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WEEKLY November 21-27, 2020

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AS A *New Scientist* reader, you probably know that the study of human origins is one of the most exciting fields around at the moment. In the past decade, we have seen a complete revolution in our understanding of how we evolved, and it seems as if not a week goes by without a new fossil or discovery that rewrites the history books.

That is why we are delighted to be launching a free monthly newsletter, Our Human Story, to chronicle these extraordinary finds. It will be written by Michael Marshall, a former *New Scientist* staff writer and regular freelancer who will no doubt be a familiar name from these pages.

The first edition, which will be going out on 24 November, is full of fascinating material. Michael will expand on his story on page 17 of this magazine, which details the twisting, decades-long tale of a fossil that may be our earliest human relative. He will also give you his dig of the month, book recommendations and more. To make sure you receive it, sign up now at newscientist.com/sign-up/our-human-story.

If bones aren't your thing, however, never fear. In the coming weeks, we will be launching another monthly newsletter on the weirdness of reality by our executive editor, Richard Webb, who has been exploring our strange cosmos for decades. You can register here to get it in your inbox as soon as it launches: newscientist.com/sign-up/reality.

Don't forget, we also have our existing weekly newsletters. Health Check by Clare Wilson is your go-to guide on everything medical, from the latest updates on the coronavirus pandemic to top tips for staying healthy. Adam Vaughan's Fix the Planet is a weekly dose of climate optimism and green living (next week, he's writing about space-based solar power), while Leah Crane brings her inimitable style to the world of rockets and astronomy with Launchpad.

Not quite ready to pick a favourite topic? We have you covered. Sam Wong's daily newsletter is a quick blast of science news, helping you stay up to date at a glance, while our weekly newsletter gives you a rundown of each edition of the magazine. Whichever way you want to get your news, you can sign up for any of these free newsletters at newscientist.com/sign-up.

**“It seems as if
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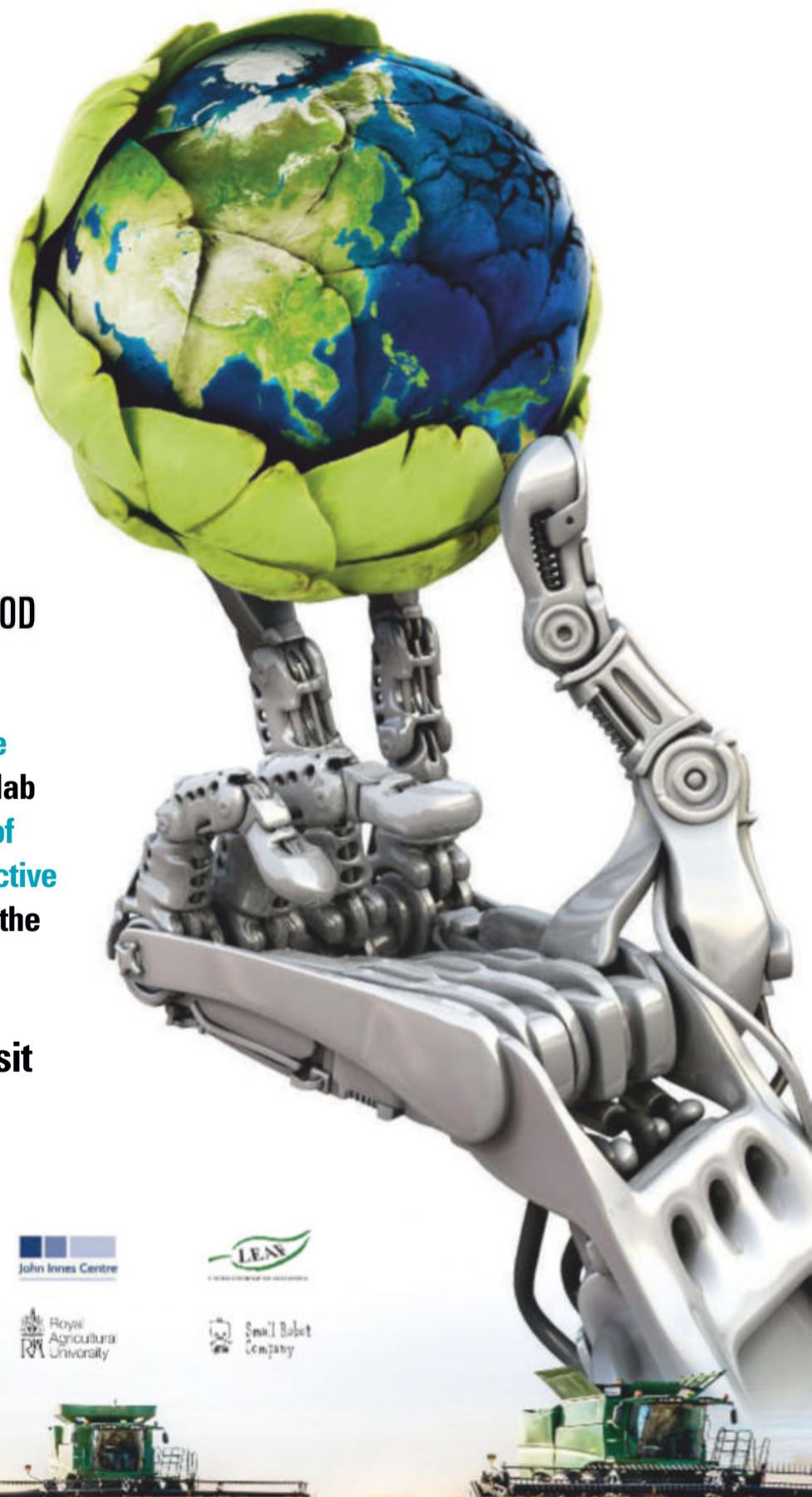
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The end is in sight

Although the road remains long, vaccine results show we can end the pandemic

WHAT a difference a week makes. In about that time, we have gone from having little more than hope that a coronavirus vaccine would work, to having promising results from not one but three trials.

As last week's issue went to press, we had just heard the news that a vaccine candidate in late-stage human trials seems to be safe and effective – at least according to interim findings. That was the vaccine from US firm Pfizer and its German partner BioNTech. Then came the results – albeit in a smaller sample – from Russia's Sputnik V vaccine. And on Monday, US firm Moderna chimed in with interim findings for its vaccine (see page 7), the most promising of all, which encouragingly seems to have an effect even for older people.

These results are a tremendous scientific achievement. This is especially true given that the two vaccines with the most

promising outcomes so far – those made by Pfizer and Moderna – use messenger RNA technology, which has never been approved for a vaccine before. This technology has incredible potential not only for helping us now with the covid-19 pandemic, but also in the future for tackling many other diseases, from flu to cancer, as Michael Le Page reports on page 14.

The fact that all three vaccines seem to work is particularly heartening given the gargantuan task of manufacturing, distributing and administering doses to the entire planet – preparations for which have been going on for months, as Carrie Arnold sets out on page 36. It suggests that we will have a choice of vaccines at our disposal. This will help production at scale and will hopefully mean that any shortfalls in efficacy of one vaccine will be covered by another.

But despite the unarguably good news, it is important to sound a strong note of caution. Yes, we now appear to be firmly on the road towards the end of this pandemic, yet the road remains a long one, as Graham Lawton writes (see page 8). We should be prepared for the fact that vaccines that are highly promising in trials may prove less effective when used in the real world.

We must also remember that a vaccine is useless unless people take it. As Heidi Larson argues on page 12, scientists and policy-makers mustn't dismiss safety concerns. They need to carefully listen to people's worries and then unambiguously set out the reasons they believe a vaccine is safe and in the best interests of the person taking it. Communication strategies will need to be clear and well planned if we want mass uptake of vaccines, and an end to this period of turmoil. ■

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US biotech firm Moderna released interim trial results on 16 November

at the injection site, tiredness, headaches and muscle or joint aches, as often happens after vaccinations. No serious side effects were reported.

The Moderna and Pfizer vaccines are messenger RNA (mRNA) vaccines, and include the gene for making the spike protein that protrudes from the coronavirus (see page 14 for more).

“It is really promising for the field of mRNA vaccines in general – it is easier to make them at scale”

Three other mRNA coronavirus vaccines are already in human trials, so the prospects for these look good, too. “It is really promising for the field of mRNA vaccines in general,” says Blakney.

What’s more, mRNA vaccines are simpler to manufacture than more traditional vaccines, she says. “It’s just so much easier to make them at scale.”

There are also five DNA vaccines in human trials. Here, the virus spike protein gene is delivered in the form of DNA rather than mRNA. However, special equipment and training is needed to dose people with DNA vaccines, unlike with mRNA ones.

Several adenovirus vaccines are also in human trials, including one being developed by AstraZeneca and the University of Oxford, and Russia’s Sputnik V. These vaccines also work by delivering the gene for the spike protein to cells, but packaged inside an empty adenovirus rather than in fatty droplets like most mRNA and DNA vaccines.

Russia claimed last week that Sputnik V is 92 per cent effective, but many experts say there have been too few covid-19 cases in its trial so far to justify this claim.

