this single case, says Gupta. The patient was also being treated for cancer and couldn't mount an effective immune response of his own. But the study shows how quickly and viciously the virus can mutate and escape under selection pressure.

The answer to these threats is surveillance, to flag up and isolate escape mutants before they spiral out of control. The UK's world-class surveillance system relies on a combination of monitoring and sequencing. Red flags are raised if something unusual happens clinically or epidemiologically, and then geneticists search for mutant viruses that could be responsible.

The new UK variant, for example, was spotted because lockdown restrictions were reducing viral spread everywhere but Kent. Surveillance would also be triggered if vaccinated people or those who had recovered started falling ill, says Kumar.

"Even though this virus is evolving slowly, we have to take surveillance very, very seriously"

About 10,000 genomes a week are sequenced in the UK and there are plans to up that to 20,000 by March. The country also has a new body called the G2P-UK National Virology Consortium to keep track of new mutations and warn about potentially dangerous ones.

"Even though this virus is evolving slowly, we do really have to take surveillance very, very seriously," says Robertson. ▮

What are the new coronavirus variants?

THERE are tens of thousands of variants of the SARS-CoV-2 virus that differ from each other by at least one mutation, according to sequencing studies that track its spread and monitor how it is evolving.

Many of these variants die out, but others spread and acquire further mutations. Overall, though, the coronavirus hasn't changed much. Any two SARS-CoV-2 coronaviruses from anywhere in the world will usually differ by fewer than 30 mutations, and they are all still regarded as one strain.

In early December, scientists looking for reasons for a rapid growth of case numbers in Kent in south-east England, noticed that one variant, now known as B.1.1.7, was spreading faster than others. The evidence that it is more transmissible is growing ever stronger.

This variant is spreading faster than different variants in other regions of the UK and in at least three other countries: Ireland, Denmark and Switzerland. It has reached many other countries, too, but because most countries sequence far fewer samples than the UK or Denmark do, it isn't yet clear whether it is outcompeting other variants in these countries as well.

Initial studies suggest that B.1.1.7 is about 50 per cent more transmissible than other variants. This might not sound like much, but it makes a huge difference over time.

Another new variant, known as B.1.351, was discovered in South Africa after an unusual surge in coronavirus cases beginning in October. It is thought to spread faster too, but there is less evidence than for B.1.1.7.

Why these variants spread faster is unclear (see page 11). B.1.1.7 has 17 defining mutations, and B.1.351 has nine. The overall number of mutations isn't unusual and many of them have been found before.

There has been much focus on the only mutation common to both viruses, known as N501Y. However, this was first seen last April, in Brazil, and a variant with it circulated in Wales for a while, so this alone cannot explain the higher transmissibility.

With many countries now looking for the new variants, reports are emerging of other versions with similar changes. In particular, the P.1 variant found in Brazil has nearly the same three mutations in the spike protein as B.1.351.

Reports of two new variants have also emerged in the US, one of which also has the N501Y mutation, as well as another mutation seen on B.1.1.7. However, it remains unclear if any of these other variants also spread faster.

B.1.1.7 and its ilk will continue to change, so there is a risk they could become even more dangerous. The more people they infect, the more chances there are for these viruses to evolve further.

Michael Le Page

Immunisation

Will vaccines work on new variants?

Some coronavirus variants seem able to partly dodge the immune system, but there is still hope for our vaccines, reports **Michael Le Page**

NELSON ALMEIDA/AFP VIA GETTY IMAGES

Production of the Sinovac vaccine in Brazil, with roll-out imminent

SOON after vaccination began in many countries, reports of faster-spreading coronavirus variants triggered fears that vaccines might not protect against them. The good news is that initial studies suggest that the existing shots will still work, although they might be slightly less effective against two variants, one that emerged in South Africa and one from Brazil.

"I am optimistic that current vaccines will remain quite useful," says Jesse Bloom at the Fred Hutchinson Cancer Research Center in Seattle. "But I do expect that eventually it will be necessary to update vaccines to account for viral evolution."

Antibodies are our main defence against viruses. When we get infected by a new virus, our immune system starts producing a range of antibodies that bind to various parts of viral proteins.

Not all antibodies are equal. Studies show that only a few antibodies can "neutralise" viruses and prevent infections. These neutralising antibodies bind to key sites on viral proteins.

For the coronavirus, one such site is the part of its so-called spike protein that binds to receptors on human cells and helps the virus get inside – the receptor binding domain. If this part of the spike protein changes, neutralising antibodies may not bind as well.

A rapidly spreading variant named B.1.1.7, first spotted in the UK, has only one mutation that affects this binding domain. Initial studies of antibodies from those previously infected by the coronavirus or given the Pfizer and BioNTech vaccine show little or no drop in effectiveness against B.1.1.7.

The variant from South Africa, called B.1.351, is of more concern. It has three mutations in the binding domain, including one named E484K as it occurs at a site called E484. The variant from Brazil, known as P.1, has almost the same three mutations.

According to a computer model, B.1.351's spread can be explained by this variant being 50 per cent more transmissible or 20 per cent better at evading immunity in previously infected people, when compared with previous variants. Lab studies point to the latter.

Bloom and his team have tested how mutations in the binding domain alter the effectiveness of antibodies from people who have been infected with the coronavirus. Mutations at the E484 site made the biggest difference, with neutralising activity falling as much as tenfold.

While that sounds alarming, current vaccines work so well that even a big drop in neutralisation might not substantially reduce protection, says Bloom. The antibodies might not be as effective, but they still get the job done. There were also differences between individuals: antibodies from some worked just as well.

More evidence comes from a study by Rino Rappuoli at GlaxoSmithKline Vaccines in Italy. When his team grew the virus in the presence of antibodies from a previously infected person, E484K was one of three mutations that let the virus become resistant.

> "A mutation in the variants from Brazil and South Africa may help the virus evade antibodies"

These findings suggest that the spread of B.1.351 and P.1 is due to the E484K mutation helping the virus evade antibodies and reinfect people who have already had covid-19. "Whether on top of this they are more infectious, I don't know," says Rappuoli.

There have been reports of reinfections in South Africa, Salim Abdool Karim, an epidemiologist advising the nation's government, said in an online presentation. There has also been a report of a woman in Brazil having more severe symptoms the second time round. But such reports are to be expected, said Karim, and in South Africa there is no evidence of a systematic rise in reinfections.

This could be because testing how well antibodies neutralise viruses outside the body doesn't tell the whole story. The so-called T-cell response is also important. T-cells spot an infected cell by detecting viral proteins on its surface, and then destroy it before it releases more viruses.

"T-cells can be incredibly valuable at preventing disease," says Shane Crotty at the La Jolla Institute for Immunology in California. "They can do it so well that the person never gets sick."

Crucially, an effective T-cell

response only requires the recognition of viral proteins, rather than the blocking of their function. This means it is harder for resistance to evolve because no single site is crucial.

The T-cell response to the coronavirus is broad, involving many parts of the spike protein as well as other proteins. "There is no way these variants are escaping T-cell immunity," says Crotty. Unfortunately, while T-cells can stop people getting symptoms, they cannot prevent infections.

The bottom line is that existing vaccines should still protect against B.1.351 and P.1, but might be slightly less effective. And there is a danger of these variants or others evolving to be much better at evading vaccine protection.

Escape variants

This means we need to step up surveillance so we can spot any such "escape variants" early and have time to update vaccines, says Angela Rasmussen at Georgetown University in Washington DC.

"It is unlikely that, overnight, a variant is going to emerge that is capable of completely evading the vaccine," she says. "But if we are not looking, then we might not find them until it's too late."

Scientists are already looking at how to update the vaccines and it will be relatively easy to update most of them. The main delay could be getting them approved. *New Scientist* asked regulators in the UK, US and Europe what manufacturers would need to do.

None has yet decided on the process, but some pointed to the updating of seasonal flu vaccines as a possible precedent. Updated flu vaccines don't have to undergo clinical trials, so the process could be rapid. "I believe it can be done very quickly," says Rappuoli. ▮

International spread

The global threat of the coronavirus variants

Michael Le Page

THE more infectious coronavirus variant from the UK has gone global, causing fears that it could lead to a new wave of infections and deaths around the world in coming months if not brought under control. That brings new urgency to vaccination efforts.

The B.1.1.7 variant has so far been reported in 55 countries. There is no evidence that it is more deadly, nor that it is yet spreading locally outside Europe and North America. But initial studies suggest that it is around 50 per cent more transmissible.

That is actually a bigger problem than if it were more deadly, says Adam Kucharski at the London School of Hygiene & Tropical Medicine.

A simple calculation illustrates why. Suppose 10,000 people are infected in a city and each infects 1.1 other people on average, the low end for the estimated rate of infection in England now. After a month, 16,000 people would have been infected. If the infection fatality rate is 0.8 per cent, as it was in England at the end of the first wave of infections, it would mean 128 deaths.

With a variant that is 50 per cent more deadly, those 16,000 cases would result in 192 deaths. But with a variant that is 50 per cent more transmissible, though no more deadly, there would be 122,000 cases after a month, leading to 976 deaths.

55

The number of countries with reported cases of the UK variant

To halt a surge in UK cases partly due to B.1.1.7, England and Scotland this month joined Wales and Northern Ireland in strict lockdown. By the start of this week, all parts of the UK had brought in tougher travel rules.

Last month, Ireland began a strict lockdown after reporting the fastest growth rate of any country in coronavirus cases.

One reason was relaxed restrictions in early December, with pubs and restaurants reopening, says Kingston Mills at Trinity College Dublin. But by last week, nearly half of all new cases were due to B.1.1.7. "I think it was a combination of both," he says.

Efforts are under way to contain a new variant in Pretoria, South Africa

PHILL MAGAKOE/AFP VIA GETTY IMAGES

The B.1.1.7 variant is now spreading locally in other nations in Europe and in some US states.

Given that the US is already hard hit and unlikely to use lockdown-type measures, Angela Rasmussen at Georgetown University in Washington DC says this is a big worry. "When you already have uncontrolled transmission and then you add another variant that is more transmissible, you are going push the healthcare system past its limit," she says.

Elsewhere in the world, most reported cases of B.1.1.7 are in travellers, says Áine O'Toole at the University of Edinburgh, UK. That means it may not yet be circulating locally and there might be time to keep it out, she says.

Yet many countries may be finding the variant only in travellers because they aren't doing genetic sequencing for local cases, says O'Toole. Most countries did little sequencing until recently, so B.1.1.7 could be spreading undetected in places.

The spread of the B.1.351 variant from South Africa appears more limited. Though more than a dozen countries have reported cases, it is only known to be transmitting locally in Botswana, Zambia and the UK, says O'Toole. The similar P.1 variant that originated in Brazil has only been found in travellers in Japan so far.

These variants might be dominating in South Africa and Brazil because they seem slightly better at evading the immune response in previously infected people and these countries have had high levels of infections, says Rino Rappuoli at GlaxoSmithKline Vaccines in Italy. If so, the variants will have no transmission advantage in countries with low levels of immunity. But this will alter as vaccination ramps up. ▮

The long view

The coronavirus could end up mild like a common cold

Anthony King

POLICY-MAKERS are scrabbling to contain the spread of the coronavirus, as more highly transmissible variants travel around the world. Yet the evolution of SARS-CoV-2 in this way comes as no surprise to virologists. In fact, it is probably just one step on a much longer evolutionary trajectory. In time, virologists predict, the virus will become more benign, following an evolutionary pathway previously taken by four other human coronaviruses that today cause nothing more than the "common cold". How could this happen, and how will our actions play a part?

Coronaviruses tend to evolve slowly compared with other RNA viruses because they proofread their genetic material as they replicate, so can filter out mutations. What's more, SARS-CoV-2 isn't currently under much pressure to change, says virologist Ralph Baric at the University of North Carolina at Chapel Hill. It is successfully colonising a new species – with an open banquet of hosts – and variants that spread faster are outcompeting others.

But evolutionary pressures are starting to kick in. As the virus encounters increasing resistance from antibodies among people who have been infected or vaccinated, new mutations become more likely to take hold. Indeed, some experts suggest that the new variants we currently see arose inside the bodies of people with long-lasting infections.

Lab studies back up this idea. "Some of these variants emerged in vitro when the virus was cultured for several days in the presence of convalescent plasma," says Manuela Sironi, an evolutionary virologist at the Scientific Institute IRCCS Eugenio Medea in Italy.

We don't know exactly what mutations might increase the speed at which the virus can spread. SARS-CoV-2 has four main structural proteins, including the spike protein that sticks out from its surface and helps it attach to cells in the body, as well as non-structural proteins that hijack the machinery inside host cells.

Changes in transmission would probably involve mutations in the spike, which is targeted by the vaccines, says Sironi.

It is impossible to say which mutations would make SARS-CoV-2 more or less deadly. "That is more casino than science at the moment," says Marc Van Ranst at KU Leuven in Belgium. "There are a gazillion possible mutations."

LUIS ALVAREZ/GETTY IMAGES

Familiar trajectory

It is also difficult to predict whether SARS-CoV-2 will evolve to be more harmful, says Sironi. But Van Ranst is optimistic. "Its aim is not to kill us or make us sick," he says. "The virus is successful when it is unnoticed and gets transmitted easily."

Most virologists tend to agree, suspecting that SARS-CoV-2 will follow a similar evolutionary trajectory to the four endemic coronaviruses that cause the "common cold", prosaically called 229E, HKU1, NL63 and OC43.

Covid-19

Why eradication is unlikely

VACCINE roll-out in a growing number of countries should eventually allow life to return to normal, but it is unlikely that we will be able to eradicate the coronavirus that causes covid-19 altogether.

"I don't see that these vaccines will be eliminating SARS-CoV-2 any time in the coming years," says Kingston Mills at Trinity College Dublin.

Despite the many variants, the coronavirus mutates less than many other viruses. "It does not seem to be as mutable a virus as influenza," says Mills. That means we shouldn't need to update vaccines every year, although occasional tweaks might be required.

Despite this, wiping out the virus will be really hard even if we manage to vaccinate most people. To stop a disease spreading, infected individuals must pass it on to less than one other person on average.

Early in the pandemic, infected people were infecting around three others on average, leading to estimates that two out of three people, or 67 per cent, need to be immune to halt transmission. This is what we mean by herd immunity.

Some people now think 70 to 90 per cent of the population may have to be immune to achieve this,

"Even vaccinating everyone on the planet might not stop the coronavirus circulating"

especially with more transmissible variants. This could be hard to do. Some covid-19 vaccines don't reach this level of effectiveness when it comes to preventing disease.

What is more, it isn't yet clear to what extent any of the vaccines prevent transmissible infections, as opposed to merely preventing symptoms, although this is still being investigated.

A few vaccines, such as the one for whooping cough, prevent symptoms, but don't block transmission, says Mills.

People at a supermarket in Germany using face masks to protect against covid-19

If so, we, as hosts, will be a crucial driver in this change. The key here is that people never seem to first encounter these endemic coronaviruses as adults. In 2013, scientists at the Chinese Center for Disease Control and Prevention (China CDC) in Beijing measured antibodies for these four common viruses. The type of antibodies generated by a first infection (immunoglobulin M, or IgM) were found only in children. Becoming a "common cold" is as much about us as the virus, says Baric. "My guess is that many of these common coronaviruses, if introduced directly into a very, very naive population of adults, would probably be pretty brutal."

Baric believes that as SARS-CoV-2 bumps into more resistance in adults, it may be pushed to evolve in this direction. "It is possible the virus has to change a little just to maintain itself in children," he says. It may evolve to escape immunity by being able to better replicate in the nose, and so turn into an upper respiratory infection, like the other endemic coronaviruses. These occasionally cause serious disease in children, but usually result in little more than a runny nose. "Children typically have less severe disease than adults," says Baric.

If SARS-CoV-2 follows this pattern, then it should become much less deadly. Other coronavirus infections in healthy adults are usually mild, but reoccur. A 1990 experiment revealed that adults infected with 229E were open to reinfection one year later. The China CDC antibody study also found that 70 per cent of adults had antibodies for the four endemic coronaviruses. Every two to three years, it seems people become more susceptible to these viruses, says Baric. They are re-infected, but retain enough immune memory to fight off severe disease and experience only mild symptoms. Reinfection seems to act as an immune booster.

4

Endemic coronaviruses cause the common cold

"Even without relevant genetic changes, SARS-CoV-2 might eventually turn into the fifth endemic coronavirus," says Sironi.

Recent modelling by epidemiologist Jennie Lavine at Emory University in Atlanta, Georgia, and her colleagues supports this, concluding that once the virus is endemic and first exposure is in childhood, SARS-CoV-2 will be relegated to a common cold. "Primary infections tend to be more severe, especially in older people," says Lavine. "As primary infections increasingly are restricted to children, we expect the disease severity to overall become mild."

Unknown timescale

This has all happened before, according to Van Ranst, who in 2005 reported that OC43 probably jumped to people from cattle and triggered a pandemic in the late 19th century dubbed the Russian flu. The bad news is that we don't know how long it took OC43 to dilute to a common cold virus or when SARS-CoV-2 will join the endemic club. "Our model suggests that the quicker people get exposed, the quicker we get to that mild state," says Lavine. Without vaccines, that would push up deaths.

What's more, endemic coronaviruses can still cause pneumonia in older people. In 2003, when a disease ran rampant in an elderly care home in Canada and killed one in 12 of the residents that it infected, a coronavirus was suspected. It turned out to be OC43. So even a much tamer SARS-CoV-2 may still be a threat to older people for a long time to come. ▮

This means that viruses – or bacteria in the case of whooping cough – can circulate largely undetected, popping up only when they spread to unvaccinated people and cause disease.

In other words, even vaccinating everyone on the planet might not be enough to stop the coronavirus circulating at low levels, and we are unlikely to get close to this.

In some countries many people say they will refuse the vaccine, such as France, where only 4 in 10 people want it. And no vaccine is yet approved for people aged under 16, who make up a quarter of the world's population.

CHRISTOPHER FURLONG/GETTY IMAGES

While vaccines offer hope, they are no guarantee that the coronavirus will be eradicated

However, we don't have to rely entirely on vaccines to achieve herd immunity. A study by Susan Hopkins at Public Health England and her colleagues suggests that natural infection with the coronavirus provides comparable protection, reducing the risk of reinfection by 83 per cent for at least five months.

Even if we did manage to eradicate the virus in humans, it might lurk in animals and jump back into people later on. SARS-CoV-2 can infect several other species, including cats, dogs, ferrets, bats, hamsters, deers and tree shrews.