If at least some of these other vaccines prove as effective, as now looks more likely, vaccinating the world’s population as soon as possible should be much easier. ■

Vaccine trial hat-trick

Moderna’s vaccine trial is the third in a week to release positive results, raising hopes for a choice of vaccines, reports **Michael Le Page**

IMPRESSIVE early trial results for another coronavirus vaccine appear to trump those released just a week ago by Pfizer and BioNTech, and ones from a Russian trial.

The latest results, for Moderna’s mRNA-1273 vaccine, suggest that it is 95 per cent effective and works in those who need protecting the most – people aged over 65 – the US-based company announced on 16 November. The vaccine can also be stored in a normal freezer or fridge, which would help with distributing it.

If the Moderna and Pfizer vaccines work as well as their results imply, the prospects look good for other coronavirus vaccines that act in the same way, several of which are already undergoing human trials. Such vaccines are desperately needed:

about 55 million covid-19 cases have now been reported globally, with cases rising especially fast in the US, which has been reporting more than 150,000 cases per day.

More than 30,000 people in the US aged 18 and over are taking part in the phase III trial of the Moderna vaccine. Half of the participants were given a placebo.

The interim analysis is based on the first 95 cases of covid-19 detected. Ninety of those people – including 15 who had severe cases – were among those given the placebo. Just five – none with severe symptoms – were among those given the vaccine.

The company says the 95 people who got covid-19 included some

aged 65 or over, and 20 people “identifying as being from diverse communities”.

This is especially promising because the results of the trial by Pfizer and BioNTech don’t reveal detailed age profiles of participants, so it isn’t clear if that vaccine works in those over 65.

However, Anna Blakney at Imperial College London says we will need to see more data to confirm that vaccination is effective in older individuals. “There’s not really a difference in efficacy between the two vaccines,” she says.

So far, the results also suggest that the Moderna vaccine is safe. Some participants reported pain



Daily coronavirus news round-up

Online every weekday at 6pm BST

[newscientist.com/coronavirus-latest](https://www.newscientist.com/coronavirus-latest)

Vaccine trials

Vaccines: hope vs reality

Are the candidate vaccines in late-stage human trials really everything the world has been waiting for, asks **Graham Lawton**

IT IS the ultimate exit strategy from covid-19. A safe and effective vaccine is of “critical importance to world health”, the World Health Organization (WHO) has said.

Vaccine developers are working flat out to make good on that. Last week, the US pharmaceutical giant Pfizer and its German partner BioNTech announced positive-looking results from their ongoing phase III trial, the last stage of testing whether a potential vaccine is safe and effective. The interim results showed a headline success rate of 90 per cent, meaning that nine out of 10 trial participants who caught the new

part due to the huge challenge of manufacturing, distributing and administering one (see page 36), plus the reluctance of a significant minority of people to get vaccinated (see page 12). However, it is also down to trial constraints, which leave a number of questions around safety and effectiveness. If you thought those were the things the trials could give us all the answers to, think again.

Complex question

“In my line of work, I get asked this nearly every day from my friends and family: will this particular vaccine or that particular vaccine work?” says Susanne Hodgson at the University of Oxford’s Jenner Institute, which researches vaccines. “And I’m always stumped by how to deliver the answer quickly. Because it is a complex question.”

The least complex part of the question is, how long will immunity last? The desired answer is “forever”, but realistically a year would be a very positive outcome. In April, the WHO published an official assessment of what would constitute a safe and effective covid-19 vaccine. On length of protection, it said its preferred outcome was at least a year, but it would accept a minimum of six months – though pointing out that this “might not be demonstrated in initial clinical studies”. The US Food and Drug Administration (FDA) has set the same goal, and the UK vaccine task force says it is prepared to have to vaccinate people twice a year.

As yet, however, even that six-month bare minimum hasn’t been attained. The Pfizer and BioNTech phase III study began vaccinating people in late

“How long will immunity last? The desired answer is ‘forever’, but realistically a year would be positive”

coronavirus had received a placebo rather than the vaccine.

The news got some people very excited indeed. Asked on BBC radio whether these results meant a probable return to normal by early next year, John Bell at the University of Oxford and a member of the UK government’s coronavirus vaccine task force channelled Meg Ryan in *When Harry Met Sally* and said: “Yes, yes, yes!” Many listeners no doubt thought: “I’ll have what he’s having.”

A few days later, another phase III trial – this one being run by the Gamaleya National Center of Epidemiology and Microbiology in Russia – reported even better interim results: a success rate of 92 per cent. And earlier this week, US company Moderna announced 95 per cent efficacy from its ongoing phase III trial (see page 7).

So things look good. But we are still a long, long way from a vaccine that will get us back to life as normal. That is in no small



NATALIA KOLESNIKOVA/AFP VIA GETTY IMAGES

July and has only just finished recruiting volunteers. As a result, it won’t have an answer until February at the earliest, because the vaccine requires two shots, three weeks apart. We simply don’t know yet how long protection from any vaccine will last.

Time isn’t something that the vaccine developers have control over. But they can control other aspects of trial design, and these raise some major questions, says Peter Doshi at the University of Maryland School of Pharmacy. Last month, he wrote an article in *The BMJ*, of which he is an associate editor, entitled “Will covid-19 vaccines save lives? Current trials aren’t designed to tell us.”

How is it possible that these trials aren’t designed to reveal

6 months

The minimum protection the WHO requires a vaccine to provide

50%

The lowest acceptable level of vaccine protection set by the WHO

90%

The protection achieved by Pfizer and BioNTech’s candidate vaccine, according to early results



A volunteer in Moscow takes part in the trial for the Sputnik V vaccine

through, as the error bars representing uncertainty in the trial data are quite large.

Another issue is that the success rate obtained in a vaccine clinical trial often exceeds that seen in the real world. As Hodgson puts it, “vaccine efficacy does not always predict vaccine effectiveness”. There are various reasons for this, she says. A major one is that the deployment of a vaccine on the ground, to millions or billions of people, is much more challenging than administering it within a tightly regimented clinical trial.

That is especially true of a two-shot vaccine that relies on people showing up to two appointments, often weeks apart. For this reason, the WHO says it would prefer a one-shot vaccine. However, all but one of the 12 vaccines in phase III trials require a couple of shots. “I think it would be prudent to anticipate that we may see some differences between covid vaccine efficacy in clinical trials and real-life settings,” says Hodgson.

According to Paul Offit, at the University of Pennsylvania and a member of the FDA’s Vaccines and Related Biological Products Advisory Committee (VRBPAC), the FDA is likely to accept six months or even less of efficacy

“We could end up with vaccines that reduce the risk of mild infection but not the risk of death”

data, even though it usually asks for at least two years and most vaccine trials last even longer. Admittedly, this is an emergency and we have to accept some uncertainty, he says, but we need to be ready to be “unpleasantly

whether the vaccines on which we are pinning so much hope will actually save lives?

The problem relates to the trials’ so-called “end point”, the bar against which success or failure is judged. It is set fairly low. The WHO and FDA have both said they will accept a vaccine that provides at least 50 per cent protection against infection. That means the trials need to show that no more than half as many people who received a vaccine get infected as people who got the placebo.

Putting aside the 90 per cent plus results for now, that isn’t good enough, says Doshi. For one thing, the 50 per cent threshold for the trials could mean that a vaccine that is only actually 30 per cent effective makes it

surprised” by a vaccine that delivers weak or short-lived immunity. And the first vaccine to succeed is rarely the best, he warns.

Nonetheless, the 90 per cent plus success rates seen so far suggest that these vaccines will easily exceed the 50 per cent threshold, so this issue may just be theoretical. The phase III trials aren’t complete yet, but it would take a major reversal to erode those high initial figures. Even with a fall to 80 or 70 per cent, a vaccine’s impact would still be far above the WHO’s minimum requirement. “Of course, we all want a vaccine which is as efficacious as possible,” says Hodgson. “But I think given the scale of the pandemic, the rates of transmission and the morbidity and mortality we’re seeing, even a partially efficacious vaccine could have a really significant impact.”

Mild cases only

Despite this, the trials aren’t going to tell us what, if any, effect a vaccine has on severe illness, according to Doshi and others. On 22 October, he told a VRBPAC hearing that “unless urgent changes are made to the way the trials are designed and evaluated, we could end up with approved vaccines that reduce the risk of a mild infection but do not decrease the risk of hospitalisation, [intensive care unit] use or death.”

This seems outlandish, but again it comes down to the trials’ end point. In all the phase III trials, this is defined as the prevention of mild covid-19 symptoms, such as a cough, fever, headache or sore throat. Any participants with these symptoms are tested to confirm whether or not they are infected by the SARS-CoV-2 virus. If there are many more such cases in the placebo group than the control ➤

How the Pfizer/BioNTech phase III trial works

More than 43,500 people are recruited to the trial



Around half are given a vaccine, half get a placebo. Neither participants nor researchers know who is in which group



When participants report mild symptoms like a cough or fever they are tested for the coronavirus



Once a certain number of people are confirmed as having had covid-19, called a “checkpoint”, the results are “unblinded” to reveal whether these positive cases had been given a vaccine or a placebo



So far, of 94 covid-19 cases, 90 per cent were among those in the placebo group



The trial will end when there have been 164 confirmed infections, the final checkpoint

group, we can see that the vaccine is working – in preventing mild cases, at least. But such a result tells us next to nothing about whether the vaccine is stopping infected people from getting really sick. The issue is compounded by these vaccines being tested in a subset of the population that is predominantly young and healthy, and so at relatively low risk of getting severe covid-19.

“In a deadly pandemic, we want to see efficacy data demonstrating a reduction in severe disease and long-term consequences,” says Doshi. “Efficacy against a transient, mild illness in relatively healthy people is far less important than protecting the most vulnerable.”

He accepts that people who are protected against catching the

“The trials appear designed to answer the easiest questions, not the most important ones”

disease cannot, by definition, go on to develop severe covid-19 or die from it. But that isn’t the point. “That is true, if you are talking about a single person. But a vaccine will not have identical efficacy in all populations,” he says. “Let’s say it works really well in healthy adults, but provides very little protection in frail elderly [people], to choose one high-risk group. In this scenario, your trial can demonstrate an effect against mild disease, but you would still have all the serious cases because the vaccine is not protecting the frail elderly.”

More than three-quarters of deaths caused by SARS-CoV-2 infection are in people over the age of 65, but they can be poorly represented in trials.

In the plans for the Pfizer and BioNTech trial, 40 per cent of phase III participants are



JUAN MABROMATA/AFP VIA GETTY IMAGES

supposed to be 55 years old or over, but the figures released from the trial don’t include an age breakdown. Neither company responded to *New Scientist’s* requests for that information.

The Gamaleya vaccine team told *New Scientist* that people aged up to 60 were vaccinated and included in the data, but again provided no actual numbers.

In any case, people aged 55 or even 60 hardly qualify as “frail elderly”, who often have weakened immune systems and don’t respond well to vaccines. Age-related decline in the immune system can kick in as early as 55,

A scientist in Argentina working on a vaccine candidate for the region

but there is huge variation from person to person, says Deborah Dunn-Walters, an immunologist at the University of Surrey, UK.

Some of the vaccines that have yet to report any results are being tested in older groups. In the University of Oxford and AstraZeneca vaccine trial, for instance, at least a quarter of participants are over 65.

The Moderna results are more promising because this vaccine was given to people over 65, and some of those who became ill with the disease were in this age bracket.

Another issue is that without regularly testing all participants, a clinical trial could fail to pick up large numbers of asymptomatic infections.

One phase III trial – of the vaccine being developed by the University of Oxford and AstraZeneca, which Hodgson is working on – is testing every participant for the virus each week. As a result, its findings may exclude the possibility of missing lots of asymptomatic

infections – at least for its own vaccine, which works in a very different way to Pfizer and BioNTech’s and Moderna’s.

The decision to omit severe disease as a primary end point is unusual. According to a research paper by an international group of industry, government and academic researchers published late last month in the *Annals of Internal Medicine*, severe disease is an end point “used in virtually all vaccine efficacy trials”. The group urged all vaccine developers to include severe covid-19 as an end point in their trials.

Doshi says the trials appear designed to answer the easiest questions in the least amount of time, not the most clinically important ones.

It is possible to do a covid-19 clinical trial with severe disease as an end point, says Hodgson, but it would be a major undertaking because that outcome is still quite rare. “The studies do not have adequate numbers of patients to be able to reliably tell us if they prevent severe disease,” she says. “We will need to give these vaccines to much larger populations in order to collect

Phase IV trials

Once vaccines are approved, they are usually closely monitored to detect any rare but potentially serious side effects that the trials were too small to spot. This evaluation, often called a phase IV trial, usually runs for a year or two because rare adverse reactions may take months or even years to be detected, says Susanne Hodgson at the University of Oxford.

One rare but serious problem is “vaccine enhanced disease”,

in which vaccinated people who go on to catch the virus their vaccine targets become more ill than they would have without the vaccine. It occurs when the immune response elicited by a vaccine backfires and actually helps the virus cause disease rather than hinder it.

Hodgson says this was seen in animal experiments on vaccines for SARS and MERS, diseases caused by coronaviruses closely related to SARS-CoV-2, the virus behind covid-19.

“But importantly, this hasn’t been seen in the animal models of covid-19 vaccines to date, and there’s no signal yet that we’ve seen anything like this in the clinical trials,” she says.

It is also worth noting that Pfizer and BioNTech’s and Moderna’s vaccines use an unproven technology (see page 14), rather than being based on the usual viral proteins or weakened form of the pathogen – so they could spring new surprises down the road.



that kind of data and get that output.”

Pfizer has said that it and BioNTech are collecting data on severe disease as a secondary end point – but the numbers still aren’t big enough. Hodgson says this may be an issue for all the trials. “It’s unlikely that they’re going to have sufficiently sized trials to reliably get an indication about whether vaccines prevent severe disease,” she says.

Worse-case scenario

Another key question the current trials are too small to answer is whether a vaccine prevents people from catching and transmitting the virus. This might sound like a crucial feature of a vaccine but it isn’t: a vaccine is designed to prevent people getting ill. It is, however, important because it is necessary (but not sufficient) to achieve herd immunity.

In fact, vaccines could, in theory, make matters worse. If they suppress disease but don’t stop people from catching and shedding the virus, they effectively convert symptomatic cases into asymptomatic ones. That may lead to large numbers of infected people who aren’t aware they have the virus going about their daily lives while releasing virus, rather than self-isolating. This “may paradoxically increase transmissions”, the *Annals* paper says.

“A worst-case scenario is a vaccine that reduces disease while permitting viral shedding,” wrote Marc Lipsitch at the Harvard T. H. Chan School of Public Health and Natalie Dean at the University of Florida in a recent perspective piece in *Science*. “This could fail to reduce transmission or conceivably even increase transmission



REUTERS/LISINIESNER

if it suppressed symptoms.”

Yet another thing that the data so far cannot tell us for sure is whether the vaccines are completely safe. Pfizer, Moderna and the Gamaleya National Center all say they haven’t seen any severe adverse reactions among participants, but are continuing to collect data to be sure that they won’t occur.

Peter Marks, who directs the FDA’s Center for Biologics Evaluation and Research, the body that evaluates applications for vaccine licences and emergency use authorisations (EUs), has said that he needs to see safety data showing that no volunteer has had a severe adverse reaction within two months of receiving their second shot. The FDA can issue EUs as a way to fast-track medical products in exceptional cases. Pfizer has said it will have collected this safety data in the coming week, at which point it will apply for one.

Nearly all adverse reactions ought to be picked up within six weeks of a second shot, says Offit, so side effects are

The idea that a vaccine could return life to normal early next year is unlikely

200
 or more coronavirus vaccines are in development

12
 of these are in phase III trials

3
 of which have published early results

probably less of a concern than efficacy, although rare side effects might take longer to spot (see “Phase IV trials”, left).

There are a couple of other unknowns too. We don’t know how people who have had the virus and recovered will respond to any of the vaccines. Pfizer has been vaccinating these so-called seropositive people but excluded their data from the latest analysis. We also don’t know whether the vaccines will put pressure on the virus to mutate.

All in all, as Hodgson says, the seemingly simple question “does this covid-19 vaccine work?” is surprisingly hard to answer.

In the end, of course, this could all just be speculative bellyaching, and none of these potential problems will actually materialise. Thus far, we have seen interim results from three of the 12 vaccine candidates that have reached phase III trials. More will undoubtedly follow.

Jeremy Farrar, director of the Wellcome Trust, says we should think of vaccine development as the creation of a portfolio rather than the search for a single magic bullet. Weaknesses in one, such as not working well in older people, may be covered by strengths in others.

Despite her words of caution, Hodgson is optimistic about the future too. “There are more than 200 vaccines in development, which is a phenomenal number, and using a variety of vaccine technologies,” she says. “It’s nearly impossible to predict exactly when, but I think the likelihood is we will have a number of candidates that are efficacious.”

So not quite yes, yes, yes! – at least not yet. But barring some disaster, we will eventually be able to have what the brave volunteers in the trials are having. ■

Interview: Heidi Larson

How to stop vaccine hesitancy

When the first covid-19 vaccines become available, there will still be work to do to convince people to take them, Heidi Larson tells **Adam Vaughan**

FOLLOWING encouraging news from pharmaceutical companies, there is a real possibility that vaccines for covid-19 will soon be made available. But there are people who are reluctant to receive them.

Heidi Larson at the London School of Hygiene & Tropical Medicine is author of *Stuck*, a book about how vaccine rumours start. *New Scientist* spoke to her about people's hesitancy around the first covid-19 vaccines.

PATRICK DOWSE



Profile

Heidi Larson is the founder of the Vaccine Confidence Project at the London School of Hygiene & Tropical Medicine

Adam Vaughan: How willing are people to take a covid-19 vaccine?

Heidi Larson: We've been doing a lot of global surveys on willingness if a vaccine is approved as safe and effective. In the UK, the US and other countries, in May only 5 per cent said they would definitely not take a vaccine. Now, that's up to more like 15 per cent.

Why have attitudes changed?

In April, there wasn't much discussion of vaccines, it was about lockdowns and "do I wear a mask or not?".

Since then, there's been more discussion of vaccines, people have seen not everyone is dropping dead, and there's a perception it's only older people dying.

One of the reasons rumours and misinformation are getting more traction now is because we have a lot of uncertainty. Things are changing every day, and people are anxious and want an answer. We have a perfect storm for rumour spread.