"I think this virus is here to stay," says Hopkins, who points out that the smallpox virus is the only one we have managed to eradicate, and that took many years from the start of the campaign to eliminate it. ▮

Michael Le Page

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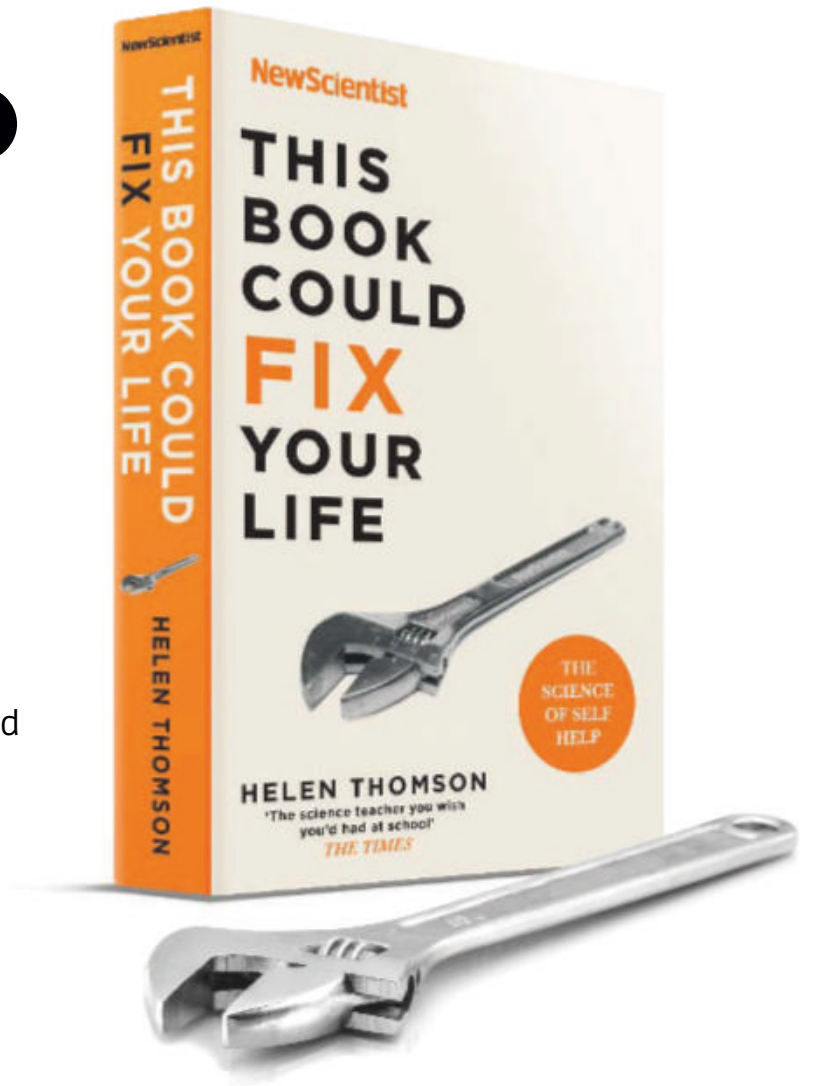

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Origins of life

How water makes life possible

Our understanding of water's role in the reactions of life is being overturned

Michael Marshall

WATER is essential for life as we know it, but why? A new analysis may rewrite the idea that it is solely the medium in which the reactions that drive life occur, instead viewing it as an active participant. The findings offer clues to the role that water played in the beginning of life on Earth, suggesting it may have "selected" the chemicals that now form the basis of life.

"While the importance of water in life is well known and appreciated, the involvement of water as the most reactive chemical participant in today's biochemistry was not well appreciated," says Moran Frenkel-Pinter at the Georgia Institute of Technology in Atlanta.

Water is often viewed as the background in which all the other chemicals, such as DNA and protein, are dissolved – in other words, the stage on which the real business of life happens. To show how active water really is, Frenkel-Pinter and her colleagues turned to a database of biochemical reactions. Out of 6500 known reactions, around 40 per cent of them either made a molecule of water or destroyed one.

That is a conservative estimate, says team member Loren Dean Williams, also at the Georgia Institute of Technology, because the precise mechanisms of many reactions aren't known and may depend on water in subtle ways.

The team also looked at the molecules produced during the life cycle of a well-studied bacterium called *Escherichia coli*. More than 99 per cent of these are water molecules, the team estimates. Each time an *E. coli* divides to form two new cells, every water molecule it contains is either transformed or drives a chemical reaction 3.7 times on average (*Journal of Molecular Evolution*, doi.org/fq3f).

"I do think there is this tendency to view water as a background actor," says Lena Vincent at the University of Wisconsin-Madison. The study "confirmed something that we already appreciated and suspected, but didn't fully grasp the extent of", she says.

Before the first living cells arose, Earth was home to a vast array of non-living chemicals that were constantly interacting and changing. Somehow, this "chemical evolution" gave rise to complex and self-sustaining structures that we would recognise as living organisms.

"The basic model we have is that organic molecules were created in the atmosphere... and they snowed down on the Earth," says Williams. There they encountered water in vast quantities, both in the seas and on land. The sheer quantity of water meant it exerted a huge influence on which chemicals survived and became part of life, and which didn't.

"There were many molecules that did not play well with water," says Frenkel-Pinter. "They were excluded, and the surviving molecules were the ones that were soluble in water." That much has long been clear, but she says that as well as needing to dissolve in water, the chemicals of life also had to be able to react with it. "This is how they were selected." ▮

A yellowbar angelfish swimming past corals in the Red Sea

JANE GOULD/ALAMY

Space

NASA gives up attempt to dig below Martian surface

NASA's "mole" on Mars has failed. After about two years of attempting to dig the InSight lander's heat probe – nicknamed the mole – into the Red Planet's surface, engineers have finally given up.

The InSight lander arrived on Mars in November 2018. Its main purpose is to study the planet's interior to help us understand the history of the solar system's rocky worlds. The lander has three main instruments to help it do that: a seismometer to catch vibrations travelling through the ground; a radio to precisely measure Mars's rotation and learn more about its metal core; and a set-up called the Heat Flow and Physical Properties Package (HP³) to measure the heat flowing out of the planet's centre.

The mole is a key part of HP³ and is a sort of self-hammering nail designed to burrow about 5 metres under the ground, deeper than any human-made device has dug on any rocky planet, moon or asteroid before. However, once the mole started its ill-fated burrowing attempts, the soil proved to be unexpectedly clumpy, so it didn't provide the instrument with the friction it needed in order to dig.

The scientists working on the mission tried everything they could think of to get the mole into the ground, even pressing down on it with the scoop on InSight's robotic arm. Nothing worked, so after a final attempt on 9 January, the team has now ended its efforts.

"We've given it everything we've got, but Mars and our heroic 'mole' remain incompatible"

"We've given it everything we've got, but Mars and our heroic mole remain incompatible," said Tilman Spohn at the German Aerospace Center, the leader of the HP³ team, in a press release. "Fortunately, we've learned a lot that will benefit future missions that attempt to dig into the subsurface."

While that particular instrument didn't work, InSight's other tools are performing well. The seismometer has already recorded nearly 500 marsquakes, and NASA has extended the mission until December 2022. ▮

Leah Crane

Physics

Superhuman sight in reach with lens that makes UV visible

Matthew Sparkes

A SERIES of coated lenses can allow people to see ultraviolet (UV) light superimposed onto the visible spectrum, extending the range of our senses without the need for electronic devices.

UV imaging can be used to diagnose skin conditions or detect faults in electrical systems. It can also help reveal normally camouflaged objects, which is perhaps why animals such as reindeer have evolved to see some forms of UV light.

There are already some devices for viewing UV light, but they have a major drawback in that they block the normally visible spectrum of light – you can see UV light, but nothing else.

Mikhail Kats at the University of Wisconsin-Madison and his colleagues have created an experimental system that allows visible light to pass through, which means it allows a viewer to see as normal, while also perceiving UV light.

The group coated a lens with crystals just 10 nanometres wide. These nanocrystals light up when hit by UV light, and further lenses focus the rays the crystals give off into a clear image. The UV light is transformed into visible green light, which is overlaid on a normal view (arxiv.org/abs/2101.02837).

Currently, the device's lenses are set up across a table, but Kats hopes that future research will shrink the apparatus until it becomes wearable. It could also be possible to add infrared vision to expand the visible spectrum in both directions at the same time.

"It enhances your range of perception, it gives you the ability to see some things that are hidden," says Kats. "You're getting towards the Geordi La Forge viewer from *Star Trek*. Having a bit of extra range in the spectrum is quite valuable." ▮

Conservation

Hope of saving rhino from extinction remains alive

Gitonga Njeru

BEN CURTIS/AP/SHUTTERSTOCK

The last two northern white rhinos, Najin and Fatu, are both female

THE northern white rhino may be able to avoid extinction for a while longer. Fertilised eggs are set to be implanted in the two remaining rhinos this year in the hope of producing offspring.

"There is still some hope left that we can save the white rhino species," says Thomas Hildebrandt at the Leibniz Institute for Zoo and Wildlife Research in Berlin, Germany, who is part of an international team working to do just that. However, time isn't on our side, he says.

The last male northern white rhino, named Sudan, died in March 2018. The only remaining northern white rhinos are two females: Najin and her daughter Fatu, both of which live in the Ol Pejeta Conservancy, a protected wildlife area in Kenya.

In 2019, Hildebrandt and his colleagues at Ol Pejeta retrieved 10 eggs from Najin and Fatu. These were then fertilised using a technique called intracytoplasm sperm injection with stored sperm from Sudan. The process resulted in two viable embryos.

The team now plans to implant the embryos in Najin and Fatu. This could happen in the next few months, but it may take longer, partly because of impacts from the covid-19 pandemic.

The gestation period of a northern white rhino is between 16 and 18 months,

"The success rate is unlikely to be high, so the team is also trying to create hybrid embryos"

so it will be a while yet before we know if there will be any more northern white rhinos.

"We hope to implant very soon as we are now more sure than ever that it will work," says Hildebrandt. "In the next few months, we hope to have a major announcement."

"Insemination will take place as soon as possible in the near future, but before 2022," says Elodie Sempere at Ol Pejeta.

White rhinos are split into two subspecies. There are northern white rhinos (*Ceratotherium simum cottoni*), the last of which live in the Ol Pejeta Conservancy, and southern white rhinos (*Ceratotherium simum simum*), found in southern Africa.

Southern white rhinos are faring much better than their northern counterparts and currently number about 20,000. However, both are at risk from poaching. The northern white rhinos are under 24-hour armed guard.

Other methods are also being worked on to save the northern white rhino from extinction. The success rate of embryo implantation is unlikely to be high, so the team is trying to create hybrid embryos too, using southern white rhino eggs and stored northern white rhino sperm. These would then be implanted in female southern white rhinos.

A third option being explored is taking stored cells from some of the last northern white rhinos and converting them into stem cells. These stem cells could then be used to make both sperm and eggs. Embryos produced in this way would also be implanted in southern white rhinos. However, this technology is unproven.

Even if attempts are successful, the resulting northern white rhino population will have a very low genetic diversity because the samples all come from a few individuals. This could make the population vulnerable to disease. ▮

18+

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Physics

A sea of gravitational waves?

We have found hints that the whole cosmos may be awash with strange ripples

Leah Crane

EVERYTHING in the universe is constantly being stretched and squeezed by disturbances in space-time that are caused by the movements of massive objects.

Now, astronomers may have caught the first glimpse of this sea of gravitational waves permeating the entire cosmos, known as the gravitational wave background.

It is the result of work by the North American Nanohertz Observatory for Gravitational Waves (NANOGrav) consortium, which used a so-called pulsar timing array to attempt to build a sort of map of gravitational waves.

The NANOGrav researchers analysed data gathered on 45 pulsars over the course of 13 years and found a gravitational wave signal that was identical across multiple pulsars. This strange, low-frequency hum could be the first evidence of the gravitational wave background.

Pulsars are neutron stars that rotate extremely rapidly and regularly, sending out beams of light that act as "ticks" in extremely precise cosmic clocks.

When a gravitational wave passes through the same region of space-time as those beams of light are travelling through, it makes the light appear to take slightly more or less time to reach us, meaning the "ticks" from a pulsar seem irregular. Using pulsar timing arrays requires radio telescopes to observe the signals from many pulsars simultaneously.

"These pulsars are spinning with millisecond periods and we are able to detect changes in the time of arrival [of signals]... at the hundreds of nanosecond level," said Joe Simon at the University of Colorado, Boulder. He presented the new work at a virtual meeting of the American Astronomical Society on 11 January.

"We are seeing incredibly significant evidence for this signal," said Simon.

However, to prove that this is coming from the gravitational wave background, we would need to see a distinctive pattern in the gravitational waves affecting each pulsar. Gathering the additional data necessary to find that pattern should only take about a year, Simon said, although analysing it may take longer.

"This will tell us more about black holes in the universe, especially supermassive ones in galactic centres"

If the signal is in fact the gravitational wave background, it will be a useful tool for understanding the most massive objects in the universe.

"This will tell us more about black holes in the universe, and especially the supermassive black holes in galactic centres," says Nelson Christensen, who is at the Observatory of Nice in France. "This NANOGrav signal is likely from [black hole] binaries with billions of solar masses," he says. As these enormous pairs of black holes merge, they emit thrums of gravitational waves powerful enough to persist throughout space-time.

The latest research will build a bridge between the gravitational waves we have already spotted coming from smaller black holes with the Laser Interferometer Gravitational-Wave Observatory (LIGO) and Virgo detectors, and those from supermassive black holes, says Christensen.

Such a bridge will help us understand how different types of black holes form, how galaxies evolve with the black holes within them, and maybe even to comprehend the larger mysterious forces at work in our universe like dark matter and dark energy. ▮

Machine learning

AI dog-trainer could teach your pooch how to sit

ARTIFICIAL intelligence could train your dog for you while you are out at work. A prototype device can issue basic commands to your pet, recognise if they are carried out and provide a treat if they are.

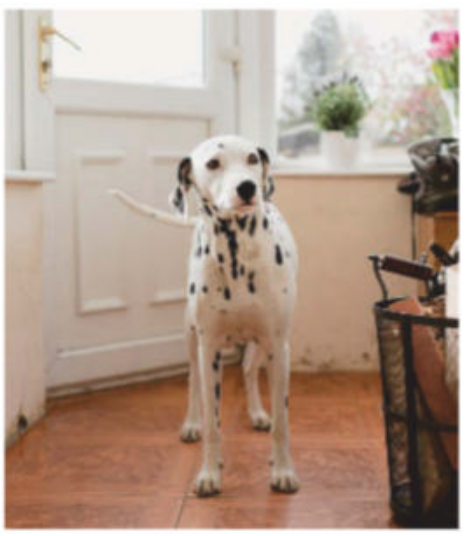
Jason Stock and Tom Cavey at Colorado State University used more than 20,000 images showing a range of breeds to train an AI to identify when dogs were sitting, standing or lying down.

The AI is a convolutional neural network – a type of algorithm often used in image processing that can break down pictures into smaller component parts to help it classify what is shown. Overall, the algorithm managed to achieve 92 per cent accuracy.

The AI was then combined with a moveable camera, a speaker for issuing instructions and a dog treat delivery tube to create an automated trainer (arXiv, arxiv.org/abs/2101.02380).

How the system did in telling a prone dog from a standing one varied depending on what part of the image it looked at. "If the AI was looking at the legs, for instance, it would do better, as opposed to looking at the shape of the back or some other feature," says Cavey.

Cavey says his motivation for the project came from finding it hard to keep his hyperactive Australian shepherd dog entertained while he was out at work.



SOLSTOCK/GETTY IMAGES

Dogs could be given treats for obedience by an AI when left at home

"It is a step forward and an exciting area," says Ilyena Hirskyj-Douglas at Aalto University, Finland, who has a PhD in dog-computer interaction. "Yet it is also ethically precarious as computers are not able to recognise the welfare of dogs as effectively as humans."

Dirk van der Linden at Northumbria University in the UK also praises the tech while having some qualms about it. "It's the automating of the human-dog relationship that I think is increasingly problematic, because it is using a technological fix for a very valuable interspecies relationship that caregivers ought to keep working on," he says.

That is something Cavey is aware of. "Our future work would be to look and see what is a good emotional state, rather than good behaviour," he says. ▮

Chris Stokel-Walker

Technology

Quantum internet signals sent using drones

Matthew Sparkes

ENTANGLED photons have been transmitted between two drones hovering a kilometre apart, demonstrating technology that could form the building blocks of a quantum internet.

When a pair of photons are quantum entangled, you can instantly deduce the state of one by measuring the other, regardless of the distance separating them. This phenomenon, which Albert Einstein dismissively called "spooky action at a distance", is the basis of quantum encryption, using entangled particles to ensure that communications are secret.

Quantum networks are far more secure than the existing internet because any attempt to eavesdrop changes the state of the photons, alerting the recipient to foul play.

Transferring information directly using entanglement would require the information to travel faster than light, which isn't possible. So instead, entanglement can be used to create the "keys" needed to encrypt and decrypt messages.

BATON 72/GETTY IMAGES

Drones could form part of a global quantum internet

1 km

The distance entangled photons were beamed between drones

In previous tests, entangled photons were sent more than 1000 kilometres between a satellite and ground stations, but now Zhenda Xie at Nanjing University in China and his colleagues have shown that links can be made over shorter distances with relatively inexpensive hardware.

It is also the first time that entangled photons have been transmitted from one moving device to another.

A laser on board one of the 35-kilogram drones created a pair of entangled photons by splitting a single photon with a crystal. One photon was sent directly to a ground station, while the other was transmitted to a second drone a kilometre away via a relay drone.

Motorised devices on each drone moved to ensure that the receivers and transmitters always lined up, and photons were focused and steered through the relay drone by a short piece of fibre-optic cable. The state of each photon was measured at the ground station and the results showed that the photons remained entangled (*Physical Review Letters*, doi.org/fqtf).

Xie hopes that connections of over 300 kilometres can be achieved by more advanced drones at high altitude, free of the distorting influence of pollution and weather, and that smaller, more cost-effective drones could be produced for local connections, perhaps even to moving vehicles.

All of these devices could link to satellites for global transmission.

The achievement marks an important step towards a functioning quantum internet, says Siddarth Joshi at the University of Bristol, UK. He agrees that drones could become the final chain in links from one part of the world to another, such as from your local relay station to your home or vehicle. "You're driving around in your car and you want to maintain secure quantum communications, so you have these drones flying around behind you," he says.

Myungshik Kim at Imperial College London believes that engineering such complex optics into moving drones, especially given that small rotational differences can make it extremely difficult to maintain quantum connections, means that this represents a significant technical advance. ▮

Palaeontology

Dinosaur found in Argentina may be largest land animal

Joshua Rapp Learn

FOSSILS of a gigantic dinosaur are emerging from the ground in Argentina after 98 million years – and the creature may be the largest land animal that scientists have ever found.

The ancient bones are from a titanosaur. At one point, this group of long-necked sauropod dinosaurs lived across the world. Some of the last titanosaurs lived in South America, where they evolved into giants including *Patagotitan*, sometimes claimed to be the largest land animal to ever exist.

The fossils unearthed by the team, which was led by researchers at Argentina's National Scientific and Technical Research Council, belong to an animal "probably exceeding *Patagotitan* in size", according to the peer-reviewed paper. The team declined to comment on the discovery for this story.

"It is one of the most complete colossal titanosaurs of that age, which considerably helps to understand the group's evolution," says Aline Ghilardi at the Federal University of Rio Grande do Norte in Brazil, who studies titanosaur parasites.

Excavations in the province of Neuquén in Argentina are ongoing. So far, the team has unearthed 24 vertebrae, parts of the pelvis bones and some other bones (*Cretaceous Research*, doi.org/fqt5).

Ghilardi is cautious about the claim that the dinosaur might be larger than *Patagotitan*, noting that several recent discoveries have been called the largest titanosaur ever found only for the statements to be revised after further analysis. "But it is undoubtedly a huge animal, among the largest ever discovered," she says, adding that she is excited to see if ongoing excavations unearth more bones to improve the accuracy of body size estimates. ▮

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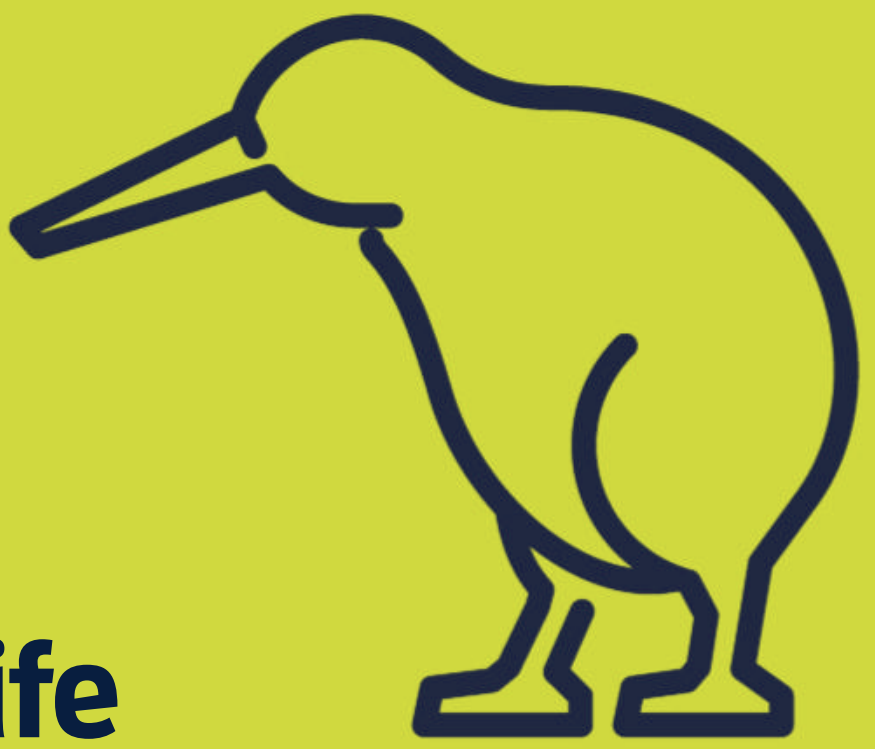

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Archaeology

BASRAN BURHAN

Warty pigs adorning cave may be oldest art of its kind

CAVE paintings found in Indonesia include depictions of animals dating back at least 45,000 years, making them possibly the world's oldest.

The pictures of three pigs were discovered in the Leang Tedongnge cave on the Indonesian island of Sulawesi by Adam Brumm at Griffith University, Australia, and his team. "It's one of the most spectacular and well-preserved figurative animal paintings known from the whole region and it just immediately blew me away," says Brumm.

Sulawesi is known for some of the world's oldest cave art, but the new paintings may predate all other examples found there so far.

Brumm and his colleagues were able to date a mineral formation that overlapped part of the image, and that must have formed after the art was produced. The formation is at least 45,500 years old, so the artwork itself could be much older (*Science Advances*, doi.org/fqq7).

Each of the three pigs depicted is more than a metre long. They were painted using a red ochre pigment and appear to show Sulawesi warty pigs (*Sus celebensis*), a short-legged wild boar endemic to the island. It was important to early hunter-gatherers in Sulawesi, says Brumm.

These pigs appear in younger cave art in the region, and we know that they were the most commonly hunted game species on Sulawesi for thousands of years.

Paul Pettitt at Durham University, UK, says that the discovery adds to evidence of early human presence in the islands of south-east Asia, but adds we can't rule out authorship by other human species, like the Neanderthals. **Ibrahim Sawal**

Psychology

You can tell a liar by the way they move

WHEN telling a lie, people may imitate the body language of the person they are lying to without realising they are doing it.

Sophie van der Zee at Erasmus University Rotterdam in the Netherlands and her team asked about 50 university students to solve a supposedly simple wooden puzzle within 5 minutes. In reality, the puzzle was far too hard to solve in the time available.

Van der Zee "hid" the puzzle solutions in the room where the students could find them, which encouraged cheating. She then asked the students not to tell her supervisor that she had left the solutions in the room because she feared professional consequences.

Van der Zee and her colleagues then recorded interviews as each student told another student about the puzzle – which, if they were complying with van der Zee's request, involved lying about how they solved it.

Using accelerometers, van der Zee's team recorded the head, chest and wrist movements of the students – both the ones talking about the puzzle and the ones listening.

They found that when a student was telling the truth, their movements differed from those of the person asking questions. But when they lied, the movements of the two tended to align (*Royal Society Open Science*, doi.org/fqsv).

This may be because lying requires so much concentration, says van der Zee, so speakers might subconsciously slip into mimicking their listener's subtlest body movements because copying requires less thinking than coming up with their own body language.

Such a way of coping with "cognitive overload" isn't obvious to the naked eye, but was detectable with accelerometers. **Christa Lesté-Lasserre**

Animal physiology

Sensory wings help flies dodge a bashing

SPECIAL hindwings on some flies seem to help them take off faster, making them harder to swat.

Many flies can be notoriously hard to catch, taking off in a fraction of a second. They mainly use sight to escape, but Alexandra Yarger at Case Western Reserve University, Ohio, and her team have found a new mechanism that might be helping them get away.

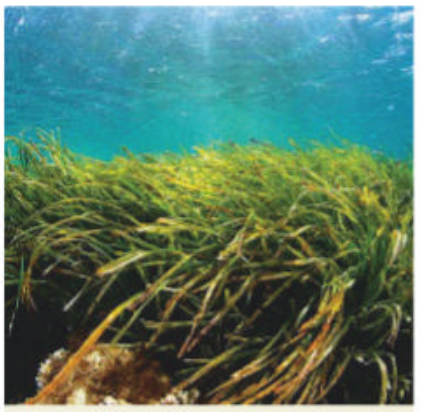
All fly species have shortened hindwings called halteres. These don't generate useful lift, but are used as sensory organs to help stabilise flight. A group of flies known as Calyptratae, including houseflies (pictured) and blowflies, rhythmically move these wings when standing. Why was a mystery. Yarger and her team checked if this affected take-offs.

PAUL FARNFIELD/ALAMY

Using high-speed cameras to film the flights of more than 20 species, they found that, overall, Calpytrate flies were roughly five times faster at taking off than other flies. Without halteres, both speed and stability of take-offs reduced in Calyptratae species (*Proceedings of the Royal Society B: Biological Sciences*, doi.org/fqst).

Yarger suggests this haltere movement increases the amount of sensory information these flies get. "There might be a pathway from halteres to the legs that's causing them to take off faster," says Yarger. "It doesn't go through any central nervous system, it's almost like a reflex," she says. **IS**

Really brief



JOSE FRANCISCO MARTIN PINATEL/ALAMY

Seagrass like a litter picker in the ocean

The seagrass *Posidonia oceanica* traps pieces of marine plastic and removes them from the water. When the seagrass sheds its leaves they form ball-like tangles that hold up to 613 plastic items per kilogram of leaves. These balls wash up on the shore (*Scientific Reports*, doi.org/fqs9).

Rainforests may start releasing CO_2

A model suggests rising temperatures could cause land-based ecosystems, including rainforests, to become net emitters of carbon within 30 years. That is because plants photosynthesise less well in warmer conditions, limiting their potential to act as carbon sinks (*Science Advances*, doi.org/fqqx).

Warmer batteries for electric cars

Electric cars use expensive lithium batteries containing nickel and cobalt – but cheaper lithium iron phosphate (LFP) batteries might be a better option. Tests show LFP batteries operating at 60°C can charge in just 10 minutes, making them a practical option for cars (*Nature Energy*, DOI: 10.1038/s41560-020-00757-7).

Space

Quasar sheds light on early black holes

ASTRONOMERS have discovered the most distant quasar seen. At about 13 billion light years away from Earth, it is showing us how the first supermassive black holes affected their galaxies.

Quasars are very bright objects at the centres of some galaxies that consist of a supermassive black hole surrounded by a disc of hot plasma. The newly identified quasar, called J0313-1806, was spotted using several powerful observatories. Feige Wang at the University of Arizona presented this work at a virtual meeting of the American Astronomical Society on 12 January.

J0313-1806 is 20 million light years further away than the previous record holder and its supermassive black hole is twice as massive: it is about 1.6 billion times as massive as the sun. "The existence of such a massive black hole... only 600 million years after the big bang really puts pressure on our understanding of the formation of supermassive black holes," said Wang.

The team calculated that, in order for the black hole to grow so large, it couldn't have formed from a collapsed star like smaller black holes. Instead, it must have started out with a "seed" black hole more than 10,000 times as massive as the sun, which could have formed as a huge amount of gas collapsed under its own gravity.

The quasar is also blasting out superheated gas that is moving at one-fifth of the speed of light. This quasar wind may eventually slow down star formation in its host galaxy, as stars need that gas to form. **Leah Crane**

Environment

MB PHOTOGRAPHY/GETTY IMAGES

Plastic particles from clothes polluting almost all Arctic seas

POLYESTER fibres make up nearly three-quarters of microplastic pollution in the Arctic and probably come from textile manufacturing and household laundry.

We already knew microplastics were present in the Arctic, but new research shines a light on the source of these tiny fragments. Peter Ross at the University of British Columbia in Canada and his team examined seawater samples from 71 spots across the Arctic taken from 3 to 8 metres below the surface.

Microplastics are pieces of plastic that are less than 5 millimetres in size. They were present in all samples except one, with a count of approximately 40 microplastic particles per cubic metre of seawater on average. Synthetic fibres made up 92 per cent of the microplastic pollution in these samples, and 73 per cent of this was polyester.

"There is strong suspicion that laundry, clothing and textiles are playing a significant role in contaminating the world's oceans with microfibres," says Ross.

The researchers found that there are more microplastics in the eastern Arctic waters fed by the Atlantic than in those of the western Arctic (*Nature Communications*, doi.org/fqss). Karina Shah

Renewables

Spice boosts solar panel performance

THE substance that gives chilli peppers their kick can make solar cells more efficient.

Ultra-thin solar cells made with lead-based materials can absorb light more efficiently than silicon-based solar cells, but they often can't convert it into electricity as efficiently because they lose some of it to heat. It turns out the solution is to add a bit of heat.

Qinye Bao at East China Normal University in Shanghai and his colleagues added capsaicin to these ultra-thin perovskite solar cells during manufacturing. Bao and his team suspected capsaicin might have an energy-boosting effect because it can free up electrons to carry charge.

They tested the capsaicin-treated material by exposing it to artificial light to simulate sunlight, measuring the electrical current running through them.

Capsaicin made the solar cells more efficient, yielding a power conversion of incoming light of 21.88 per cent, versus 19.1 per cent without it. Further analysis revealed addition of capsaicin did indeed lead to a greater number of free electrons available to conduct current at the solar cells' surface. This reduced energy loss via heat (*Joule*, doi.org/ghs387). **KS**

Signal Boost

Welcome to our Signal Boost project – a page for charitable organisations to get their message out to a global audience, free of charge. Today, a message from **The Humane League**

STEPHANIE FRANKLE AT ANIMAL PLACE

Moving beyond the geological era of the chicken

Since the middle of the 20th century chicken farming has been on a rapid path of industrialisation. In the UK we now raise and kill over 1 billion chickens per year, over 90% on intensive farms. On a global scale, the figure is over 21 billion. Some are calling this the geological age of the chicken.

Today, chickens are purposefully bred for excessive daily weight gain to get bigger, faster. An animal whose wild ancestor the red junglefowl would only reach 1-1.5kg fully grown now grows to 2kg in just 40 days. This fast growth leads to health and welfare issues such as white striping, wooden breast syndrome, and green muscle disease, as well as significant leg pain, gait problems, and reduced mobility.

Such is our disregard for them as individuals capable of complex emotions, that gram for gram chicken meat is often sold for cheaper than a can of dog food.

But the glimpse of a revolution is on the horizon. In 2018, leading animal protection groups banded together to create The Better Chicken Commitment (BCC), an agreement to drastically improve the lives of chickens.

The BCC ensures food businesses end the use of fast-growing breeds, improve space allowance, air quality, light, and enrichment, reduce distress at slaughter, and implement third-party auditing. Over 200 companies in the UK and EU have now committed to meeting this criteria.

UK charity The Humane League UK works relentlessly to end the abuse of animals raised for food and has been instrumental in gaining BCC commitments from major food brands across Europe, including KFC, Pizza Hut, and Kraft-Heinz.

But we are facing uncertain times and we can't continue this work without financial support. Donating to The Humane League ensures funds will be spent on science-led, research-backed programs to advance animal welfare. The Humane League has been named Top Charity by independent organisation Animal Charity Evaluators for every rating period, thanks to our targeted approach, our effectiveness in reducing animal suffering and our efficient use of donations.

When historians of the future look back at this period in time, let's make sure they know we didn't stand by and watch while the era of the chicken consumed us.

Want to help?
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Views

Comment

Vaccine transparency

We must start publishing ethnicity data for covid-19 vaccinations to make sure no group is treated unfairly, says **Layal Liverpool**

MICHELLE D'URBANO

THE race to vaccinate as many people as possible against covid-19 is under way, but unless we track who receives the vaccine we won't be able to ensure the benefits are spread equitably. Publishing ethnicity and other demographic data must become a priority.

Detangling data to reveal patterns in subgroups of a population is a powerful tool to address inequality. After all, you can't fix a problem if you don't know it is there. Globally, breaking down covid-19 cases based on factors such as age and sex has been enormously helpful for our understanding of the disease. Knowing that the risk of severe illness rises with age, for instance, has helped inform interventions.

Countries in which information on race and ethnicity for cases was published early on during the pandemic, including the US, the UK and Norway, were among the first to reveal worrying trends of people from racial and ethnic minority groups being at higher risk from covid-19. Similar patterns have since been seen in other nations that have looked for them, such as Australia and Brazil.

Collecting and publicising this kind of data can help drive governments to take action. Data published in the UK in April, which revealed that people from Black, Asian and minority ethnic (BAME) backgrounds were over-represented among critically ill covid-19 patients, prompted the UK government to launch an inquiry into the issue and led Public Health England to start recording covid-19 cases and deaths by ethnicity. In June, the UK government announced £4.3 million in funding for new research aiming to "explain and mitigate" the disparity.

Many other European countries have traditionally shied away from race or ethnicity data, due to concerns over discrimination and privacy. But in September last year, the European Union committed to investigating the obstacles to collecting such data across member states by the end of 2021.

As countries around the world are rolling out covid-19 vaccination programmes, and given our knowledge about the disproportionate impact the pandemic is having on certain subgroups, we must double down on efforts to collect ethnicity and other demographic data on covid-19 vaccinations, such as age, sex and socioeconomic status.

Surveys in the US and UK last year suggested that hesitancy about covid-19 vaccines may be more prevalent among racial and ethnic minority groups, raising concerns that this might result in lower vaccine uptake among those most at risk from the disease.

Similar trends have been seen with other vaccinations. A 2017 study in England found uptake of the shingles vaccine was lower among people of Black or mixed ethnicity compared with white people, and last year there were concerns about lower uptake of the flu vaccine among BAME groups in some parts of the country. Uptake of the flu vaccine has additionally been found to be lower in more deprived areas of the UK, which have also seen disproportionate numbers of deaths from covid-19.

To find out whether concerns about vaccine hesitancy are founded, and to ensure equal access to covid-19 vaccines across communities, it is crucial that governments gather and release data on who is being vaccinated in real-time. Currently, no country in the UK has released this data and when I asked the bodies responsible, only the one for Wales confirmed it was collecting it.

The US Centers for Disease Control and Prevention says it is collecting information on the race and ethnicity of people who get vaccinated across the US, but is yet to publish it.

Figures released by Mississippi, North Carolina and Maryland suggest a disproportionate number of vaccines have gone to white people relative to their share of the population in those states.

We must get more transparency around who is being inoculated. ▮

Layal Liverpool is a trainee digital reporter at *New Scientist*
@layallivs

For another example of missing ethnicity data, this time in genetics research, turn to page 44

This changes everything

Trapped between an insurrection and a strike Silicon Valley has enabled the US to get into a huge mess. It must start taking responsibility for its political power, writes **Annalee Newitz**

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

Annalee's week

What I'm reading
Witchmark *by C. L. Polk, an alternate first world war history in which a witch army doctor discovers a magical form of post-traumatic stress disorder – and a terrifying conspiracy.*

What I'm watching
The new French series Lupin*, about a gloriously competent gentleman thief.*

What I'm working on
Researching how the civil war tore California apart.

This column appears monthly. Up next week: James Wong

MANY of us here in the US can't decide which is more momentous: President Trump being impeached for a second time, or President Trump being kicked off Twitter, Facebook and YouTube. Truly, he was the first social media president. Now we have to decide what it means to have tech companies take his online podium away.

Like previous Republican presidents Ronald Reagan and George W. Bush, Donald Trump has always hated the mainstream media. Unlike his predecessors, though, he had an alternative platform to make himself heard. Trump's tweets kicked up daily news doom spirals, and earned him the kind of hardcore fans that Beyoncé can only dream of.

Social media gave Trump a broad platform, but perhaps more importantly it offered a set of narrower, more targeted ones too. Facebook's targeted advertising system enabled Trump's team to aim extremist content at his core audience, while aiming more palatable stuff at centrist voters. He could be one candidate for white supremacists who wanted to build a wall, and quite another for unemployed labourers who wanted the coal mines back open.