Who does your research show is less likely to take the vaccine?

What we see across the UK and US is if you [have a] lower income, your education is below post-graduate and you are non-white and female, you are more likely to refuse a covid vaccine.

It seems like the poorest in society face a double whammy, as they were already hit harder by covid-19 and now are one of the groups least likely to take a vaccine.

They need it the most. We don't have a misinformation problem as much as we have a relationship problem [between the public and health systems].

These communities could benefit the most but they are the least trusting of government. They're not crazy.

What reasons do people give for not wanting to use the vaccine?

The top one is safety. Another one is just that it's "too new". I understand people's anxieties around a brand new vaccine, especially when it's a brand new virus and we are still trying to understand the nature of the virus.

One of the concerns coming up is "could we get long covid from the vaccine". It's not going to give you long covid. The trials have been going probably long enough to pick up anything that would be a common serious side effect – we'd know by now, by giving it to tens of thousands of people. [However] there may be,

and you'd only know this with hundreds of thousands of people, there may be a rare thing that comes up with genetic propensity, certain situations and certain groups.

That's true with any new vaccine, that's why you have post-marketing surveillance [in which

"One reason misinformation is getting more traction now is because we have a lot of uncertainty"

any side effects are monitored after the vaccine is rolled out].

Down the line there might be some rare thing we haven't seen yet, that's true, but it would be extremely rare – and are we going to wait for that?

There is an urgent need for a vaccine but does a rapid regulatory approval process risk fuelling vaccine hesitancy, and how can that risk be reduced?

We have to do a better job of explaining why things are moving faster. We are not short-cutting old processes. It's because we have brand new [vaccine] platforms, new technology.

You are not going to get a vaccine out the door that is not considered to be safe and effective enough. Emergency approval doesn't mean the first in line will be the first to have taken the vaccine. We should be making clear how many people have already taken it.

We hear a lot about online misinformation, but does it really have an effect?

What we found in the UK was that 54 per cent said they'd definitely take a vaccine if it was proven safe and effective. After being shown misinformation, that dropped 6.4 percentage points.

People waiting to take part in a covid-19 vaccine trial in Abu Dhabi

REUTERS/KHUSHNUM BHANDARI





REUTERS/BRIAN SNYDER

That's significant, because 54 per cent was at the lowest end of levels needed for herd immunity [via vaccination]. We're in a borderline situation, so even a small impact is a significant one.

How do we tackle that misinformation?

Anti-vaccine groups are quite sophisticated and extremely responsive to public concerns. On the health authority side, you get more formalistic "everybody do this" messages, it's almost

monotone. The public have a lot of different questions. So when they hear the same message they think we [public health officials] really don't hear them, that's not answering their questions.

Are technology platforms such as Facebook doing enough to tackle misinformation?

We can all do better. Tech companies can do more but we shouldn't underestimate that it's really complex. There's a lot of stuff [posts and comments]

Demonstrators at a "no mandatory flu shot" rally in Massachusetts in August 2020

undermining trust, which is not so straightforward to take down.

We also have to remember this is about deep human emotions. You could shut down Facebook tomorrow and this problem will not go away. It will jump to other platforms that are under the radar, and go offline.

Is there any point engaging with anti-vaccine opponents online?

Some of the individuals in groups have come to me. They said: "our message to you, and tell your peers Dr Heidi, was if they talk more nicely, more people would be getting vaccinated."

They showed me a dossier of public figures calling anyone who questioned [taking a vaccine] idiots, stupid. There are people

"We have to do a better job of explaining why vaccine development is moving fast"

on the edges of these groups who aren't getting what they need from authorities. We need to find some common ground.

Is there a wider opportunity here, given everyone will be able to see the benefit of a covid-19 vaccine, to turn the tide against rising anti-vaccination sentiment generally?

Absolutely. It's one of my biggest hope messages. And it's not just about vaccine hesitancy. The covid response is a real opportunity to change [health authorities'] relationship with the public.

If we rebuild our relationship with the public so they feel we are a caring, listening health authority or government, that will make a huge difference. ■

For a review of Heidi Larson's book *Stuck*, turn to page 30

Messenger RNA vaccines

The promise of mRNA extends far beyond the current pandemic

Michael Le Page

A COLLECTIVE wave of excitement swept around the world when Pfizer and BioNTech announced positive early results from their coronavirus vaccine trial last week. Now, biotechnology firm Moderna has announced even better findings (see page 7). These are no ordinary vaccines: they could be the first messenger RNA (mRNA) vaccines to be approved. If this technology lives up to its promise, it could bring huge benefits for healthcare, not just for tackling the coronavirus.

“Part of the reason why the results from Pfizer are so exciting is that nobody has ever shown in humans that an mRNA vaccine can be effective,” says Anna Blakney at Imperial College London, who is working on a different vaccine. “I think it will change the way we make a lot of vaccines.”

Viruses consist of the recipe for making more viruses wrapped in a protein coat. Our immune system fights them by learning to recognise that outer protein.

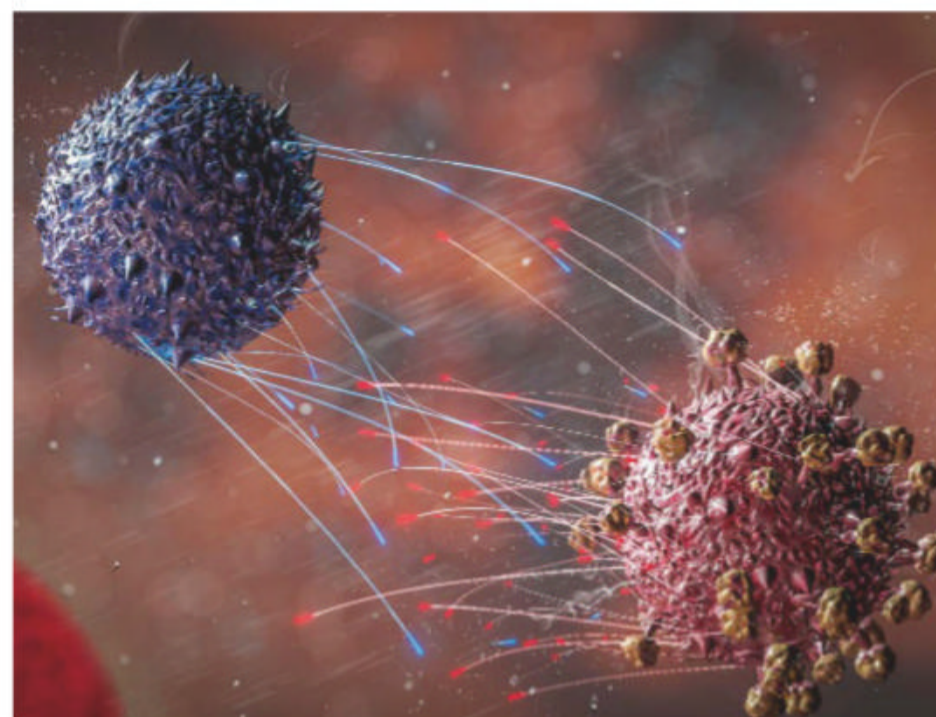
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As many doses can be made with self-amplifying vaccines from the same amount of mRNA

Almost all vaccines physically contain such a viral protein in some form. Many vaccines contain entire viruses, coat proteins and all, using either harmless strains of dangerous viruses or inactivated viruses. Some more modern ones, called subunit vaccines, just contain the outer protein.

All of these vaccines are tricky to develop and manufacture, not least because viruses and proteins can only be made in living cells. Flu vaccines are typically grown in chicken eggs, for instance.

By contrast, mRNA vaccines



An artist's representation of a T-cell (blue) attacking the new coronavirus

mRNAs into someone's arm, they are quickly chewed up by enzymes in the blood.

One way to solve this is to deliver the gene for the viral protein inside the empty shell of a harmless virus, which is the basis of several potential coronavirus vaccines. With vaccines like Pfizer's and Moderna's, the mRNAs are packaged in tiny droplets of fat called lipid nanoparticles, which protect them and help them get into cells.

Some mRNA vaccines, such as the one being developed at Imperial College London, use a trick that further speeds up manufacture. This vaccine is “self amplifying”. It consists of a longer piece of mRNA that also codes for enzymes that encourage cells to make more copies of the mRNA, so more viral proteins are produced. With a self-amplifying vaccine, 100 times as many doses can typically be made from the same amount of mRNAs.

“Obviously, that's really important with a global pandemic where you're trying to produce billions of doses of a vaccine,” says Blakney.

If other mRNA vaccines prove to be as effective, they could be used to prevent many other diseases, from herpes to flu. They also show promise as a way of treating cancers. Tumour cells often make mutant proteins. These can be found by sequencing the genome of cancer cells, and a personalised mRNA vaccine can then be made.

Yet it is still early days. Both the Pfizer and Moderna results are just interim analyses, so we will have to wait to see whether mRNA vaccines deliver on the shot of optimism they have promised. ■

contain the instructions for making the viral protein instead of the protein itself. mRNAs are an essential part of cellular biology – they are copies of the genes in our genome and act as a template for making proteins. If mRNAs that code for a viral gene are added to a human cell, the cell will start making that viral protein and continue to make it for several weeks until the mRNAs break down. Because only the outer protein is made, not the whole virus, there is no chance of an actual infection.