Put in the language of Silicon Valley, Trump was able to trumpet in real time, at scale, using mobile apps.

As we watched live feeds of insurrectionists storming our Capitol building on 6 January, it became clear that incitement to deadly violence isn't just rhetoric or "free speech". Under certain circumstances, it can lead to murder and sedition.

The most awful part is that Trump's presidency was in some ways a boost for Silicon Valley. Twitter's business model, if one can call it that, is to reel in new users with its roster of chatty celebrity accounts. What could be a bigger draw than the ultimate celebrity, the president himself? Meanwhile, for Facebook, Trump's election win in 2016 cemented its status as a soapbox for the world's political leaders, key to winning hearts and minds.

Social media algorithms, optimised for "engagement", amplified Trump and his followers' most extreme rhetoric, spotlighting conspiracy groups like QAnon

"Trump's election win in 2016 cemented Facebook's status as a soapbox for winning hearts and minds"

and the far-right neo-fascist Proud Boys. Targeted content fomented divisiveness, ushering in the age of "alternate facts". Once the pandemic was under way, it became especially obvious that fake news wasn't just annoying, it could kill people. Speech wasn't free; it was weaponised.

A few days before Trump's mob stormed the Capitol Building in Washington DC, a group of Alphabet employees – which include Google and YouTube workers – announced that they had formed a union. Among other motivations, the union wants to make it safe for employees to speak up about any unethical behaviour or discrimination. This is after AI engineer Timnit Gebru said she was fired from Google after co-authoring a paper about racial bias in the algorithms Google uses for some of its products. Google denies this allegation. Tech workers at other big companies are watching the Alphabet union closely, and could well follow its lead.

Facing internal pressure from workers, and external pressure from the general public, Silicon Valley's social media giants finally banned Trump. Because they are privately owned companies, they didn't need any reason to do it – they are exempt from the nation's free speech provisions, as are all non-governmental entities in the US.

These companies could have closed Trump's account at any time, for any reason. But they waited until after an armed insurrection at the Capitol to ban Trump for violating policies against inciting violence – despite years of similar rhetoric.

As we stand in the teetering tower of our democracy, it is clear that the time has come for Silicon Valley companies to acknowledge that they are key to our political process. They aren't neutral platforms on which everyone's words peacefully coexist. Social media is political media. The question is, how do we as a nation respond to what we have learned?

The public can demand that policy-makers regulate tech companies through an agency like the Federal Communications Commission, which controls political ads on TV, among other things. Workers can threaten strikes when companies design products that could heighten social divisions and disseminate lies. Hackers can engage in direct action. In the coming year, we are likely to see movement on all of those fronts.

In the 2020s, the social media industry will face its biggest challenge: to slow down and repair the things it has broken. ▮

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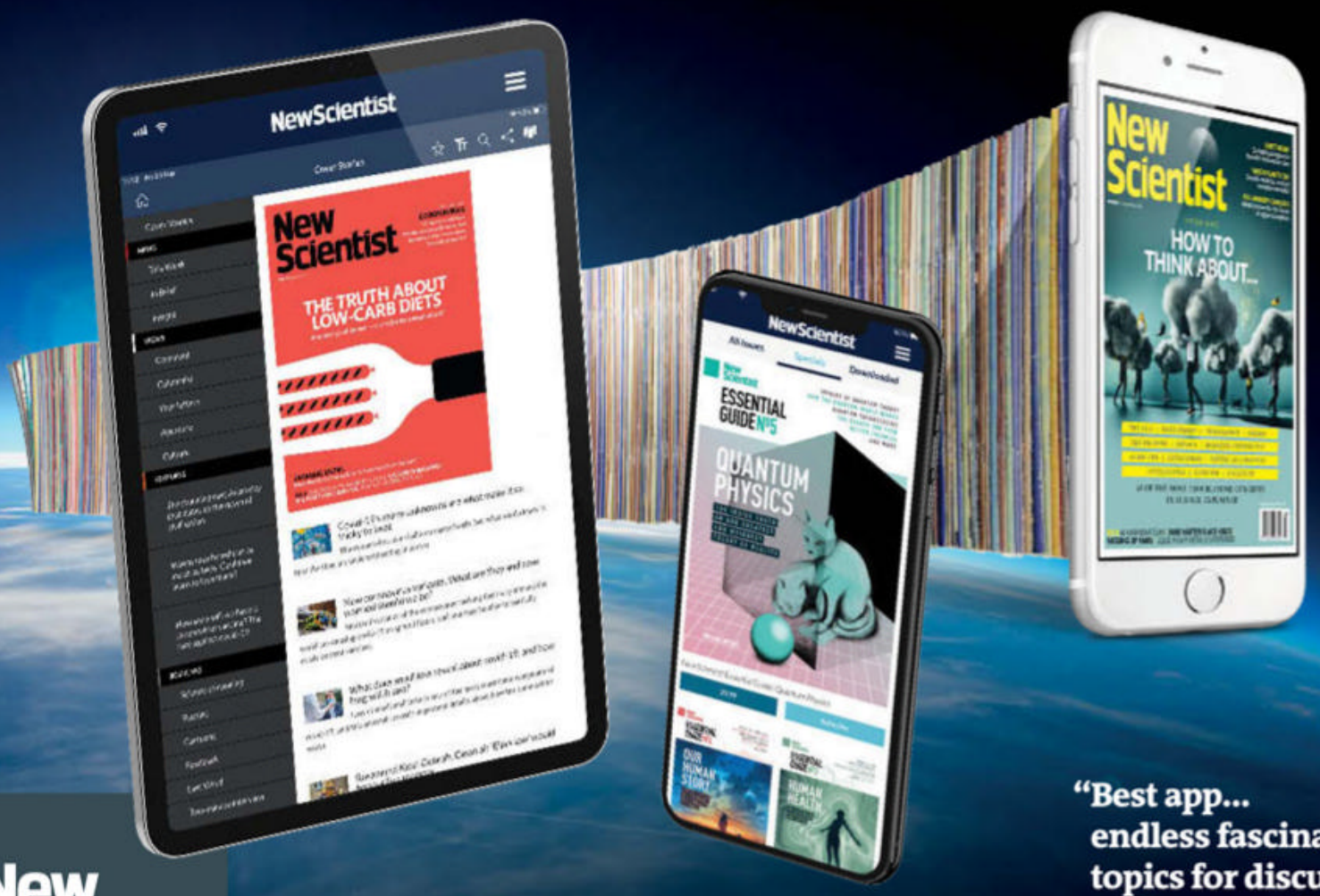

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Editor's pick

Will a vaccine be the cure we need for long covid?

Letters, 2 January

From Bernard Norman, London, UK

I share Mark Spinney's suspicion that long covid symptoms may be due to the virus remaining active in tissues, somehow hiding from the immune system.

A wine connoisseur friend of mine lost his sense of smell to covid-19 in March 2020 and it never recovered – at least not until a few days after receiving the first dose of the vaccine, when suddenly he could smell the delicious aromas of his wines again. I wondered if the vaccine gave his immune system the boost it needed to finally expel the virus from his olfactory nerve.

If so, this could bode well for using vaccination to treat a variety of long covid symptoms.

Let's do all we can to cut the risk of viral variants

9 January, p 8

From Michael Ross, Oxenhope, West Yorkshire, UK

If lockdowns are indeed partially effective in reducing transmission of the coronavirus, as they seem to be, might an unexpected consequence be to selectively support mutant variants with enhanced transmissibility?

From Crispin Piney, Mougins, France

Let's not repeat the mistake of potentially creating conditions for the emergence of new variants of the virus as we roll out vaccines.

In particular, let's avoid the well-meaning idea of delivering the second dose of vaccine much later than specified, in order to provide twice as many people with a single dose. I see this as similar to halving the dose of an antibiotic so as to share it with someone else: it raises the prospect of letting vaccine-resistant organisms thrive.

We must abide by the complete immunisation process exactly as it was performed in the phase-III clinical trials of the vaccines.

There may be another way to boost immunity

19/26 December 2020, p 10

From Robin Pepper, Lewes, East Sussex, UK

In view of the uncertainty over the strength and persistence of the immunity induced by the covid-19 vaccines, and given the virus will probably be circulating for many months yet, could the protective effect of vaccines be enhanced by exposure to the "street" virus a suitable time after inoculation?

If so, the benefits might outweigh the downsides of an infection, which, post-vaccination, would most likely be mild.

Proof of vaccination would be open to fraud

Letters, 19/26 December 2020

From John Oxborrow, Coniston, Cumbria, UK

Geoff Willmetts writes that people who have been vaccinated should have a secure badge to prove it. In the world of scams, fraud and fakes, nothing is secure. If this idea were implemented, it would be 24 hours at most before badges were for sale on the internet – perhaps costing £50 or £60 for next day delivery.

One reason to stay away from the keto diet

9 January, p 32

From Greg Nuttgens, Porthcawl, Mid Glamorgan, UK

The discussion about the medical pros and cons of the low-carb "keto" diet completely ignored the social and environmental aspects of diet. In affluent societies, most people have more choice over what they eat, though this may change as the disastrous environmental consequences of large-scale meat and dairy production become more apparent.

Promoting the keto diet in more places is likely to accelerate these effects, as people are encouraged to eat more meat. Any discussion of a diet should assess its sustainability, locally and globally.

Fusion power has many problems to overcome

12 December 2020, p 18

From John Evans, Abingdon, Oxfordshire, UK

Your article on the UK's proposed fusion power plant, STEP, gives the impression that once the conditions to enable fusion of deuterium and tritium are met, then a working electricity-generating reactor will quickly follow. However, there are many other challenges. These include the massive problem of dealing with radiologically unpleasant and potentially explosive tritium.

Because tritium's availability from natural sources is essentially zero, a fusion reactor must make it by bombarding lithium with neutrons, then extract it. This looks to be an extremely difficult task. The situation isn't helped by the fact that the tritium would be made in a hot environment where leakage would be hard to prevent.

These problems have been clear for decades. Given the ambitious aims of STEP, perhaps it is time to urgently address such issues.

Places where wheeled animals can come to life

19/26 December 2020, p 50

From Natalie Roberts, Watford, Hertfordshire, UK

In "Why don't wildebeest have wheels?", Michael Marshall made some excellent points, especially that "in nature, smooth, flat surfaces are rare, so there is no reason for evolution to favour wheels" and that "it is hard to imagine how the wheel might receive nutrients from the rest of the body". However, two fantasy authors have already pondered these points, one coming up with answers and the other providing the ultimate put-down.

In *The Amber Spyglass*, Philip Pullman proposes a savannah covered in interconnected, solidified lava flows that make up natural roads. A quadrupedal race – the mulefa – has naturally evolved an axle in the form of an extra long, extra strong claw on each foot. To these they attach naturally occurring, wheel-shaped seed pods, no nutrients required.

At the other extreme, Terry Pratchett had his wizard characters meet the god of evolution in *The Last Continent*. This being is busy designing an elephant on wheels. "Diversify and fill all niches, that's the ticket," he enthuses. "But is lying on your side in a mud hole with your wheels spinning a very important niche?" comes the diplomatic reply from one of the wizards.

Why space naturism probably won't take off

Letters, 2 January

From Sam Edge, Ringwood, Hampshire, UK

I like the simplicity of Guy Cox's solution to the laundry problem on the ISS – nudity – although I suspect that tethering or taping might be required for some duties.

It would certainly boost viewing figures for ISS broadcasts, but I am not sure it would be a runner with NASA, given the belief of some that even a glimpse of a naked body on TV would destroy the very fabric of society.

Places where wheeled animals can come to life

19/26 December 2020, p 50

From Natalie Roberts, Watford, Hertfordshire, UK

In "Why don't wildebeest have wheels?", Michael Marshall made some excellent points, especially

For the record

In the quick quiz (9 January, p 52), we meant to ask roughly how many light years are in a parsec, the answer being three.

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New Scientist Podcast

New Scientist Escape Pod

Hello and welcome to the Escape Pod. Your flight will last about 15 minutes and we expect no turbulence, just a smooth, pleasant ride

Yes, this is a new lockdown podcast from *New Scientist*, with host Rowan Hooper. This podcast won't include any references to coronaviruses or other unpleasant happenings on the planet below. There are plenty of other places you can find out about those.

Instead this is about escapism. Sit back, relax and let us whisk your mind away to... pretty much anywhere or anything that will inspire and distract you. Coming up in episode one we will be talking about self-awareness and theory of mind in dolphins and whales; the incredible things that dancers and gymnasts are able to do without blacking out – and we will have to mention the legendary Simone Biles here and her triple double at the Olympics - and we will discuss the Chinese boardgame Go, and how there are more moves in the game than there are atoms in the universe.

Do join us on the escape pod – A lockdown podcast from *New Scientist* to take your mind away from the relentless news cycle - and to brighten up your week. Tickets are free. See you then.

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A rare beauty

Photographer Ugo Mellone

THIS tranquil shot is the first high-resolution image of a Cuvier's gazelle (*Gazella cuvieri*) in a desert environment, says photographer Ugo Mellone. The gazelle and her calf are roaming in a remote part of the Sahara desert. They are a rare sight, with estimated numbers of individuals in the wild in the low thousands.

The species once flourished across northern Africa, but excessive hunting in the early 20th century slashed its numbers. Cuvier's gazelles are now found in remote or desert regions of Algeria, Morocco and Tunisia, where they usually live in small herds away from humans.

Mellone set up a solar-powered camera on the rocky desert plains that shot anything that triggered its motion sensors, a technique called photo trapping. More than 10 weeks later, he was rewarded with what he calls "the most sought photo of my life". The image, which features in Mellone's latest photography book, *Sahara Erg|Reg*, is one of only four shots of the gazelles taken with this camera, underlining the species' sparse distribution and low numbers.

Most of the large animal species that used to roam the Sahara desert are now endangered or extinct, due to hunting, climate change and lack of conservation. The Sahara desert "is probably the most neglected ecosystem" on Earth, says Mellone. Yet the Cuvier's gazelle is resisting, he says, despite its population density being very low. Even so, he adds that the species is still heavily hunted "just for fun". ▮

Gege Li

At one with the ocean

Film-maker Mike deGruy survived a shark attack and captured iconic scenes of orcas snatching sea lion pups. **Elle Hunt** explores a fond documentary about him

Film

Diving Deep: The life and times of Mike deGruy
Mimi Armstrong deGruy
Streaming on Apple and Amazon Prime from 19 January

ADVENTURE ENTERTAINMENT

DeGruy exploring more than 117 metres below the surface in a diving suit

IT SPEAKS volumes about the kind of person Mike deGruy was that, after he nearly lost his life in a shark attack, he not only continued diving, he returned to the scene to figure out where he had gone wrong.

The film-maker and biologist is the subject of *Diving Deep*, a documentary directed by his widow, fellow film-maker Mimi Armstrong deGruy, in the wake of his death. Mike DeGruy was killed in a helicopter crash – along with Australian film-maker Andrew Wight – while on assignment in Australia in 2012.

The film takes a fond look at his adventurous and compassionate life, leaving no doubt that he lived it to the fullest and what he would want his legacy to be.

In 30 years of marine film-making, deGruy gained a reputation for both his stubborn pursuit of the shot, often in unprecedented conditions, and his passion: he was remembered at his funeral as a "human exclamation mark".

In 1986, deGruy filmed a volcano eruption in Hawaii as experienced underwater, pushing his bodyboard straight into the oncoming lava. Later, he put himself in the path of hunting orcas, capturing the first film of them seizing sea lion pups from the water's edge – footage that is now iconic in nature film-making.

David Attenborough – who voiced deGruy's footage for many years, including on the Emmy and Bafta-winning *The Blue Planet* – recalls it causing "a sensation" at the BBC: "Everybody was talking about it… Those pioneering sequences hold their place in the history of discovery."

Between archival footage and fond recollections from family and collaborators, deGruy is an engaging person to get to know. His life's story is one that might inspire you to make more of yours, if only through the sheer force of his enthusiasm.

"When a shark took off part of his arm while shooting, deGruy's response was to make a film exploring why"

DeGruy was a risk-taker, but an informed one. His fearlessness in the face of sharks was rooted in an understanding of them and their behaviour, so when one took off part of his right arm while he was filming in the Marshall Islands in 1978, requiring 11 operations, deGruy's response was to make a film exploring why.

He later campaigned, as a shark-attack survivor, for shark conservation and used his clout as a fixture on cult TV show *Shark Week* to push back against sensationalist treatment of them. This led him to be identified on television news as a victim of "Sharkholm syndrome".

But it wasn't until the 2010 Deepwater Horizon oil spill in the Gulf of Mexico, where deGruy had grown up learning to freedive, that he really embraced activism. The devastation he documented at the scene, and the reluctance from many quarters to accept responsibility for it, drew out a new and urgent purpose to his film-making.

Footage of deGruy rallying against the disparity between polluters' profits and funding for science was what prompted his widow to put together *Diving Deep*.

Today, more than a decade later, the full impact of Deepwater Horizon is still unclear because so much of the ocean is undocumented, especially at depth. "We were in some ways working in the dark," says Charles Fisher, a marine biologist at Pennsylvania State University.

As the technology evolved to take him to greater and greater depths, DeGruy was drawn to uncover the mysteries of the deep and what lessons they might hold for humanity. He had been due to join James Cameron's Deepsea Challenge, venturing into the Mariana Trench, when he died.

Paying tribute to deGruy in the film, Cameron offers a theory for the lack of impetus and investment in deep-sea exploration compared with that for outer space. The space race, he says, represents man's desire to conquer his environment, but you don't conquer the ocean, he says. "You understand the ocean, you become intimate with the ocean, you let it teach you."

DeGruy's life stands as a testament to the possibilities of that approach. It is demonstrated in the film's opening sequence as he ventures more than 117 metres deep in a diving suit, an underwater astronaut wearing a blissful smile, a man completely immersed. ▮

Elle Hunt is a freelance writer and critic

A whole world to change

Millions of young people are fighting for action on climate change. **Sandrine Ceurstemont** listens to a podcast that tells their stories

Podcast

Inherited

Critical Frequency

GRETA THUNBERG has been the star of the youth climate movement since her first school strike in 2018, in which she sat outside the Swedish parliament to demand action on the Paris climate agreement. Yet she is just one of millions of young people coming to terms with a crisis they inherited.

"There are tons of young people fighting today, and many who have fought before, and we all feel the same terrifying weight," says writer and audio producer Georgia Wright in an episode of *Inherited*, a podcast she co-hosts and produces with Julianna Bradley. The show shares the experiences of teenagers and twenty-somethings dedicating their lives to the climate emergency.

Its four-episode pilot season features guests telling their own stories, bringing the challenges and emotions they face to life while also touching on the origins of the crisis.

Age is often a barrier because it prevents young people being taken seriously. *Inherited*'s first episode follows the early days of the Sunrise Movement, a political group led by young people in the US aiming to stop climate change. One member was described as "young and naive" when she challenged a politician about action on the issue, spurring the group on to disprove the patronising remark. The result was a protest organised in 2018 that was a turning point for Sunrise.

At that time, the latest report from the Intergovernmental Panel on Climate Change (IPCC) had just been released, warning that society had 12 years to control climate change. Yet Nancy Pelosi, then incoming speaker of the US House of Representatives, didn't seem to be making climate a priority in the next session of Congress. Sunrise organised a sit-in at her office, attracting a lot of media coverage. Since then, the movement has bloomed and it has helped elect climate-minded politicians.

The success of Sunrise touches on another theme of this podcast: community. Many young people suffer from climate grief, anxiety and guilt. Climate activist Xiye Bastida, a guest on the show, recalls how she collapsed after hearing that US president Donald Trump was rolling back certain environmental regulations. But connecting with others experiencing the same thing can help. "We are in a climate crisis, but we can't live in a state of crisis," says Bastida. "If we go through our days with hopelessness, we're not going… to get anything done."

It can be difficult, however, to convince some people that climate change is real. In one episode, a guest named Jenna describes how her community in the Rockaways area of New York City was ravaged by Hurricane Sandy in 2012. A day after the storm, local houses were flooded and fires raged. She didn't go back to school for three weeks and the relief effort took years.

Although the hurricane changed her life and drove her to pursue a climate-related career, some who lived through the disaster still denied the links to climate change. "Often [humans] prefer to shut off these big abstract thoughts… focusing on challenges that are more manageable," says Bradley.

***Inherited* highlights how informed and dedicated many young people are when it comes to climate change. The season ends on a hopeful note. Past generations may be responsible for the crisis, but the message is that today's youth can choose what comes next. "Instead of resigning ourselves to a terrible fate, we're dreaming up a new path," says Bradley.**

Sandrine Ceurstemont is a science and technology writer based in Morocco

A mural depicting climate activist Greta Thunberg in Brighton, UK

JON SANTA CRUZ/SHUTTERSTOCK

Don't miss

Listen

From Now, created by Rhys Wakefield and William Day Frank, is podcast company QCode's drama about brothers reunited across space and time. Brian Cox and Richard Madden play identical twins, set at loggerheads by relativity.

Explore

Climate Change: Why should we care? features mathematician Hannah Fry and luminaries including conservationist Jane Goodall (pictured), at London's Science Museum on 28 January. Join in online to discover the difference that climate efforts make.

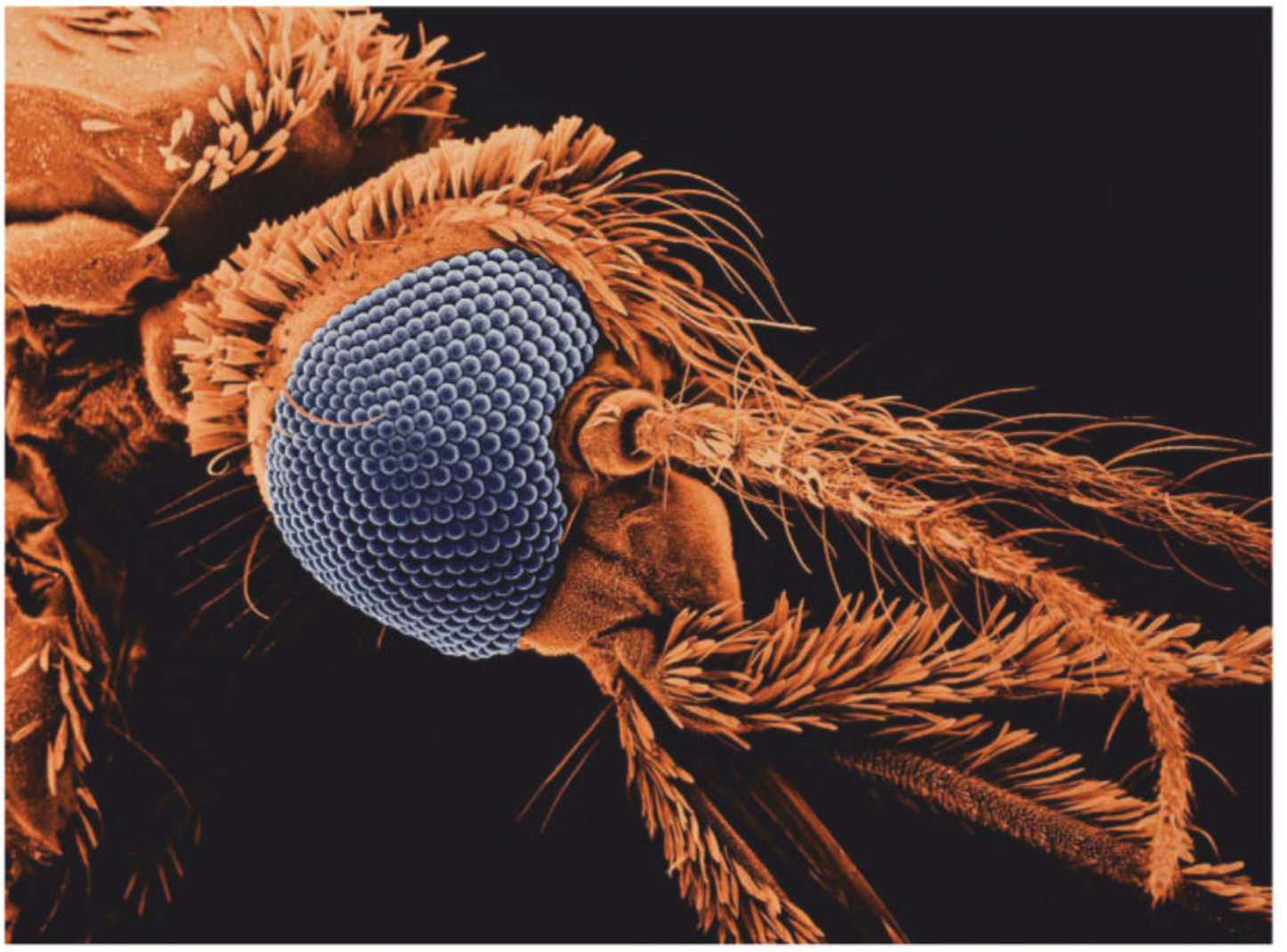
Read

Small Gases, Big Effect: This is climate change by David Nelles and Christian Serrer explains climate change with the help of more than 100 scientists, presenting complex science in a way that everyone will find easy to understand.

QCODE; STUART CLARKE; PENGUIN

Playing with death

Remote Control tells the story of Fatima, a sickly Ghanaian girl who gains a terrifying superpower. It is a tale that mixes folklore with a thriller, says **Layal Liverpool**



PETER FINCH/GETTY IMAGES

In *Remote Control*, deadly mosquitoes fall victim to Sankofa's lethal power

Book

Remote Control
Nnedi Okorafor
Tor.com

WHAT if you could become invincible, resistant to everything from bullets to disease? Nnedi Okorafor explores this idea in her novella *Remote Control*, but with a dark twist: her protagonist's invincibility comes at the cost of other human lives.

The story follows a child in Wulugu, a town in northern Ghana, whose life takes a drastic turn after she discovers a strange, green, glowing object that falls from the sky during a meteor shower. Fatima, once a sickly child who experienced regular bouts of malaria, is transformed into Sankofa – a girl who will soon become notorious far beyond her home town for her terrifying ability to evade death and take life.

As Sankofa starts discovering her power, the story temporarily feels light and playful. We are reminded that she is just a child and has no idea what she is wielding, like Peter Parker after he is bitten by a radioactive spider in the *Spider-Man* films. But Sankofa is soon perceived as more of a villain than a superhero.

Her first casualties are insects, like malaria-carrying mosquitoes. Her skin glows green and they die before they can bite her. Then she kills a wasp, egged-on by her brother. Their games soon reveal the terrible consequences of her power, leading Sankofa on a journey away from Wulugu as she tries to understand her unique ability and to gain control of it.

In the process, she faces profound loneliness, because people avoid her out of fear. We see Sankofa grow up and start to use her abilities to try to help people, as well as in self-defence. "I only take life when people ask me to, when people are sick and in too much pain to live. The word is euthanasia... or when people threaten my life," she explains.

"*Remote Control* is thrilling and surprising. There is definitely room for the story to continue"

Okorafor imagines a futuristic Ghana, which Sankofa travels through as she comes to terms with herself and her power. In one part of the story, she passes through RoboTown, a place where intelligent robots called "robocops" guide traffic on the roads. Announcements are made in Twi, a group of dialects that is widely spoken in parts of Ghana, and mysterious, beetle-like drones hover overhead.

Sankofa soon realises that the drones are watching her. She starts to suspect it has something to do with her power, and with a US corporation called LifeGen that recently set up in Ghana. She and the reader soon learn she is part of something larger than herself.

To me, *Remote Control* felt like a combination of West African folklore and a sci-fi thriller. The colourful imagery of Ghana and the somewhat cautionary tale of Sankofa reminded me of the Anansi stories – Ghanaian folk tales about a trickster that could take the shape of a spider, which I recall from my childhood – but with a tantalising sci-fi mystery woven through it.

Sankofa is a Twi word that translates as "go back and get it", which refers to learning from the past. That idea is also symbolised by a bird with its head turned backwards. In *Remote Control*, Sankofa must eventually return to her home town to find out more about her power and ultimately use her strength to try to save the world from destruction.

I love a good mystery and *Remote Control* is thrilling and surprising all the way through. Even the book's ending comes suddenly and unexpectedly. I think there is definitely room for the story to continue and I very much hope it does. ▮

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DOMENIC BAHMANN

Salt power!

The world desperately needs cheap, plentiful batteries. Can we make them from common sodium chloride? **Katharine Sanderson** investigates

THEY are the widgets that quietly power our lives: lithium-ion batteries. Our phones, laptops and increasingly our cars rely on them. They already seem ubiquitous, yet the real battery revolution is still coming. Just take electric vehicles: in 2019, the number of electric cars on the world's roads was just over 7 million, but that is expected to shoot up to some 200 million by 2030. And then consider our hopes of running the future on green electricity from wind turbines and solar panels. That will also depend on huge batteries that can store electricity for when it is needed, smoothing out peaks and troughs in demand.

Firms around the world are ploughing billions into battery factories to meet the demand. But that is going to require a lot of lithium. So much, in fact, that it isn't obvious if we can mine enough of it to keep up, at least not without ravaging the environment even more. There may come a point where lithium becomes too scarce or expensive to be the key ingredient in this revolution.

What if we could make batteries using something so common that you almost certainly have it in your kitchen? Researchers have for years been working on batteries based not on lithium, but its close chemical cousin sodium, one half of sodium chloride or common table salt. It hasn't been easy. You might even say it has been a grind. But at last we might have a way out of this lithium bottleneck. Might the batteries of the future be made from salt?

To understand how a condiment can ride to our rescue, it first helps to know the basics of how batteries work. Think of them as a circuit that is part electrical, part chemical. Things kick off at the battery's anode, made of a material that can release electrons and, in the case of a lithium-based battery, lithium. Switch on whatever device is connected to the battery, and it sucks electrons from the battery to power itself. Meanwhile, positively charged lithium ions, having lost their electrons, diffuse from the anode, through a liquid or gel electrolyte, and insert themselves into pores in the cathode.

Fully charged

Eventually, the anode runs out of electrons, at which point you will see that low-battery icon flashing balefully on your screen. But the delightful thing about a rechargeable battery is that the process works both ways. Provide it with an external source of electricity by connecting it to the mains and everything happens in reverse: the lithium ions flow back to the anode and recombine with new electrons, ready for the process to start afresh. A typical lithium-ion-based smartphone battery can be recharged an impressive 500 times or so before there is a notable loss of performance.

The lithium-ion battery's path to superiority began in 1980, when chemist John Goodenough, now at the University of Texas at Austin, developed a prototype ›

that was more powerful than any other at the time. Together with Akira Yoshino and Stanley Whittingham, he won a Nobel prize for the work in 2019.

Lithium batteries soon came to dominate the market and they have remained peerless for reasons of inescapable chemistry. In the periodic table, lithium appears at the top of the group 1 metals, a set of elements whose atoms tend to bear a charge of +1. Lithium is the smallest and lightest of the bunch and so has the highest charge density, meaning that a lithium battery can pack in more ions and so hold more power than a battery of the same weight made from another group 1 metal. It is easy to see why that is attractive for smartphone users and electric car makers.

But lithium batteries come with serious environmental drawbacks. While lithium isn't the rarest of metals, sizeable production happens in two places: mines in Australia and salt flats in the "lithium triangle" around the borders of Chile, Bolivia and Argentina. In South America, lithium brines are sequentially dissolved and allowed to evaporate to remove impurities. This requires about 1.9 million litres of water per tonne of lithium, a prodigious amount that leaves local farms and communities parched. With lithium found in so few countries, there is also a risk of geopolitical ructions between producers and big consumers, such as China, if – as is predicted – the supply becomes more scarce.

There are efforts to get around these difficulties (see "Fresh lithium", right). But our best batteries have another grave problem: cobalt. Goodenough's design, still in use today, uses a cathode made of lithium cobalt oxide. Cobalt is rare stuff indeed. Around two-thirds of mined cobalt comes from one country, the Democratic Republic of the Congo. Much of the metal is dug up by miners, including children, who often work without safety equipment in awful conditions and earn $3 a day or less. Another type of lithium battery uses a cathode made of manganese and nickel, which are both also rare.

"Purifying a tonne of lithium brine can require 1.9 million litres of water"

Sodium's potential as a replacement for lithium is suggested by a glance at the periodic table. It sits in the square below lithium, also in group 1, but weightier. While having almost the same chemistry as lithium, it has none of the environmental baggage or geographical limitations. "Sodium is so democratic," says battery researcher Maria Helena Braga at the University of Porto in Portugal. The US Geological Survey doesn't even attempt to put a number on the size of Earth's salt reserves, simply saying: "World continental resources of salt are vast."

Sodium isn't an automatic solution though. Largely, that is because it is quite a bit heavier, with a relative mass of 23 to lithium's 7. This is reflected in the standard potentials of the

Salar de Uyuni in Bolivia is the world's largest salt flat and a hub for lithium extraction

GTW/IMAGEBROKER/SHUTTERSTOCK

Fresh lithium

The vast majority of the world's lithium comes from just two places: Australia and South America. In both cases, its extraction is damaging to the environment. But there are plans afoot to get lithium from other areas using gentler methods.

Some of the action is happening in Cornwall, an area of the UK best known for its beautiful beaches. A company called Cornish Lithium has discovered that beneath the peninsula's granite bedrock are pools of lithium-rich hot brines.

The firm wants to get at it in a relatively environmentally friendly way, drilling 1-kilometre-deep boreholes and pumping the brine to the surface. The liquid will then be fed though a column of beads that lithium ions cling to, with the remaining water then washed back underground.

If it works, it could provide a much needed raw material for battery makers in the UK. "The world is hurtling down this lithium route," says Cornish Lithium's CEO Jeremy Wrathall. "Either we have to find a way of mining lithium in an environmentally benign way or we go to another technology."

two metals, an indication of the maximum amount of work that a battery made from them can do. Lithium, at -3.03 volts, has the best value of any metal, with sodium trailing behind at -2.71 volts. "Sodium is heavier, it has a lower voltage," says Nuria Tapia-Ruiz, a battery researcher at Lancaster University, UK. "To make it comparable to a lithium-ion battery, we need much more material, and so we are going to make heavier batteries." This is why sodium batteries tend to conjure up images of electric vehicles with all the dynamism of a milk float.

Big, but not bad

But a bulky battery isn't always bad. "If you want to store energy from solar panels or a wind farm, what you want is a very big battery. You don't necessarily worry about energy density or how heavy it is," says Robert Armstrong at the University of St Andrews, UK. Spurred by this thought, research into sodium cells – and all sorts of other battery designs – has been going on for ages (see "Bizarre batteries", page 38).

It isn't possible to simply use sodium ions in existing lithium batteries. Instead, each of the three battery components must be redesigned. But in doing so, we have learned that sodium batteries have benefits that go beyond the environment.

First, the cathode, which in lithium-ion batteries requires metals such as cobalt. The good news is that we have already learned to make sodium battery cathodes from layers of more sustainable metal oxides, such as magnesium, iron and copper. "We're always trying to avoid cobalt and nickel," says Tapia-Ruiz. These cathodes have made it into working batteries, including those made by HiNa Battery Technology in China.

Second is the anode. This is made of graphite in lithium-ion batteries, but the pores of this material are too small for sodium. The best alternative found so far is an engineered form of charcoal, which has bigger pores. Not enough is yet known about how much charcoal expands and contracts as sodium ions move in and out – too much of this and the battery will lose performance and possibly short circuit. Tapia-Ruiz says she and others are trying different alloys and forms of carbon to find the best option.

Third is the most challenging component, the electrolyte. The trouble is that in metal-ion batteries of all kinds the electrolyte can react with the anode and cathode, forming a layer on them that depletes performance. This happens in lithium-ion batteries, but it isn't a problem because the layer remains stable after the first charging cycle. In sodium battery prototypes, however, the solid layer tends to build up. Getting a working sodium battery, then, involves redesigning each of the three components and getting them to work together seamlessly. ›

SEBASTIAN MEYER/GETTY IMAGES

A young miner ties up bags of cobalt near Kolwezi, in the Democratic Republic of the Congo

In June 2020, Yuehe Lin at Washington State University and his team did just that, reporting a prototype sodium-ion battery that had a capacity similar to some lithium-ion batteries and that could be recharged more than 1000 times while maintaining 80 per cent of its performance. The crucial ingredient was a highly concentrated electrolyte that didn't lose performance even if some of it reacted with the electrodes.

Prototypes like this aren't, of course, finished products that can be slotted into a camera or other device. Getting to that point requires plating the electrodes onto metals so they connect neatly to electronic circuits, among other things. Happily, this stage of development yields more good news for sodium.

"Sodium has the same chemistry as lithium, but none of the environmental baggage"

In a lithium-ion battery, the cathode is plated on to aluminium. But that same metal can't be used at the anode because lithium ions can form an alloy with it, and so copper is used instead. Unfortunately, having different metals at each end means the battery always has an electric potential, even when not in use. As a result, lithium-ion

Bizarre batteries

There isn't going to be a single type of battery that will address all the world's energy storage needs, which is why people have been dreaming up all sorts of variations

MAGNESIUM

Lithium and sodium are both good battery ingredients (see main story). However, their ions can only carry an electrical charge of +1. Why not use an ion that can carry a greater charge – like magnesium, with its +2 charge? Several research teams are working on just this. It is early days, but magnesium could one day be the basis of batteries more powerful and safe than those made with lithium or sodium.