Some of the viral proteins stick out from the membrane of the cell, where they are spotted by immune cells. This triggers the production of antibodies. Their role is to bind to matching viruses and stop them entering cells.

Crucially, the protruding proteins also stimulate the production of T-cells that detect infected cells. Destroying infected cells prevents more viruses being released. A strong T-cell response is thought to be crucial for immunity to the coronavirus, but not all vaccines produce one.

Perhaps the biggest advantage

of mRNA vaccines is that they can be developed and manufactured quickly once the genome of a virus has been sequenced. Moderna started testing its mRNA vaccine in people just 66 days after the coronavirus was sequenced.

This speed is obviously a huge advantage when new viruses emerge. It also means that if, say, the virus mutated in a way that made vaccines less effective, any mRNA vaccine could be quickly altered by tweaking the sequence.

The big obstacle to mRNA vaccines until recently has been delivery. If you simply inject

Pfizer and BioNTech had positive early results for their mRNA vaccine



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Neuroscience

Living electrodes could link brains to computers

Michael Le Page

NERVE cells modified to respond to light and act as “living electrodes” have been successfully implanted in the brains of animals. The hope is that they will provide a better and longer-lasting way to link brains with computers than conventional electrodes.

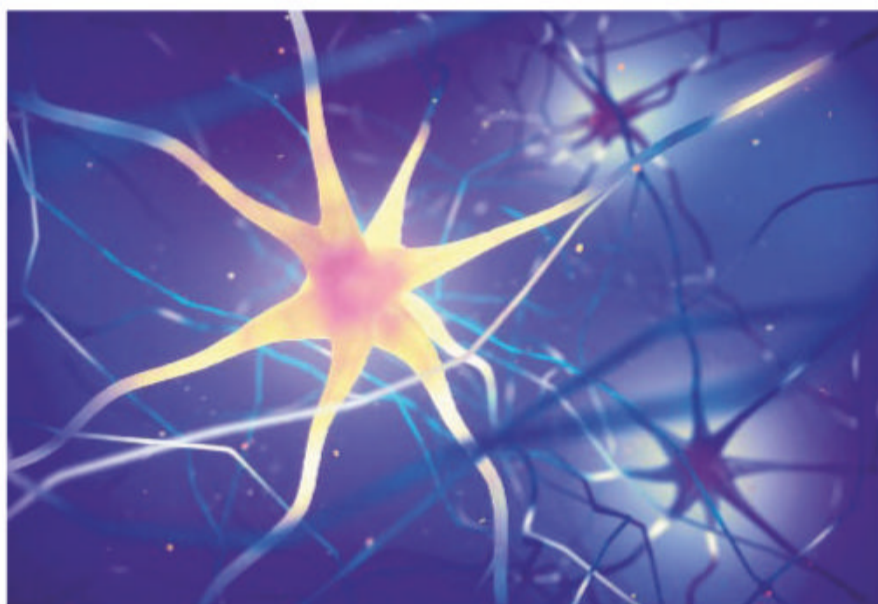
“It allows our technology to be speaking the language of the nervous system, instead of electrical jolts, which is what is done now,” says Kacy Cullen at the University of Pennsylvania. “When our implanted neurons are activated, the deeper part of the brain they are connected to then becomes activated by a natural synaptic mechanism.”

Electrodes implanted in the brain have been used since the 1950s for everything from treating Parkinson’s disease to helping people who are paralysed to communicate, move and even sense things. “There have been some fantastic successes,” says Cullen.

But there are problems with conventional electrodes. Putting a foreign object in the brain provokes an immune response that can cause scarring, making the performance of the electrode change or degrade. Electrodes also affect all adjacent neurons, not just the target ones, which can lead to unwanted effects.

Cullen’s approach instead relies on optogenetics: genetically modifying neurons so they respond to light signals. About 10,000 modified cells are then placed at the top of a dissolvable gel cylinder just twice the diameter of a human hair.

The axons of the neurons – the living wires down which the nerve system’s electrical messages are sent – grow along the cylinder and out of the end.



NOBEAST/SCIENCE/ALAMY

When 1.5-millimetre-long cylinders containing modified rat neurons were implanted in the visual cortex of rats, the axons of many of the implanted cells grew into the cortex and made connections with the cells there. “If we have a problem, it’s too many connections rather than too few,” says Cullen (bioRxiv, doi.org/fhw8).

The challenge now is to show that desirable connections can be reinforced and unwanted ones pruned, so that implants can achieve specific effects, such as preventing epileptic seizures.

“Our technology can speak the language of the nervous system, instead of electrical jolts”

The implanted neurons can be of a type that activate the cells they connect to, or that dampen down activity, or a mix of both types. By modifying the cells to fluoresce when activated, implants should be able to monitor brain activity as well as controlling it.

For treating patients, Cullen envisages generating neurons from matched cells stored in stem cell banks, to avoid

An artist’s impression of a group of connected human neurons

immune rejection. It would be prohibitively expensive to generate neurons from each individual’s own cells, he says.

To control the neurons, an LED array would be implanted on the brain surface, just above the upper end of the implanted nerves. “Being on the brain surface, we don’t expect that they will elicit the same immune reaction as penetrating electrodes,” says Cullen.

Anthony Hannan at the University of Melbourne says living electrodes may be better for some applications than conventional ones. “However, they do not yet have evidence that it would be far superior to any other type of electrode,” he says. Using living electrodes also brings a new set of challenges, such as preventing infections and achieving consistent results, says Hannan.

Cullen has set up a firm called Innervace to commercialise the technology. But he stresses that the work is at an early stage. “It is several years away from clinical applications.” ■

Space

Flashing lights could prevent catastrophic satellite collisions

Jonathan O’Callaghan

A SMALL satellite launching in early 2021 will test a novel method to track objects in orbit – using light-emitting diodes (LEDs) that flash to relay its position to the ground.

LEDSAT, a cube-shaped satellite measuring around 10 centimetres on each side, will be equipped with 140 LEDs across its faces. These will flash every few seconds, enough to be noticeable to observers. The solar-powered satellite is designed to operate for at least a year.

The LEDs won’t be visible to the naked eye and will be dimmer than most stars in the night sky, so they aren’t expected to cause any problems for astronomers. But the light should still be bright enough to spot the satellite from Earth using a telescope, while different coloured LEDs on each side will reveal which face of the satellite is pointing towards our planet (*Acta Astronautica*, doi.org/fhw3).

“You recognise the stars that are behind the flashing pattern,” says Paolo Marzioli at the Sapienza University of Rome. “So you know which position the satellite is [in].”

Currently, satellites are tracked in a number of ways, including by radar. It is also possible to track larger satellites by spotting them in the sky, but this is generally only possible at twilight, when the satellites are illuminated by the sun. LEDs could allow for optical tracking throughout the night.

CubeSats like LEDSAT can also be difficult to track because of their small size, but the lights could make them easier to spot. “Below half a metre, it’s very difficult to see something,” says Marzioli.

Furthermore, LEDs could also help us keep on top of space debris, providing an easier way to track larger satellites that are no longer operational and so avoid collisions, he says. ■

The war over Toumai's femur

A long-awaited study of an ancient human relative suggests it walked on four legs

Michael Marshall

AFTER more than a decade in limbo, a crucial fossil of an early human relative has finally been scientifically described. The leg bone suggests that *Sahelanthropus tchadensis*, the earliest species generally regarded as an early human, or hominin, didn't walk on two legs, and therefore may not have been a hominin at all, but rather was more closely related to other apes like chimps.

A paper from a rival group, not yet peer-reviewed, disputes this. The studies are the latest twist in a bitter saga that has seen the fossil held back from publication and its existence ignored.

"We have been anxiously awaiting the publication of this femur for many years," says Kelsey Pugh at the American Museum of Natural History in New York.

7 million

The age in years of bones of *Sahelanthropus tchadensis*

Michel Brunet from the University of Poitiers in France and his colleagues discovered the remains of *Sahelanthropus tchadensis* in Chad in 2001. The team described a skull, dubbed Toumai, plus fragments of lower jaw and some teeth (*Nature*, doi.org/c66kw6).

Brunet and his colleagues have always maintained that *Sahelanthropus* habitually walked on two legs – like modern humans but unlike chimpanzees and other apes. This was based on an analysis of the base of the skull, suggesting that the spine was held upright. Many other researchers have argued that this isn't sufficient evidence for bipedality.

This *Sahelanthropus tchadensis* skull was nicknamed Toumai

Resolving this is key, because the *Sahelanthropus* bones are believed to be 7 million years old, far older than other human relatives like *Australopithecus*. If it was a biped, that would make it the oldest known hominin. If not, it may not be that closely related to us.

The researchers found a femur, or thigh bone, along with two ulnas, or forearm bones, that would help clarify the matter, but they published nothing about them for almost two decades, prompting criticism from colleagues. Brunet didn't respond to a request for comment from *New Scientist*.

The bones were brought to the University of Poitiers. There, Aude Bergeret-Medina, who discussed the bones with one of her tutors, Roberto Macchiarelli, identified a long, unlabelled bone as a femur, probably from a primate, in 2004.

Bergeret-Medina had been given permission by her superiors to cut the femur into pieces, but she became uneasy about doing this. Macchiarelli examined it and advised her to wait until this could be checked with Brunet and his team, most of whom were in Chad.

Later, Bergeret-Medina was unable to find the femur. Neither



FRANCK GUY/UNIVERSITÉ DE POITIERS

The shape of the femur from *Sahelanthropus tchadensis* is typical of apes like chimps

she nor Macchiarelli ever saw it again. However, when Brunet's team didn't describe the femur, she and Macchiarelli prepared a study using her photos and measurements.

She and her colleagues first tried to present their findings at a 2018 conference in Poitiers, but the presentation was rejected by the organisers. In late 2019, they submitted a paper that has now been published (*Journal of Human Evolution*, doi.org/fhwp).

Bergeret-Medina's team

argues that the femur isn't that of a bipedal animal. "There are a lot of indicators which deeply discourage bipedal gait," says Macchiarelli. In particular, the bone is curved, not straight, typical of apes like chimps.

No bones about it

However, a second study, posted on a Nature Research journals preprint server, disputes this, though it has not yet passed peer review (In Review, doi.org/fhwq). Its lead author is Franck Guy at the University of Poitiers, a co-author on the original *Sahelanthropus* paper, who declined to comment.

Guy and his colleagues say the femur does show signs of bipedality. For instance, it has a hard ridge near the top, which they say would support an upright body. Macchiarelli declined to comment on the paper, but shared with *New Scientist* a copy of a letter he sent to *Nature* detailing claimed inaccuracies.

Other palaeoanthropologists agree with the analysis by Bergeret-Medina's team. "The shape of the femur and general morphology doesn't look like a biped to me," says Brigitte Senut at the National Museum of Natural History in Paris, France.

And Madelaine Böhme at the University of Tübingen in Germany says: "I saw the pictures 10 or 12 years ago, and it was clear to me that it's more similar to a chimp than to any other hominin."

It remains unclear when and where bipedalism first evolved, says Böhme. Another African species, *Orrorin tugenensis*, lived 6 million years ago and has clear signs of bipedality. But prior to that, most apes lived in Eurasia, not Africa, and she has found tentative evidence that bipedality emerged there. ■



JOHN R. FOSTER/SCIENCE PHOTO LIBRARY

Astronomy

Weak radio bursts in our galaxy

A star in the Milky Way that releases fast radio bursts also sends out weaker signals

Jonathan O'Callaghan

MYSTERIOUS fast radio bursts (FRBs), brief and powerful blasts of radio waves in space, may not be quite as rare and unusual as we thought. Astronomers have discovered that a star inside our galaxy that produces FRBs may also create weaker but more frequent bursts.

"What we show here is FRBs can go down in luminosity much further than we thought," says Franz Kirsten at the Chalmers University of Technology in Gothenburg, Sweden. "We conclude that FRBs are probably a lot more common than we think."

Earlier this month, researchers said they had located an FRB source inside our galaxy for the first time. The conclusion was based on observations made in April by the CHIME telescope in Canada and the STARE2 radio receivers in California and Utah. Astronomers suggested that the FRB source was a magnetar – a neutron star with a strong magnetic field – sitting about 30,000 light years from Earth.

Intriguingly, a few days after those observations, another team used the FAST telescope in Guizhou, China, to detect a pulse

from the magnetar, called SGR 1935+2154, that was a million times weaker than the initial FRB.

Now Kirsten and his colleagues say they have detected two further weak bursts from SGR 1935+2154, each lasting just a millisecond and separated by 1.4 seconds. The weaker bursts were detected in May by the Westerbork Synthesis Radio Telescope in the Netherlands. Both of the May bursts were about 10,000 times weaker than April's initial FRB (*Nature Astronomy*, DOI: 10.1038/s41550-020-01246-3).

"The exciting thing is these bursts bridge the gap between

single pulses that are fairly weak and FRB-like bursts," says Chris Bochenek at the California Institute of Technology, who led part of the initial discovery of the FRB source in April. "We [now] know there are processes happening all along this spectrum of energies."

An FRB is loosely defined as any radio burst that is bright enough to be seen from another galaxy. But it is possible that the weaker bursts being detected – only visible to astronomers because their source

The Westerbork Synthesis Radio Telescope

is relatively near to Earth – could be produced by the same mechanism as FRBs. They may even be FRBs, albeit weaker ones.

At the moment, the mechanism of FRB production isn't understood. "There are many theories," says Daniele Michilli, a member of the CHIME team who is based at McGill University in Montreal, Canada. "The first class is where the emission comes from the magnetosphere of the star. A second class of theories is where there is like a fireball that ignites emission from a plasma cloud farther away from the star."

Further observations of magnetars like SGR 1935+2154 may provide more evidence of burst activity in different ranges. Factors such as the age of the star might play a role, say Kirsten and his colleagues, with younger magnetars producing brighter FRBs. Other cosmic objects, such as binary stars, could also be producing FRBs alongside magnetars.

"This paper opens up new questions," says Bochenek. "Is this like FRB emission? Where does one [emission] stop and the other one start? And what is an FRB?" ■



SANDER MEERTS/ALAMY

Animal behaviour

Some male spiders tie up females to avoid being eaten

MANY male spiders engage in courtship rituals during mating, but some attack females instead and tie them up to avoid being eaten.

In April 2019, Lenka Sentenská, now at the University of Toronto Scarborough in Canada, was studying the behaviour of a spider species (*Thanatus fabricii*) that is native to Israel. She realised that

males behaved oddly during mating, but the action was so quick that it was difficult to observe.

Sentenská and her colleagues collected some of the spiders and brought them to the lab to film their behaviour in slow motion.

"The male just rushed towards the female," says Sentenská. The male spider would bite the female, which seemed to startle her into pulling in her legs and playing dead. At this point, the male would begin to lay down some strands of silk on the female's body, binding her legs.

The male spider would then mate with the female for the next 19 minutes, on average, before running away.

The behaviour is savage, but it may be the best way for males to come out of the mating process alive. The team observed that some males were eaten by the slightly larger females before they could

"It appears brutal, that the female has no choice, but that's probably not how it is"

begin biting (*Animal Behaviour*, doi.org/fhw2).

Even when tied up, the female spiders may be in control. Sentenská says it doesn't take a female spider long to break free. She speculates that the silk may contain a chemical message about the male spider's suitability. If he is to her liking, a female spider may decide to let the male continue mating.

"It appears brutal, that the female has no choice, but that's probably not how it is," she says. ■
Joshua Rapp Learn

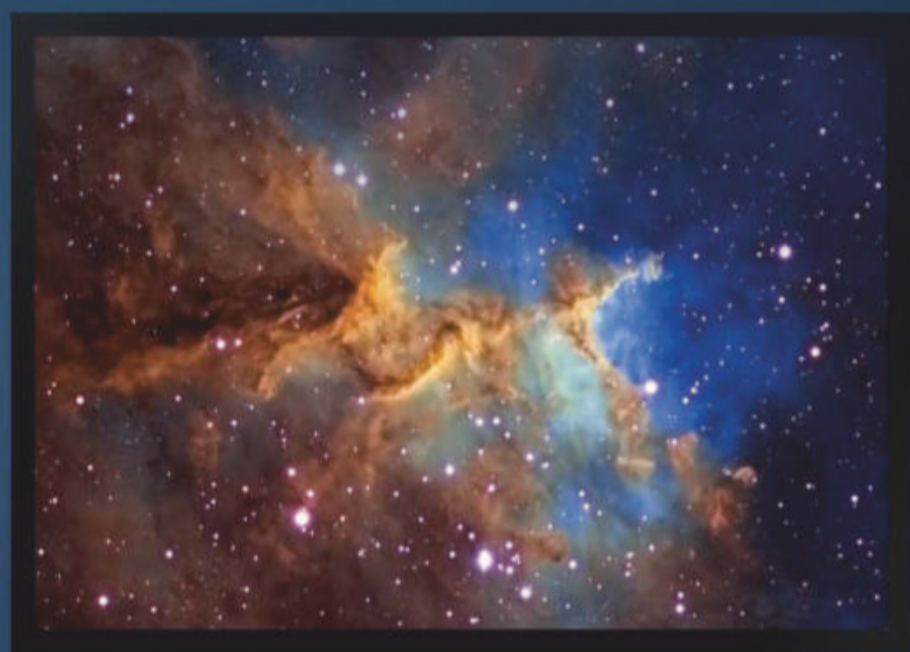


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HANNE & JENSEN/NATUREPL

Biomimetics

Camels inspire new material that cools without electricity

A THIN gel layer that works like camel fur could help insulate objects, potentially keeping them cool for days, without electricity.

Researchers have long been interested in hydrogels, which can absorb water and then release it through evaporation to produce a passive cooling effect. But a key challenge has been finding ways to make this effect last longer.

Jeffrey Grossman at the Massachusetts Institute of Technology and his team looked to camels for inspiration by combining hydrogel with a thin layer of another gel – aerogel – which is a light, porous insulating material.

The hydrogel layer is like the camel's sweat gland, allowing water to evaporate and provide a cooling effect, whereas the aerogel layer plays the same role as the camel's

fur, he says, providing insulation to keep out ambient heat, while still allowing water to escape through it. Altogether, the gel bilayer is about 10 millimetres thick.