SEAWATER

A major selling point of sodium batteries is that they can be made from a plentiful resource, salt. And what better place to find salt than in seawater? This is why Stefano Passerini's team at the Karlsruhe Institute of Technology in Germany has developed a prototype battery based on seawater, with the sodium that is naturally dissolved in it carrying the charge. Passerini says he already has keen interest from investors in South Korea.

GLASS BATTERIES

Maria Helena Braga at the University of Porto in Portugal has been working on an unusual battery with John Goodenough, the Nobel prizewinning inventor of the lithium-ion battery. The key component is the electrolyte, which is made of glass spiked with sodium ions, which can travel through it. Every material needed is easy to source. "It's the most eco-friendly cell you can find," says Braga. The battery apparently has extraordinary properties: Braga says it can outperform lithium-based batteries; the one in her office has been powering an LED for five years. Others are having trouble replicating the device. Still, with backing from the likes of Goodenough, this is one battery to watch.

FUEL CELLS

Think of fuel cells as batteries that you charge by adding fuel rather than plugging them into the mains. John Andrews at RMIT University in Melbourne, Australia, has developed one that splits protons from water, which are then stored inside the battery. To release this power, oxygen from air is fed through the machine, which combines with the protons to produce water and electricity. "It's a very neat principle," says Andrews. "The challenge is to make it work in a practical device."

LIQUID BATTERIES

Otherwise known as flow batteries, these work on a similar principle to regular batteries, but all the components are dissolved in liquids. Chemist Lee Cronin at the University of Glasgow, UK, and his team have developed one such battery based on an enormous tungsten-containing molecule. The advantage is that a charged-up liquid battery could be pumped into a car quickly, much as petrol is today. The main barrier at the moment is that all that electrical charge makes the liquid electrolyte sticky and therefore difficult to pump.

batteries can short circuit, overheat and catch fire when disconnected. This is especially a risk when lots of batteries are being shipped around together. Sodium batteries can use aluminium at both cathode and anode, which eliminates this problem at a stroke.

On your bike

Sodium-ion batteries might be heavier than lithium ones, but with advantages at almost every other turn, that is starting to look like a worthy compromise. That's certainly the attitude of Faradion, a company based in Sheffield, UK. It produces a 1-kilogram sodium-ion battery that it says has a similar performance to a lithium cell. In 2015, the firm demonstrated an electric bike powered by its product. "You can certainly see them competing with lithium-ion," says Armstrong.

Perhaps the most original approach to sodium batteries comes from a firm called Natron Energy. The company's founder Colin Wessells developed an electrode material based on the pigment Prussian blue. This iron-based molecule has pores that are much bigger than a sodium ion and so it can let them in and out with almost no resistance, giving it a long life. "There's basically no wear out mechanism," says Jack Pouchet at Natron. "We have shown 37,000 cycles with no end in sight." The company is selling its wares mostly to data centres, servers that support the internet. These need extra battery power during periods of peak energy demand and as an insurance against mains power outages. For applications like this, a heavy battery isn't a problem.

More conventional sodium battery technology is set to improve quickly, according to forecasts from Stefano Passerini at the Karlsruhe Institute of Technology in Germany and his colleagues. The researchers totted up the materials needed to make lithium-ion and sodium-ion batteries with a capacity of 11.5 kilowatt hours, about a third of what is required in a small electric car. Then they repeated the exercise considering advanced prototype batteries and expected future developments. The results suggest that we can shave 32 kilograms off a lithium battery and 42 kilograms off a sodium battery of this capacity. The price of sodium batteries is set to come down quickly too. They will be competitive with lithium batteries by about 2025, estimates Passerini.

We shouldn't necessarily expect sodium batteries to directly replace lithium ones. Instead, it might make sense to use sodium cells in certain applications and so, hopefully, take pressure off our lithium reserves. What is important is that we can store electricity from renewable sources without wrecking the planet in the process. If they are to aid in that goal, batteries will, one way or another, need a total recharge. ▮

WIRESTOCK/ALAMY

The battery-making Tesla Gigafactory in Nevada is one of the world's largest buildings

VCG/GETTY IMAGES

Numbers of electric cars are shooting up. These ones are charging in Shanghai, China

Katharine Sanderson is a science journalist based in Cornwall, UK

“What we found was shocking. The stress levels of burned-out parents were higher than those of people in severe pain”

Moïra Mikolajczak is at the forefront of research into parental burnout. She talks to Jessica Hamzelou about what causes this kind of extreme exhaustion, what to do about it – and the sometimes surprising impact of lockdown

ROCIO MONTOYA

"A STATE of vital exhaustion." This is a surprisingly poetic description of burnout by the World Health Organization. Burnout – severe exhaustion caused by uncontrolled chronic stress – is increasingly becoming the focus of health research. It was originally identified as a work-related phenomenon, but now a form that affects parents is coming under the spotlight.

Any parent can relate to the fatigue associated with looking after a child. But for some parents, that tiredness can tip into harmful exhaustion, leaving them physically unwell and damaging their relationships with their children and partners.

Moïra Mikolajczak at the Catholic University of Louvain (UCL) in Belgium has been at the forefront of research into parental burnout. Over the past five years, she and her colleagues have found that it isn't something that just affects parents of ill children – it can affect any parent, although it is more likely to affect highly educated people who are perfectionists and put too much pressure on themselves.

Since Mikolajczak began studying the phenomenon, the field has expanded. A consortium of researchers she launched a few years ago to investigate parental burnout now has 90 members. The advent of covid-19 lockdowns, which have led to many parents juggling childcare with homeworking, has made the research more relevant and the need to understand this condition more urgent, says Mikolajczak. She tells *New Scientist* which factors can tip parents over the edge and how all parents can help protect themselves from extreme exhaustion.

Jessica Hamzelou: What is parental burnout?
Moïra Mikolajczak: Parental burnout is like any burnout. It's an exhaustion disorder, but takes place in the parental domain. You are exhausted because of your parental role, even if you don't have difficult or ill children.

What are the symptoms?
There are three main ones. The first is exhaustion, which is not a mere fatigue. It is more than fatigue. If you're exhausted, and especially if you're emotionally exhausted, it won't disappear with a good night's sleep. The second symptom is emotional distancing from your children. At some point, you keep the little energy you have left for yourself. The last symptom is the loss of pleasure and fulfilment in your parental role.

Can you see burnout signs in a person's body?
We have looked at levels of cortisol in hair, which is a marker of chronic stress, and can show the level of stress that you have been exposed to over the past three months.

We took hair from more than 100 parents seeking treatment for parental burnout, and compared cortisol levels with around 70 parents who were in the same family situation, and had the same number of children, but were well. ›

What did this study show?
What we found was shocking. The level of hair cortisol in burned-out parents was twice as much as the other parents, and was even higher than that seen in people suffering from severe chronic pain. If you meet a parent in burnout, you can see they are exhausted and overwhelmed by stress. This study shows it beautifully.

Who is most likely to be affected?
Parental burnout affects around 5 per cent of parents, but this figure varies hugely from country to country. In many African countries there is almost no burnout, while in some Western countries, such as the US, Belgium and Poland, the prevalence is more than 8 per cent. Clearly the culture in which a parent is living is a risk or protective factor.

Women are more likely to experience this, and you are also more at risk if you have a high level of education or if you're a stay-at-home mother or father. Work is a protective factor, which isn't surprising because it gives you a place to breathe.

But we have shown that, weirdly enough, these socio-demographic risk factors are less important than personal factors like perfectionism and parenting practices. Sometimes parents just put too much pressure on themselves with children's extracurricular activities or trying to cook organic meals.

In one of your studies, you mention that some parents feel like they have to fake happiness.
Yes, this pressure comes from the positive parenting culture that we are experiencing in Western countries.

It is not enough now to just educate your children, send them to school and make sure that they are healthy. You have to make sure that your children can develop to the maximum of their potential in every domain, that they feel emotionally secure, that they feel competent, valued and proud of themselves. We have found that this has a cost for parents.

"Sometimes parents just put too much pressure on themselves"

Stay-at-home mothers and fathers are more at risk of burnout

KNIEL SYNNATZSCHKE/PLAINPICTURE

Where has this pressure come from?
A historian at our university, Aurore François, is currently working to trace the origin of that pressure. It seems it can be traced back to the aftermath of the second world war when it was recognised that orphaned children who didn't receive any physical or emotional affection would suffer. Developmental psychology expanded, and psychologists started to write books to tell parents how to raise their children. Progressively, the pressure on parents increased, subtly but surely.

As a result of this rising pressure, parents are more exhausted. But that does not mean that parental burnout did not exist before. Aurore found a case of a mother who was sent to a psychiatric hospital in Belgium because of family exhaustion 100 years ago.

Is parental burnout a recognised condition?
It is not yet recognised by the mental health diagnostic manuals, but job-related burnout isn't either. Burnout as a whole is not yet recognised as a medical disorder in the DSM [Diagnostic and Statistical Manual of Mental Disorders] or ICD [International Classification of Diseases]. But the DSM and ICD are updated all the time. It is not the case that because a disorder is not in the DSM that it's not a disorder.

What is the impact on children?
The impact on children is especially worrying, because we have found that parental burnout increases neglectful and violent behaviours, even in parents who are opposed to violence. The violence is in great part verbal, but can become physical. Parental burnout makes you become the opposite of what you were and aim to be.

Have you seen any trends in cases of parental burnout as a result of the covid-19 pandemic?
We are conducting a study in 20 countries. I don't yet have the full results, but I can tell you what we have found in Belgium.

We expected that parental burnout would increase during lockdown, but when we surveyed more than 1000 parents we found

ROEL BURGLER/PLAINPICTURE

It helps to know that you aren't alone if you are feeling burned out

"About a third of parents deteriorated during the lockdown"

that, overall, it did not increase. But this stability hid variation between individuals. About a third of parents deteriorated during the lockdown. They were much more exhausted. These were parents who had young children at home, and who had to work from home at the same time. They perceived the lockdown as a burden and as extremely stressful.

On the other hand, a third of parents' situations were improved thanks to the lockdown. They didn't have any extracurricular activities to run and could enjoy life at home, doing things they normally didn't have the time to do. Approximately a third of parents remained the same.

Is there a treatment for parental burnout?
We have started to research different approaches. Group therapy, where parents gather and talk, works well. Parents feel less guilty and ashamed in this setting – it normalises the situation. It is terribly helpful to know that you are not alone. Parents suddenly feel understood and valued as a person again. They start to find a solution together.

What about mindfulness? Does that help?
In another study, we compared group therapy with a mindfulness-based therapy. When it works, mindfulness works very well. But about a fifth of parents [who tried it] severely deteriorated. So mindfulness can be helpful or harmful. As a clinician, I guess that, for some people, mindfulness just adds another thing to do – now you have to meditate in addition to everything else. And if you don't meditate, you feel guilty because you were provided with a way to get better, but were not able to do it. We don't know who is likely to benefit, so for now we have stopped offering mindfulness.

What advice do you have for people who might be worried that they have, or are at risk of developing, parental burnout?
The advice is to be aware of both your stress-enhancing factors and your resources. And to make sure that you always care to rebalance any addition of a stress factor by the addition of a resource. You may have to solicit the help of others, or to lower your expectations if you are a very perfectionist person.

But it depends on the severity. If the parent is experiencing severe parental burnout, then we not only advise you to work on the resources, but also to go and see a professional. A parent in burnout can think that there is nothing that can be done. They often think that only one factor is responsible for their situation – a difficult child or a partner who is not present enough or parents who aren't helpful. This is inaccurate. We have found in our research that no single factor can produce parental burnout alone. It's always the combination of several different factors.

Is there a way to find out if you have this condition?
We developed a test that people can take online. It is available at en.burnoutparental.com. ▮

Jessica Hamzelou is a reporter for *New Scientist*. Follow her @JessHamzelou

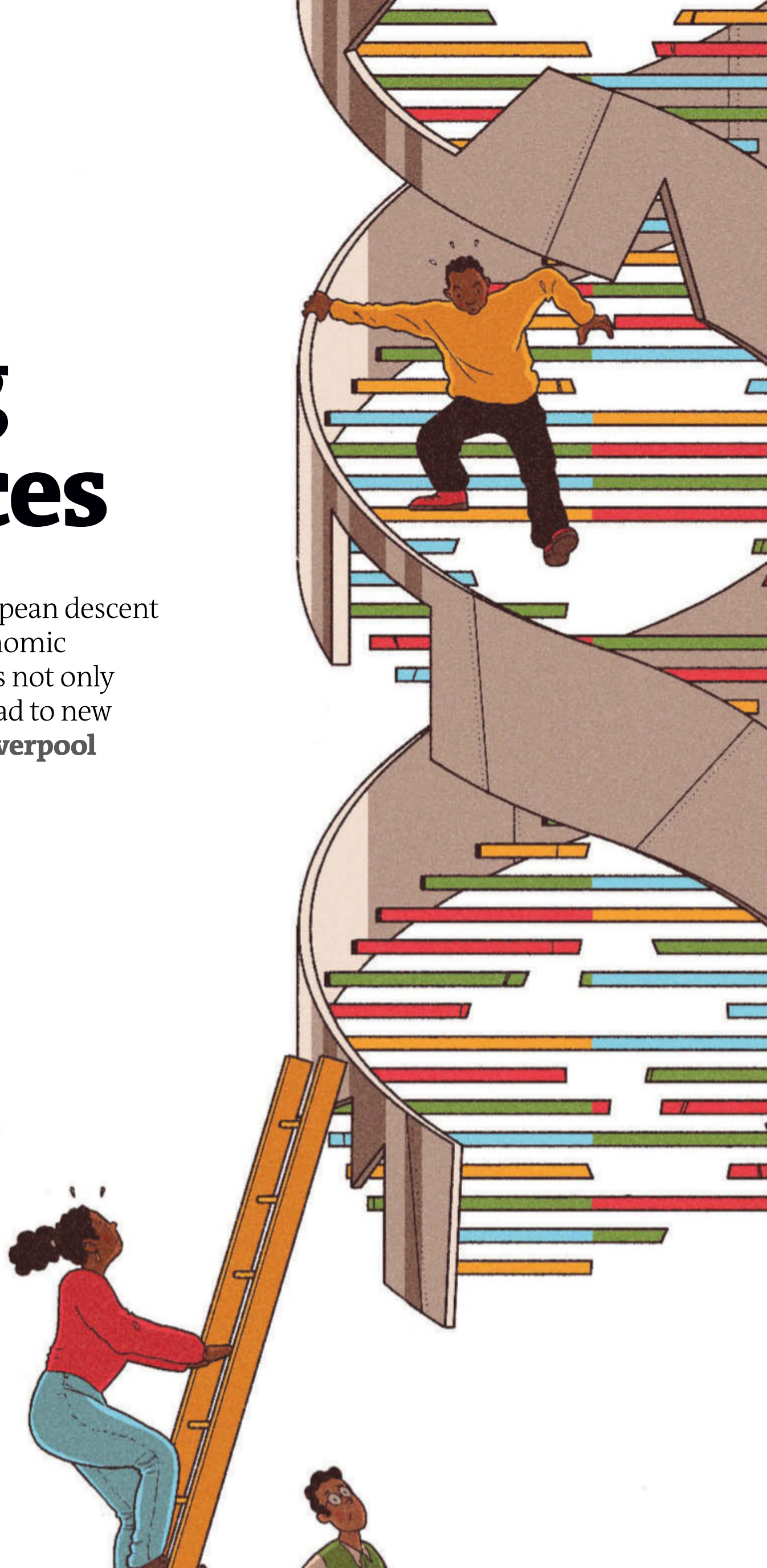
Missing sequences

DNA from people of non-European descent is conspicuously absent in genomic research. Fixing the problem is not only a matter of justice – it could lead to new treatments too, finds **Layal Liverpool**

IF YOUR doctor suspects you might have type 2 diabetes, they will want to know your average blood sugar level, which typically means taking a glycated haemoglobin test. This method of diagnosis is recommended by the World Health Organization and used pretty much everywhere. The problem, as Deepti Gurdasani discovered in 2019, is that the test may not work for everyone.

Gurdasani and her colleagues found that a gene variant present in almost a quarter of people with sub-Saharan African ancestry alters the levels of glycated haemoglobin in their blood independent of blood sugar. This suggests they will be more likely to be falsely diagnosed with diabetes, she says.

Gurdasani's discovery is just the latest in a growing list of medical injustices resulting from the fact that the vast majority of people who have had their DNA sequenced are of European descent. Again and again, people from under-represented backgrounds find that drugs and diagnostics based on research that makes connections between DNA and disease don't work for them. The dearth of diversity in these studies also means that



RUBY FRESSEN

people in overlooked populations are more likely to get inaccurate results from tests that look at an individual's genetic risk of developing a condition, excluding them from the much-vaunted promise of personalised medicine.

All of which explains why researchers like Gurdasani, a geneticist at Queen Mary, University of London, are sequencing the DNA of thousands of people from under-represented populations around the world. This isn't just about justice: increasing the diversity of genetic studies could also uncover novel genetic variants associated with disease, providing targets for treatments that would otherwise go undiscovered.

"There's this treasure trove of human genetic variation that could lead to a new understanding of human biology," says Keolu Fox, an anthropologist and genome scientist at the University of California, San Diego. The challenge now is to make sure that in the rush to harness it, geneticists don't exploit the very people they seek to include.

Medical revolution

Genetics' transformation of medicine started with the Human Genome Project. Completed in 2003, it gave us the entire genetic blueprint of a human for the first time. As whole genome sequencing got faster and cheaper, ventures like the 100,000 Genomes Project sprang up, improving our understanding of human DNA. These days, we can pore over tens of thousands of whole human genome sequences, comparing them in forensic detail to make connections between genetic variants – the tiny portions of the genome that differ between individuals – and disease.

These genome-wide association studies (GWAS) have identified gene variants behind all manner of conditions and even led to the development of new treatments for several, including rheumatoid arthritis and inflammatory bowel disease. The growing catalogue of human genomes that makes GWAS possible also underpins the promise of genetic testing in medicine, where it is being used to predict which conditions a person is susceptible to and, in some cases, to suggest preventative treatments.

But as things stand, it is mainly people with European ancestry who stand to benefit – as they make up the vast majority of those whose genomes we have sequenced. According to an analysis by Sarah Tishkoff at the University of Pennsylvania in Philadelphia and her colleagues, 78 per cent of individuals included in genomic studies of disease up to 2018 were of European descent, 10 per cent had Asian backgrounds and just 2 per cent were of African descent. That means that gene-disease associations based on these studies are unlikely to capture the full diversity of the human population. That's a major problem. "The lack of ethnic diversity in human genomic studies means that our ability to translate genetic research into clinical practice or public health policy may be dangerously incomplete or, worse, mistaken," the authors concluded.

Gurdasani's discovery that the test for diabetes is anything but universal shows this lack of diversity is already having an effect on people's lives. A similar issue is seen with cystic fibrosis, which often goes undiagnosed in people of African descent. Tests for the condition frequently look for known mutations within the *CFTR* gene, such as the deltaF508 mutation that is found in 70 per cent of people of European descent with the condition. But in people with African ancestry, that particular mutation only accounts for 29 per cent of cystic fibrosis cases. Instead, the cause is often one of a number of other mutations in the same gene – markers that may be less likely to be detected as most investigations undertaken to identify mutations in the *CFTR* gene have been conducted in European ancestry populations.

Similar bias may also influence the effectiveness of medicines, such as the breast cancer drug tamoxifen. The way our bodies process drugs like tamoxifen is strongly influenced by a gene called *CYP2D6*. There are more than 100 different versions of this gene, all of which occur at different frequencies in different populations – and various studies have shown that people of Asian or African ancestry are more likely than people of European descent to have a version that means they metabolise ›

tamoxifen less well, meaning they may benefit less from it.

These kinds of genomic inequities are starting to be challenged in court. In 2014, the anti-blood clotting drug clopidogrel, sold under the trade name Plavix, became the subject of a lawsuit, for instance, when studies suggested that a genetic predisposition common in people of East Asian or Pacific Island descent results in poor metabolism of the drug, potentially leading to negative effects. The state of Hawaii sued the manufacturers of Plavix, Bristol-Myers Squibb and Sanofi, over their marketing of the drug in the state, claiming the companies failed to properly warn consumers about the drug's potential risks. (The two companies counter-sued, arguing that the demand for what they consider unnecessary warning labels breaches their rights to free speech. But the counter-suit was dismissed in October last year.)

Not for everyone

While predicting a person's risk of developing a condition based on their genome sequence remains an imperfect science, there is mounting evidence that it works far less well in people of non-European descent. Last year, a team led by Alicia Martin at Massachusetts General Hospital in Boston found that the accuracy of such disease prediction is about twofold lower in populations of Asian descent than those with European ancestry, and roughly fivefold lower in populations of African descent. Other research has found that genetic tests vastly overestimate the risk of schizophrenia in people of African descent.

"If we continue to sample Europeans and extend our findings to other populations then that certainly is not going to work for everyone," says Gurdasani. If anything, it is going to exacerbate existing inequalities related to health.

That's the scenario many in the field are now working to avoid. Several large-scale efforts to sequence more people from under-represented backgrounds are under way. The GenomeAsia 100K project has sequenced the genomes of nearly 2000 people from 64 countries across Asia so far. The H3Africa initiative consists of 51 projects around the continent led by local researchers, including population-based genomic studies of disease. And the US National Institutes of Health is almost three years into a programme called All of Us, designed to create a database of genetic information and other health records from more than a million people with diverse ancestry across the country. Even commercial genetic testing companies like 23andMe are actively seeking more samples from people of under-represented backgrounds.

In some cases, belated efforts to chart the fullness of human genomic diversity are already beginning to bear fruit, as previously overlooked sequences reveal novel gene variants. Nowhere is that more apparent than in Africa, where genetic diversity far exceeds that in any other part of the world. That's because all humans originated there, and those who migrated outwards only took a fraction of that original diversity with them.

Gurdasani and her colleagues collected DNA sequences from more than 6000 people across 25 villages in south-west Uganda, including almost 2000 complete genomes, alongside information from participants about their health. When they analysed it alongside similar data from 8000 people from across Africa, they found various gene variants associated with cardiovascular and metabolic disease, 23 of which hadn't been discovered before.

Blood samples at the UK Biobank project, which holds genetic and health data

CHRISTOPHER FURLONG/GETTY IMAGES

"There's this new modality of treating Indigenous people's genomes like coal or cobalt"

One of those is a variant that offers protection against malaria – the same variant that renders the most common test for diabetes useless for many people of African ancestry. Several gene variants Gurdasani identified during subsequent sequencing efforts are equally intriguing, including one that could be a potential target for HIV treatments. That work isn't yet published.

Tishkoff, too, has found previously unknown gene variants by sequencing volunteers in Ethiopia, Tanzania and Botswana. One newly identified variant associated with skin pigmentation could play a role in skin cancer. And in November 2020, a study from the H3Africa initiative reported the discovery of more than 3 million novel genetic variants.

This is just the start. Despite people of non-European descent accounting for a smaller proportion of participants in GWAS studies, they already contribute more in terms of genetic discoveries, says Gurdasani. "The more diverse populations you study, the more opportunities you have to identify associations with disease, which is what leads us to targets for drugs and new therapies," she says. What's more, those therapies will be more likely to work for everyone.

There is also a push to sequence smaller, more isolated populations, including

JUSTIN LEWIS/GETTY IMAGES

The genomes of Greenlandic Inuits could tell us more about heart health

Indigenous peoples, on the basis that many of these populations have adapted to extreme environments. Greenlandic Inuits, for example, have relatively low levels of heart disease even though they have traditionally eaten a diet rich in fat, so biologists have begun to study gene variants within these populations in the hope it could improve our understanding of heart health and inform the development of new treatments. By sequencing the genomes of a group of Melanesian individuals, researchers were able to discover new variation in several genes associated with metabolism.

Genomic justice

"We're starting to see the true value of this data," says Fox. But as the possibilities for enhancing our understanding of disease and developing new treatments become clear, Fox warns that researchers must properly reckon with the ethical considerations involved in sequencing the DNA of people from under-represented groups – not least the very real danger that efforts to increase diversity end up exploiting the populations they set out to include.

"There's this new modality of treating Indigenous people's genomes like coal, cobalt, diamonds or oil," says Fox. "Because you can't tell me these sequencing experiments are actually going to result in an improvement in brown people's lives. The real issues have to do with access to clean water, malaria and so on."

Gurdasani also emphasises the need to tread carefully. "There is a long history of samples and data [taken from under-represented groups] being used, without consent, for other purposes," she says. One notorious case dates to the 1950s, when cancer cells were taken from an African-American woman called Henrietta Lacks without her or her family's consent. They went on to provide the first immortalised human cell line, meaning they are cultivated and reproduce indefinitely. The cells are still widely used for medical research today. This is far from the only example. In 2019, the Wellcome Sanger Institute in the UK was accused of commercialising a genetic testing product without the consent of the hundreds of African people whose donated DNA was used to develop it.

Tishkoff says researchers must prioritise ethical considerations. "You can't just go there, grab blood and leave," she says. Instead, you have to engage with the communities involved, building trust and collaborations – and accept that there is no one-size-fits-all strategy. "It takes time if you're doing it the proper way," she says.

As genetic studies have the potential to reveal underlying genetic conditions that participants may be unaware of, Gurdasani says it is crucial that researchers build medical infrastructure when working in regions with limited healthcare services. During her study in Uganda, for example, Gurdasani and her team, including scientists based at the UK Medical Research Council's Uganda Medical Informatics Centre, worked to develop infrastructure so that study participants had access to treatment and genetic counselling. "You can't diagnose people with disease and then not have a pathway of care," she says.

Fox is particularly concerned about the pharmaceutical industry recruiting people from under-represented backgrounds to identify mutations that lead to the development of profitable drugs, without giving anything back to the people themselves. "It's extractive," says Fox. "It's colonial. But there's this illusion of inclusion." He has the same concern about consumer genetics companies, some of which have started to partner with drug manufacturers – as a collaboration between GlaxoSmithKline and 23andMe shows.

Fox argues that all genetic studies should be led by people from the groups being studied and provide direct benefit to them. In 2018, he and his colleagues published a framework for enhancing ethical genomic research within Indigenous communities, and he hopes to set up a network of labs dedicated to genetic research led by Indigenous people. He also points to existing examples, such as LunaDNA, a community-owned platform for biomedical research that distributes proceeds to people who share their DNA.

Tishkoff is optimistic that we can do this in the right way. "I think we're going in the right direction," she says. "But at the same time, there's a long way to go." ▮

Layal Liverpool is a trainee digital journalist at *New Scientist*

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The back pages

Science of cooking

Getting the best out of beans

Beans can provide a source of protein if you want to cut back on meat. But you need to know how to cook them, says **Sam Wong**

Sam Wong is social media editor and self-appointed chief gourmand at *New Scientist*. Follow him @samwong1

What you need

Beans
Tahini
Garlic
Lemon juice
Chilli flakes
Salt
Water
Red onion
Olive oil
Parsley

Science of cooking appears every four weeks

Next week

Science of gardening

IF YOU are taking part in Veganuary or just cutting down on meat, beans are a valuable source of protein for anyone on a plant-based diet. They owe their high protein content to a symbiosis with *Rhizobium* bacteria, which the plants foster inside nodules in their roots. These bacteria can absorb nitrogen from the air and convert it into ammonia, which the plants can use to make protein-building amino acids.

Beans, peas and lentils – and peanuts – are the seeds of legume plants. They have a tough coat made up mostly of cell-wall carbohydrates. Inside the seed are two embryonic leaves called cotyledons, which store starch and protein to nourish a seedling. Some beans, such as kidney beans, contain phytohaemagglutinin, a toxin that causes red blood cells to clump, but it is destroyed with proper cooking.

Tinned beans are convenient, but their flavour is a poor relation to that of dried beans cooked at home. You can cook them without pre-soaking, but they cook more quickly and evenly after being soaked for at least 12 hours. The low permeability of the seed coat means they absorb water slowly, letting it in initially through the hilum or "eye" of a bean. After 12 hours, beans have typically doubled in weight.

Once a bean is hydrated, its structural polymers are sensitive to heat and molecular changes can soften it: unfolding of proteins, gelatinisation of starch and solubilisation of pectin.

SHUTTERSTOCK/ESIN DENIZ

In the seed coat and the cotyledons, cells are held together tightly by pectin molecules, with calcium ions forming strong cross links between the pectin. The pectin molecules must break apart and dissolve for the beans to soften.

Hard water with a lot of calcium or magnesium in can reinforce the bean cell walls, increasing the time needed to cook them. Many people say you shouldn't add salt when you soak and cook beans, but I found that beans soaked and cooked in salted (2 teaspoons per litre) water softened faster and tasted better than beans soaked in unsalted water. The sodium ions may weaken the bonds between pectin molecules.

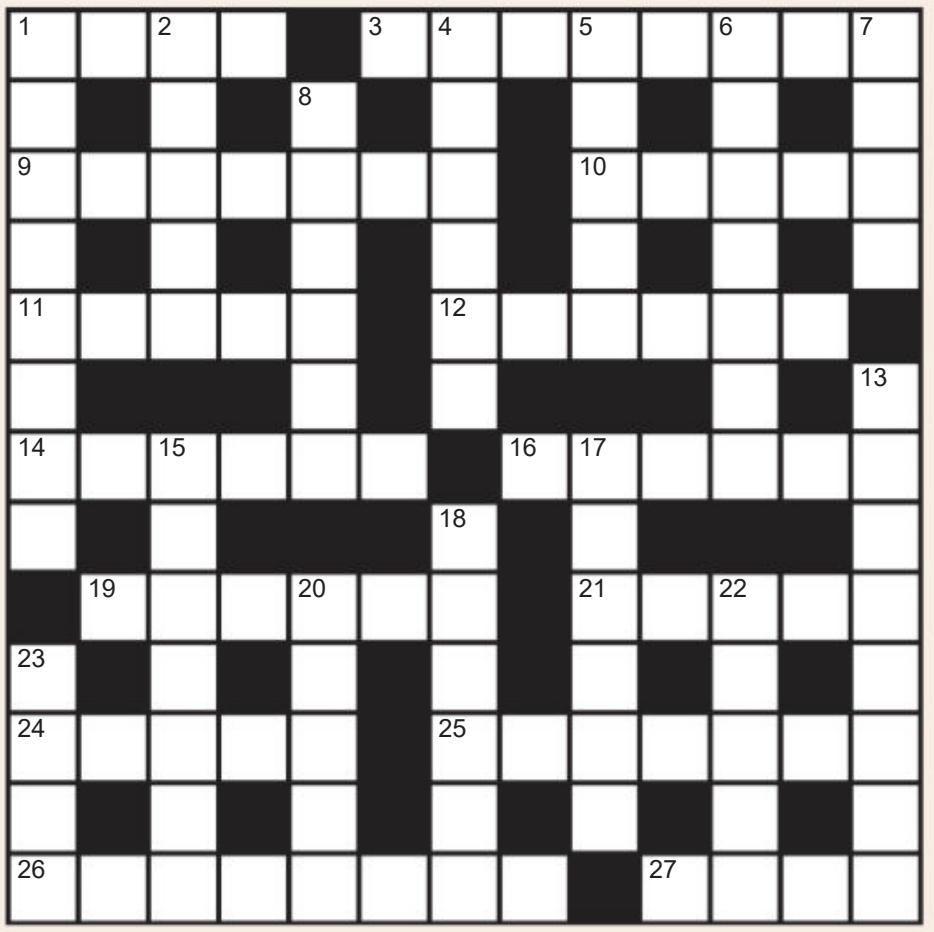
You can cut the cooking time further by adding a teaspoon of bicarbonate of soda per litre to the salted water. This makes the water alkaline, helping to weaken pectin as well as unfolding proteins.

Acids, on the other hand, inhibit softening, which is why beans can be simmered for hours in tomato sauce without falling apart. It is best to cook beans alone before adding them to soups if you aren't planning a lengthy cooking time.

The Turkish salad piyaz (pictured) is a delicious way to enjoy any bean. Mix tahini, garlic, lemon juice, chilli flakes and salt, adding water to make a smooth sauce. Use this to dress cold, cooked beans along with finely chopped red onion. Drizzle with olive oil and scatter over some parsley. ▮

These articles are posted each week at newscientist.com/maker

Cryptic crossword #49 *Set by Wingding*



Scribble zone

Answers and the next quick crossword next week

ACROSS

1 Twisted metal and seaweed (4)
3 Tuna centre to the east of Scotland (8)
9 Spooner's fur-insect is a show of affection (4,3)
10 Map covering Italian flat area (5)
11 Spanish city holds 1000 fruit (5)
12 Voice assistant overcomes one reading disorder (6)
14 Only function with endless happiness (6)
16 Protect group after function (6)
19 Microbe farm loses bear regularly (6)
21 Endangered species is fine, leaders of animal park insist (5)
24 Oil producer wants nothing to exist (5)
25 Getting right into untrue fabrication? It's not in one's nature (7)
26 Headache caused by crystal energy accompanying musical note (8)
27 Opening function missing the point (4)

DOWN

1 Blue rinse engineered with no resistance to make spray (8)
2 Mass under existing field (5)
4 Function held up by traffic blockage (6)
5 Plentiful beer drenching politician (5)
6 Oxygen changes reproductive organs (7)
7 Volcano raising stake (4)
8 Bird in cold place mostly making organic compound (6)
13 Submarine's primary weapon making loud noise (8)
15 Laudanum binge incompletely alleviating pain (7)
17 Mapping agency filled with severe smells (6)
18 Function with new home for chemical made up of 8 downs (6)
20 Chaps in A&E turn over for this procedure? (5)
22 Butterfly makes AstraZeneca certain to dismiss head (5)
23 Communication tool lets menagerie get on top of admin, essentially (4)

Quick quiz #85

1 Dan Shechtman is credited with the discovery of which rule-breaking solids?

2 In which lobe of the human brain would you find Broca's area?

3 What is the atomic number of iron?

4 The serpent-entwined rod associated with medicine is a symbol of which Greek god?

5 What is the most common type of coral reef?

Answers on page 55

Puzzle
set by Zoe Mensch
#97 Cabinet reshuffle

The Ruritanian prime minister is in a fix. Thanks to a series of incompetent policy decisions, all five of her senior ministers need to be axed from their posts. However, the PM cannot afford to sack them completely, because they will wreak havoc if moved to the back benches.

She has a solution: a reshuffle! She will move each of the five ministers to one of the other top posts, but no two of them will directly swap with each other. Anerdine will move to the department of the person who will become chancellor. Brinkman will replace the person who will be the new home secretary. Crass will take over the post being vacated by the person who will take Eejit's job. Dyer will be become health secretary even though he has been lobbying to become chancellor. The current defence secretary will get the department of the person who is becoming the education secretary.

Can you figure out who currently has which job, and where they are moving to?

Answers next week

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Seeing small

What is the smallest animal with eyes and could it see a molecule?

Hillary Shaw
Newport, Shropshire, UK
It depends what one means by "see", "eye" and "molecule".

A single cell could be light-sensitive, but it would only "see" shades of light and dark. Does seeing imply some degree of comprehension, rather than just instinctual action such as light-avoidance? That would necessitate an eye that could focus and form an image on a retina and a brain capable of understanding that image.

The smallest image that could then be "seen" would be the size of one light-detecting cell, which is considerably larger than a molecule, unless you count things such as long-chain polymer plastics as a molecule.

We are almost certainly the only animal whose brain "knows" what a molecule is, anyway.

Lewis O'Shaughnessy
Nottingham, UK
Camera-type eyes like those possessed by humans, with a lens to focus light captured through an aperture onto photoreceptors,

"No matter how small an eye is, it wouldn't be able to discern a single molecule using visible light"

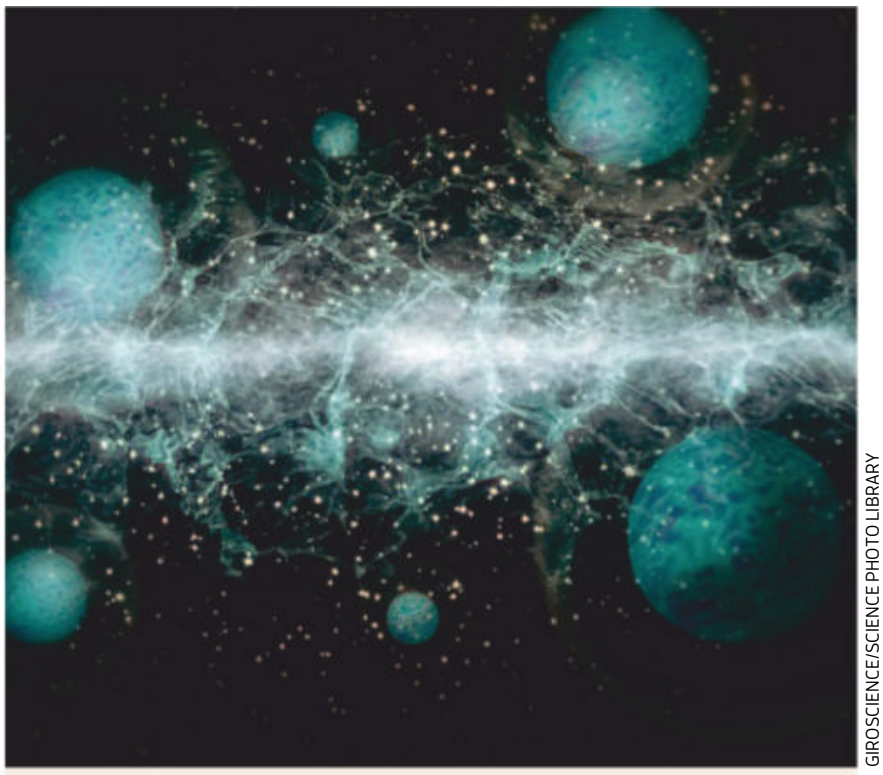
are fascinatingly complex with many different tissues playing unique and essential roles.