The team tested this in a humidity and temperature-controlled chamber. It was able to cool an object to 7°C below its surroundings, while also keeping it cool for longer compared with just using a hydrogel layer.

The team found that, compared with the hydrogel layer alone, the addition of the aerogel resulted in an effective cooling time five times as long (*Joule*, doi.org/ghjtp). "This translates to over 250 hours of cooling," says Grossman.

He says the gel bilayer could be used to keep food or medical supplies cool, as well as helping cool buildings. **Layal Liverpool**

Evolution

How legless lizards got their limbs back

IN THE distant past, climate change may have driven limbless lizards to evolve legs – having already lost them before.

The once-four-legged, ancient lizards of the *Brachymeles* genus first emerged in dry conditions in what is now South-East Asia. They lost all four limbs about 62 million years ago, but 40 million years later, some species grew them back, says Philip Bergmann at Clark University in Massachusetts.

This coincided with a shift from a very dry climate to a monsoonal climate with rainfall pretty much all year, says Bergmann. Growing limbs back probably helped these burrowing animals dig into wetter, more packed ground, he says.

To further investigate this idea, Bergmann and his team caught and carried out measurements on nearly 150 wild lizards from 13 different species of modern

Brachymeles in the Philippines and Thailand. They subjected them to various running and burrowing tests over different soils.

They found that the more snake-like the lizards were, the less force they used to push into the soil with their heads, which were narrower. By contrast, legged lizards dug into the soil with their limbs, using greater force – an ability that probably helps them live in wetter environments where soil has four times greater resistance compared with dry, loose soil (*Proceedings of the Royal Society B*, doi.org/fhwh).

Whether *Brachymeles* will change body forms once more as the climate changes again is yet to be seen, says Bergmann. But given the tens of thousands of years required for such a drastic evolutionary change as limb loss, it is more likely that they will either need to find other ways to adapt to global warming or just fail and go extinct, he says.

Christa Lesté-Lasserre

Technology

Fibre-optic glove has a sense of touch

A GLOVE made from stretchable fibre optics can detect distortion and pressure and could be used in robotics, sport and medicine.

Hedan Bai at Cornell University in Ithaca, New York, and her team created the touch-sensitive glove using elastomeric polyurethane optical fibres that transmit light from an LED. The light is disrupted when the fibres are bent, stretched or put under pressure.



HEDAN BAI

The team dyed parts of the fibres with various colours, so that, as they are distorted, the colour of light exiting the fibres changes. The researchers analyse this light to estimate the location of and type of distortion in the glove (*Science*, doi.org/fhwg).

Because the sensors stretch, they could be used in clothing, wearables and soft robots. The team is also looking at sport and medical applications. One is measuring respiration and muscle contractions, says team member Rob Shepherd, also at Cornell. Another is to provide information on a baseball player's interactions with a ball. "This will provide a lot of insight that the coach can draw on to improve the player's performance," says Bai.

"These sensors can do it all," says Andrew Spielberg at the Massachusetts Institute of Technology. "The fact that it can measure so many deformation modes at once – bend, stretch and press – is promising." **Karina Shah**



Really brief

OSTERHAGE ET AL. (PLOS ONE, 2020)



Ultra-rare squid seen near Australia

The extremely rare bigfin squid, found more than 2 kilometres underwater, has been spotted in Australian waters for the first time. One specimen had 1.5-metre-long tentacles. Previously, these creatures had been sighted in the southern hemisphere only three times (*PLoS One*, doi.org/fht9).

Rivers in the sky can melt polar sea ice

Rivers of warm air that cross vast distances may help trigger the large-scale melting of Antarctic sea ice. The "rivers" can travel from South America to the Weddell Sea off Antarctica, where they can raise water temperatures by 10°C (*Science Advances*, DOI: 10.1126/sciadv.eabc2695).

Some seals evolved south of the equator

The oldest known monk seal fossils have been found in New Zealand. The 3-million-year-old remains of *Eomonachus belegaerensis* suggest that the ancestors of elephant and monk seals evolved in the southern hemisphere, not the north as thought (*Proceedings of the Royal Society B*, doi.org/fhvb).

Microbiology

Bacteria from yogurt speed bone healing

IMPLANTS coated in bacteria could be used during bone fracture surgery to help speed healing and prevent post-operative infections.

When someone breaks a bone, surgery can be needed to help it mend correctly. A common technique is to use a metal implant to keep fractured bones aligned while healing. The bone fuses to the metal as it mends.

Lei Tan at Hubei University in

Wuhan, China, and his colleagues tested whether coating an implant in the bacterium *Lactobacillus casei*, found in yogurt, could improve recovery. This species is known to regulate the immune environment, which could support tissue generation, and to release antibacterial substances.

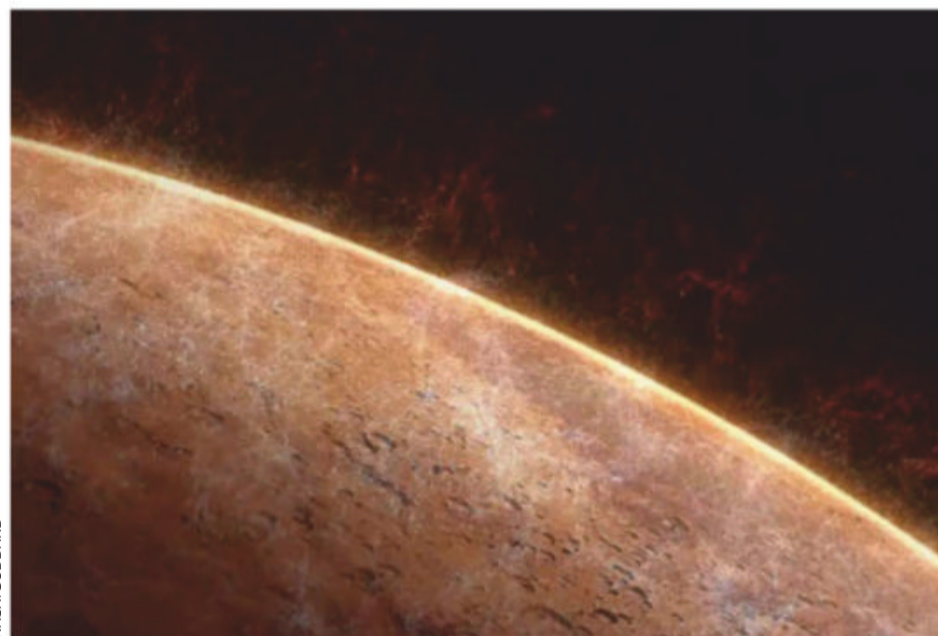
The researchers gave titanium implants to rats with broken tibias. Three received standard implants and three had implants coated in dead *L. casei* bacteria.

After four weeks, the team found there was a 27 per cent increase in bone tissue in the

rats with the bacteria-covered implants compared with a 16 per cent increase in rats with regular implants. An increase in bone tissue is a sign of fracture healing.

One potential risk of implants is infection where the implant meets the bone. So the team also tested if their *L. casei*-treated implant was more resilient to infection by coating it in multi-drug resistant MRSA bacteria, which can cause infections. After 12 hours, the team found that 99.9 per cent of these pathogens were dead (*Science Advances*, DOI: 10.1126/sciadv.aba5723). **Krista Charles**

Solar system



NASA/GODDARD

Martian sandstorms helped turn planet into a dry world

DUST storms may have played a significant role in making Mars the arid place it is now.

Scientists have long known that Mars is losing water, but thought it was largely because of a slow process that breaks water down in the lower atmosphere. Now, data from NASA's Mars Atmosphere and Volatile Evolution (MAVEN) orbiter has revealed water in the upper layer of the atmosphere for the first time, pointing to a more efficient process that may be dumping even more water off the planet.

Shane Stone at the University of Arizona and his team analysed the MAVEN data and found the upper

atmosphere contained the most water when Mars was closest to the sun or during a major dust storm. The atmospheric warming caused by those events allows water to float higher in the Martian air.

In the upper atmosphere, water should be quickly broken down by energetic particles. The resulting hydrogen and oxygen float off into space. This happens 10 times faster than water-loss processes in the lower atmosphere, Stone says. Over the past billion years, Mars's upper atmosphere may have lost enough water to cover the planet in a liquid layer 61 centimetres deep (*Science*, doi.org/fhwj). **Leah Crane**

Animal behaviour

Godzilla wasps are water-loving terrors

WASPS aren't known for their swimming, but one recently identified species is at home in the water. Godzilla wasps (*Microgaster godzilla*) dive to hunt aquatic caterpillars, surfacing in a way that is reminiscent of the Japanese monster emerging from the sea.

José Fernández-Triana at the Canadian National Collection of Insects, Arachnids, and Nematodes in Ottawa worked with researchers at Osaka Prefecture and Kobe universities in Japan, who first found the creatures.

The tiny wasps are parasitoids, implanting their eggs inside the bodies of other insects, where they hatch. The larvae go on to eat their living hosts from the inside out. In this case, the wasps' hosts were aquatic caterpillars of the *Elophila turbata* moth, which live near the water's surface in a case fashioned from plant fragments.