This complexity limits the minimum size of such eyes, which is why smaller animals often have proportionally larger eyes. Still, this kind of eye can be remarkably small – minute vertebrates possess these complex eyes, including *Brookesia micra*, a tiny species of chameleon.

For even smaller eyes, insects are a good place to look. Their eyes are much simpler than ours and so the images are much less clearly defined – a bit like reducing the number of pixels on your computer screen.

We could look even smaller (and this is where we stretch the definition of an eye). Some bacteria can produce light-sensitive proteins, which might guide their navigation. Not quite an eye as we would normally consider it, but not bad for single-celled organisms.

Richard Bradford
Sheffield, South Yorkshire, UK
The problem is that, no matter how small the animal, it wouldn't be able to discern an individual molecule using visible light. To make out an object, the wavelength of light hitting it has to be shorter than the size of the object being observed. The wavelength of visible light ranges from about 400 nanometres (violet) to 700 nm (red) whereas a water molecule is about 0.27 nm across its largest dimension. Even a large molecule, such as DNA, has a diameter of only about 2 nm.



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This week's new questions

Pull the other one **If there are other universes, would our universe feel their gravity? *Don Kearley**, Sydney, Australia*

Fear and trembling **Why do our hands shake when we are nervous? *Michael Crouch**, Norwich, Norfolk, UK*

In a spin

Earth spins round the sun, the sun round the galaxy and galaxies spin on their axes. Where does all this spin come from? The big bang?

Mike Follows
Sutton Coldfield, West Midlands, UK
The formation of star clusters and galaxies is due to fluctuations in the density of cosmic matter, and hence gravity's pull. The fact that all these objects are spinning is due to the conservation of angular momentum.

In a multiverse, can the different universes feel the gravity of the others?

Clumps of dark matter formed first, and acted as "seeds" for the formation of structures, providing gravitational potential wells that pulled in atoms of normal matter.

If these potential wells and all the matter falling into them had all been perfectly spherically symmetric (that is, symmetric along any axis) then there would be no spin. However, when one atom doesn't fall towards the very centre of the well, it produces a tiny torque, which becomes accentuated as the clump of matter collapses. This is due to the conservation of angular momentum, observed when a figure skater spins faster as they pull in their arms.

The change in spin radius as a vast molecular cloud collapses into a star is so enormous that an imperceptible spin in the cloud manifests itself as a spinning solar system with planets orbiting a star.

Guy Cox
St Albans, New South Wales, Australia
It is a case of spin or fall in. After the big bang, matter moved away from its origin at high speed. We know from the cosmic microwave background that the distribution of matter wasn't uniform – if it had been, the universe as we know it wouldn't exist.

Wherever there was a concentration of matter, gravity tended to pull it closer together, and eventually the first stars were formed. For matter to avoid falling into a star, it had to have sufficient angular momentum to orbit it, forming the accretion disc from which planets coalesced. These planets in turn attracted material, some of which circled around them and became moons. The same applies at a larger scale, with stars attracting other stars and so forming galaxies. The big bang gave linear motion. Gravity turned it into orbital motion.

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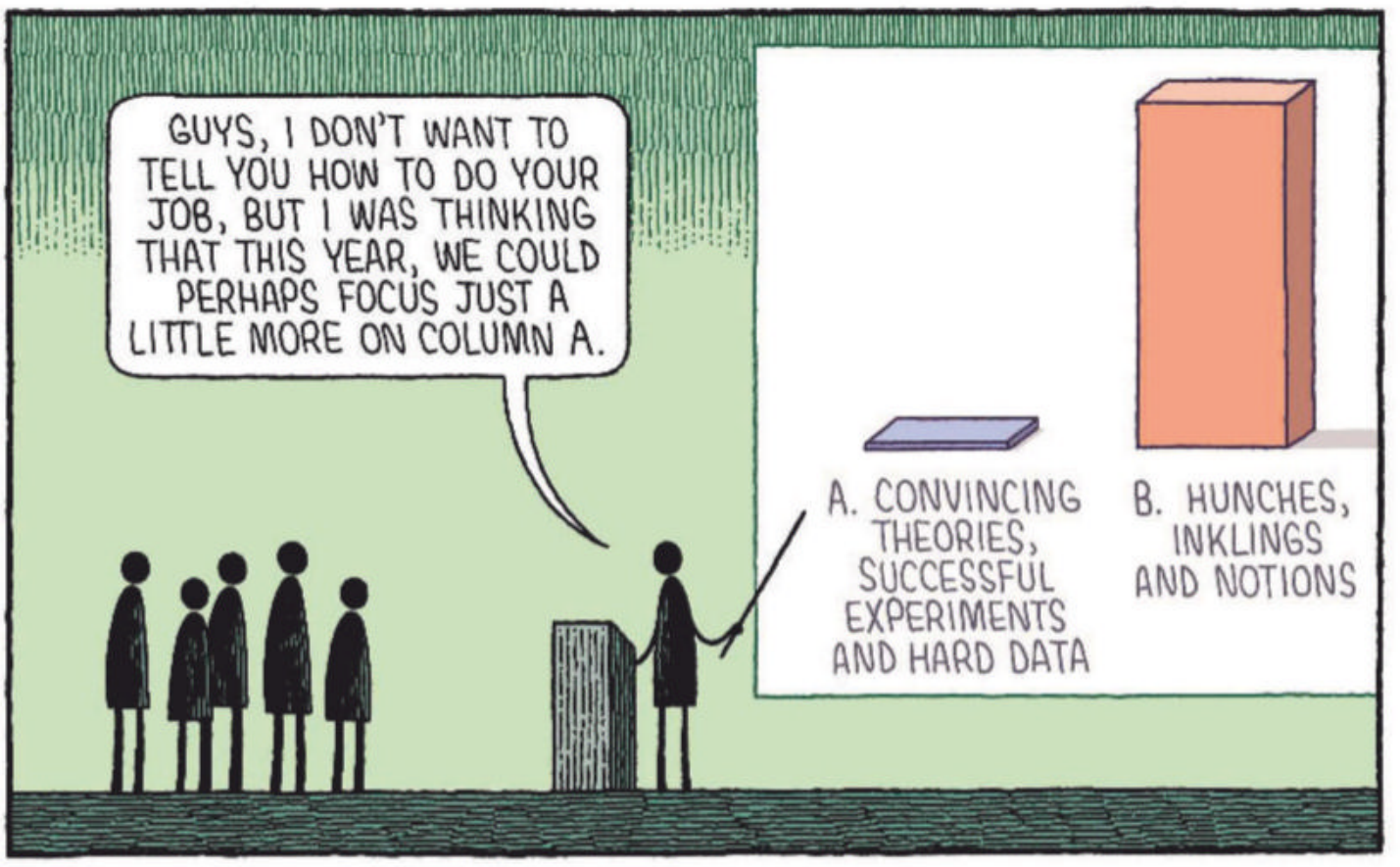
Tom Gauld
for New Scientist



Plastic pong

If plastic is inert, why does it have a taste and smell? Plastic bin bags have a strong smell when first opened and water left in plastic bottles can acquire a distinct taste.

Greg Cash
Goodna, Queensland, Australia
Plastics in everyday use are usually made of artificial polymers that comprise a string of monomers derived from oil. The polymers consist of numerous, very long chains of atoms. In thermoplastics, these chain-like molecules aren't chemically bonded to each other. In thermoset plastics, the polymer strands are cross-linked.

Any smell won't come from these polymers, but must be from small molecules that are volatile at room temperatures. These could be additives, left over monomers from the polymerisation process or breakdown products.

Non-rigid PVC (polyvinyl chloride) contains plasticisers such as phthalates which have noticeable odours. They are added to make a rigid polymer flexible.

"Water in clear drinks bottles left in the sun can get contaminated with the products used to make the plastic"

As a retired polymer chemist, I can smell the phthalates in the oxygen masks when I have minor procedures at my hospital.

The water in clear drinks bottles made of PET (polyethylene terephthalate) that are left in the sun can become contaminated with some of the starting products used to make the plastic of the bottle. One of these is bisphenol A and could be the source of the taste in the water.

I have a number of tubs at home made from LDPE (low density polyethylene) in which I store my PET bottles for recycling. Over time, these have developed an odour that I know as polyethylene oxide and which signifies the breakdown of the polymer by free radicals.

They will soon split and I will then need to put them in the rubbish bin. Sending them for recycling could contaminate clean polyethylene and cause it to degrade prematurely.

A fourth example I recalled after a trip to the dentist is acrylic. This is a clear rigid plastic with lots of applications. It is mainly PMMA (polymethyl methacrylate), but if you cut it with a saw you will get the sharp smell of methyl methacrylate (the starting material) which my dentist uses as part of the preparation for modern dental "fillings".

Talia Morris
Cape Tribulation, Queensland, Australia
Plastics have a taste and smell because they aren't as inert as we would like to think they are.

Common plastics exude their more-volatile components – plasticisers such as bisphenols, for example. These can be smelled and tasted by us, and can also mimic oestrogen. ▮

Answers

Quick quiz #85 *Answers*

1 Quasicrystals

2 The frontal lobe

3 26

4 Asclepius (also known as Hepius)

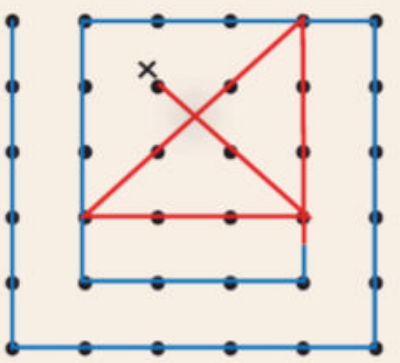
5 Fringing reefs

Quick Crossword #74 *Answers*

ACROSS 9 Upper, **10** North Pole, **11** Jan Oort, **12** Nominal, **13** Knees, **15** Nth, **16** Era, **17** Awl, **19** Eidetic, **20** KHz, **23** Vet, **24** Bus, **25** Lit up, **27** New idea, **29** Aspirin, **32** Gyrfalcon, **33** Twins

DOWN 1 Burj, **2** Sponge, **3** Arco, **4** Knot, **5** Bronchitis, **6** Chem, **7** Moonwalk, **8** Reflex, **13** Kea, **14** Sweat, **15** Nudibranch, **16** Excel, **18** Live wire, **21** Zip, **22** Ginkgo, **26** Tar pit, **28** Drag, **29** Acne, **30** Path, **31** Nash

#96 Inside the box *Solution*



Start at X and work outwards. The red lines that link nine dots arranged in a square follow the path of the classic four line/nine dot "out of the box" solution.

Smarty pants

"Round and round the garden, like a teddy bear; One step, two step, tickle you under there!" Ah, how well we recall Papa Feedback first introducing us to the delights of the type of tickling known as gargalesis – or is it knismesis? – with this nursery rhyme way back in the blue remembered gardens of childhood.

This sudden wave of nostalgia is unleashed on us by a startling instance of thrusting modernity: hot pants that sense your movements in order to tickle you to better athletic performance.

The "Inpulse smart shorts" were designed by neuroscientist Devon Lewis at the University of Southampton, UK, initially with cyclists in mind. As reported in various UK media, they come equipped with sensors that monitor muscle performance – plus an AI tool that assesses patterns in the sensor signals and delivers tiny electric shocks to muscle groups deemed to be underperforming.

Whatever tickles your fancy, we suppose. Feedback would need rather more significant electric shock therapy to be induced into Lycra, let alone wired Lycra. But we can see this technology moving in one of a number of ways, and not just of the "is that an AI tool delivering electric shocks in your hot pants, or...?" variety.

A modified version of the set-up could also be a boon in the socially distanced gardens of today's childhood, allowing toddlers to tickle themselves without other people needing to be present. Or, equipped with a remote control, it could be just the thing to help parents keep home-schooled infants in line.

Twisteddoodles *for New Scientist*

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

Blowing hard

Gerben Wierda writes in from Heerlen in the Netherlands to draw our attention to a hair-raising thermodynamic measure mentioned in *The Guardian*.

According to data from climate scientist John Abraham's team, in the past year, Earth "absorbed about 20 zettajoules of heat, equivalent to the heat given off by 630bn common household hairdryers blowing all day and night, 360 days a year".

So many questions. Who bought all the hairdryers? What are they doing with them all day and night? And what happens on the other five days? This could be a solution to global warming staring us in the... well, just above the face.

Chop and change

A sad blow to nominative determinism – and to our declared intention of keeping nominative determinism out of these pages this year – comes with the news, from reader Barry Cash, of the retirement last November of Austin, Texas, based urologist and vasectomist Dr Richard Chopp.

Sticking point

Feedback has had cause in recent months to muse on the efficacy of products employing scalar-wave technology to solve all manner of ills (3 October 2020, p 56).

Scalar waves are essentially waves without the wavy bit, and with their attendant scalar faster-than-light energy are one of the best bits of physics that mainstream accounts unaccountably miss out. One thing scalar-wave technology has proved useful for is "energy dots": stickers that, when applied to the back of a mobile phone casing, release emanations claimed to shield the user from harmful radiation.

Alas, now an investigation for BBC News by the University of Surrey, UK, concludes that the stickers have no effect on either the frequency or power of the radiation emitted. Ah, we wonder, but did they test their effectiveness in conjunction with the regulation tin foil hat?

Resistance is utile

What the peddlers of fruitloopery need is more futility testing. We recently came across this concept in our relentless quest for self-improvement – well, in an email from reader Adam Green – in the context of a rapid covid-19 test reported to have "successfully passed the Department of Health and Social Care (DHSC) futility testing process defined by the UK government".

Dashing our hopes for a little pointed political satire at the expense of the UK government's less than hapful covid-19 response, futility testing, we discover, is a Thing. Its principle is to reverse the null and alternative hypotheses of a standard scientific test: instead of assuming something doesn't work, and demanding evidence that it does, you start out assuming it does work, and look for evidence that it falls short of actually being useful.

This, apparently, can be a quicker way of distinguishing things that are utterly useless from things you merely can't be sure about. No, that's not an opening for political satire, either. Feedback has some things in mind we would be interested in using the principle on, but we welcome your suggestions.

100 not out

Michelle Munro writes from Ottawa, Canada, asking if we can give a mention to her father-in-law, Tony Fryar in Sidmouth, UK. Michelle writes that in his career as an engineer, Tony – Bob to his colleagues – designed the chassis of the London Routemaster and other classic British buses.

An avid *New Scientist* reader, Tony turns 100 next week. Say no more, Michelle. Tony, it is a pleasure and an honour to have you along for the ride. We shall raise a glass. ▮

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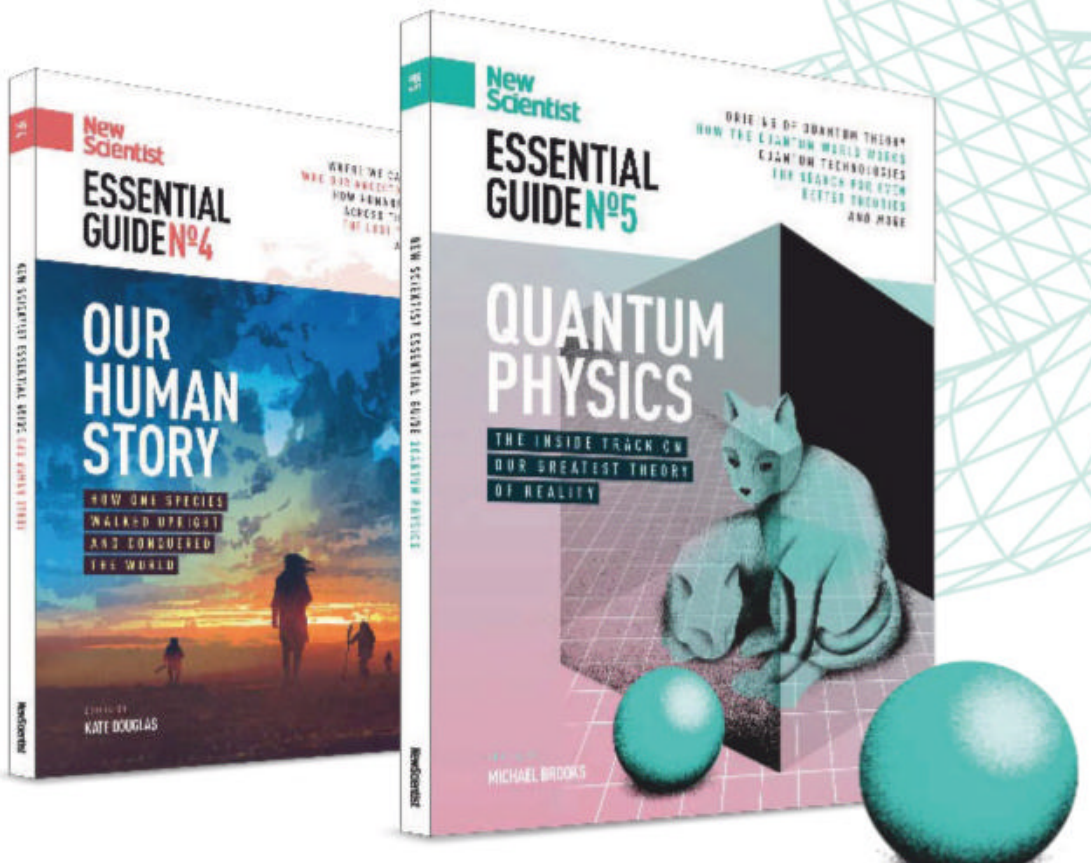

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