The team studied how the adult wasps hunted. In an aquarium, as in a natural setting, the insects walked along floating plants on the surface as they searched for caterpillars. Sometimes, the wasps would dive underwater for several seconds and grab the caterpillar cases from underneath (*Journal of Hymenoptera Research*, doi.org/fhwm). **Jake Buehler**



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origin of animals and
overpopulation

Episode 41

The function of dreams, billions
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Episode 40

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vampires, the science of ghosts,
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Episode 39

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Signal Boost

Welcome to our Signal Boost project – a weekly page for charitable organisations to get their message out to a global audience, free of charge. Today, a message from **Estuarine & Coastal Sciences Association**



ECSA promotes estuarine and coastal sciences, and celebrates its 50th anniversary in 2021. We are an international society and our mission is to promote and advance multidisciplinary research into all aspects of estuarine and coastal environments, and to support the application of science and technology for their sustainable environmental management. To achieve this our main aims are:

- To promote excellence in estuarine and coastal marine science, technology and management
- To focus on promoting young scientists and early-career academics
- To actively engage in global outreach with an emphasis on developing countries

We run science meetings at local and international scales to promote knowledge dissemination, and to provide young scientists with opportunities to present their work, and to network with more established scientists. We hope to have an international meeting in India in the next few years (recent ones have been in

Australia, Germany and China). A joint meeting with EMECS (the International Center for Environmental Management of Enclosed Coastal Seas) due to be held in Hull, UK this year has been postponed to 2021 because of covid-19. We have run many workshops, and also produce handbooks and other publications. ECSA members, and members of ECSA Council, come from a wide range of academic, regulatory, consultancy and other backgrounds. The covid-19 crisis is likely to mean changes to how we all operate, and we are further developing our website to extend online communications and resources.

We are keen to encourage the next generation of scientists in a range of disciplines and career areas, particularly workers in developing countries. To do this we have a range of membership fees. We have a range of

awards to support members' attendance at our conferences. For our most recent international meeting in Australia we awarded 32 grants to cover travel and fees. We can support research work where individuals need small grants to support their work, for example enabling the purchase of sampling equipment.

We have a student/early career representative on ECSA Council, and are actively engaging with student members.

The world needs to address major threats to marine and coastal ecosystems – climate change, sea-level rise, ocean acidification, ecosystem shifts, plastic pollution, mineral resource exploitation, biodiversity loss and more. To help do this we need to share knowledge and ideas, and ECSA actively promotes this type of knowledge gathering and exchange. We all need to rise to the challenge.

Want to help?

Join the ECSA community to help understand and protect our coastal and estuarine ecosystems for a better world. To find out more, please visit [ecsainternational](https://ecsainternational.org)

The columnist

Annalee Newitz on employment rights in the gig economy **p26**

Letters

Readers thoughts on bouncing black holes **p28**

Culture

A new book looks at how to tackle vaccine misinformation **p30**

Culture columnist

Simon Ings enjoys the feature-length animation *Away* **p32**

Comment

A dangerous narrative

Worries that the pandemic would lead to a rise in suicides haven't come true. We must now avoid creating a self-fulfilling prophecy, says **Clare Wilson**



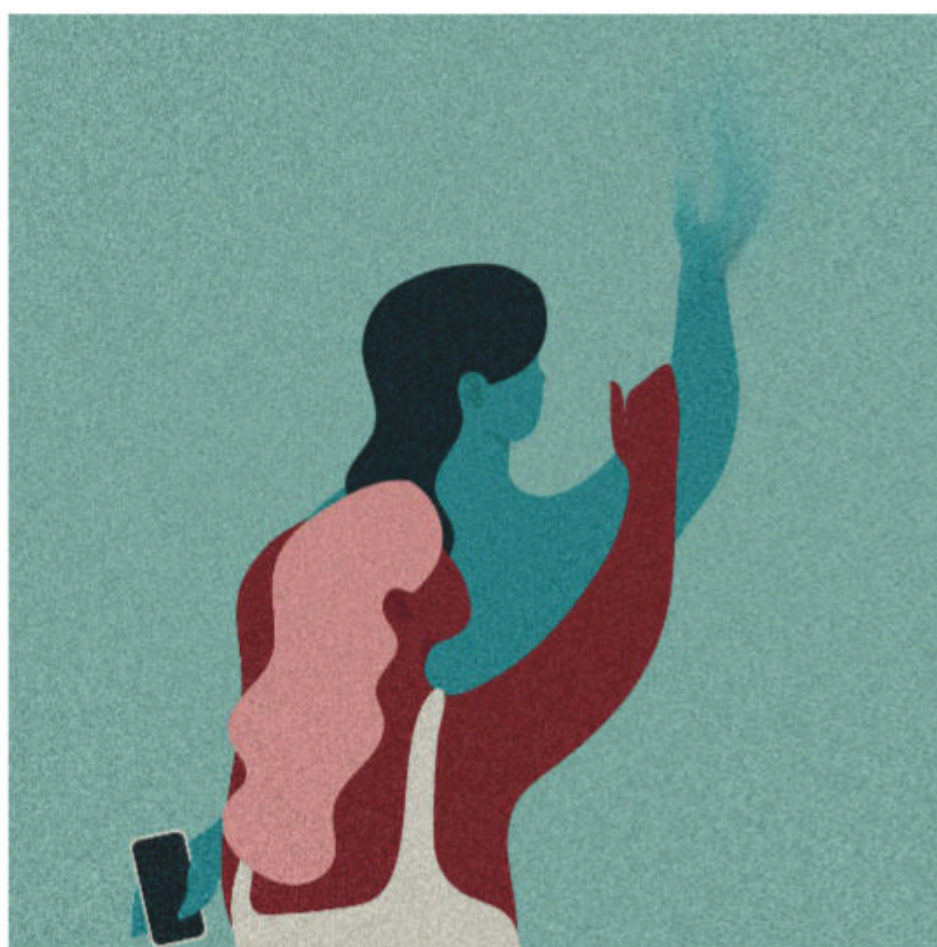
Clare Wilson is a medical reporter at New Scientist @ClareWilsonMed

AS THE world grapples with the consequences of the coronavirus pandemic, there have been widespread predictions that the fallout would lead to a rise in suicide rates. Fortunately, figures available so far suggest that this hasn't been happening. So it is important that we now rein in this alarmist narrative to avoid creating a self-fulfilling prophecy.

It is understandable that when lockdowns were first brought in, there were fears over the impact on mental health of such an extreme measure. Humans are naturally sociable, and so forcing people to reduce contact with their friends and families was always going to be difficult.

Mix in fear of catching a potentially deadly virus, loss of income and less access to mental health services and it seemed like a recipe for disaster. Some commentators made predictions of a large rise in suicides, which was reported in some cases with sensationalist language. But so far, thankfully, this hasn't been borne out. While the publishing of suicide figures normally takes many months, the initial indications for 2020 suggest that there hasn't been a rise this year.

In the Australian state of Victoria, where a very strict 16-week lockdown ended last month, recent figures show there was no difference in suicide numbers in the eight months from January to August 2020 compared with the same months in the previous year.



In British Columbia, equivalent numbers seem to be slightly down on last year.

Now a report has just been published online containing suicide data for three unnamed areas of England with a total population of 9 million people. Although there was a small increase from April to August 2020 compared with the previous year, the authors of the report believe that is because not all cases were recorded in 2019 as police and coroners were still getting used to the new real-time reporting system. Reassuringly, the average monthly figure for April to August

2020 was about the same as for January to March 2020. Official lockdown in England began on 23 March.

It is important to note that these are only the earliest figures available, and don't preclude suicide rates from rising over the longer term. They also don't negate the fact that several studies suggest there has been a rise in people who say they feel anxious or distressed, presumably because of the pandemic or its knock-on effects. But concluding that such feelings will lead more people to take their own lives is a massive assumption.

It is also potentially dangerous, because suicide deaths have an unusual feature. Unlike deaths from heart disease or cancer, say, media coverage can lead to an increase in deaths by suicide. It is well established that news of a celebrity's suicide can lead to a subsequent rise in such deaths among the public, especially in those using the same method. A similar effect is seen if newspapers report on an unusual number of suicides at a particular location.

Mental health charities have long had guidelines on this subject for how the media should report suicide to try to minimise this risk. They say coverage shouldn't include sensationalised language, nor should it suggest that anyone's death had a simple single cause, as this can encourage others in a similar situation to follow suit.

Some researchers have become concerned that sensationalist predictions about a surge in suicide could risk normalising the idea that this is a rational way to respond to the pandemic. Now that the first figures are in, we can see that the claims that suicides would increase during the pandemic seem to be wrong. It's time for such dangerous predictions to stop. ■

Need a listening ear? UK Samaritans: 116123 (samaritans.org). Visit bit.ly/SuicideHelplines for hotlines and websites for other countries

This changes everything

Working for an app A measure passed in California removes many employment rights for gig workers. Similar rules could soon come to a place near you, 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

Culture Warlords, in which journalist Talia Lavin infiltrates radical right-wing groups on the web, and satirises the hell out of them.

What I'm watching

Star Trek: Lower Decks, a sarcastic animated comedy that is the best Star Trek show in ages.

What I'm working on

I'm researching neolithic clay balls, which is an actual thing and not a dirty joke.

This column appears monthly. Up next week: James Wong

PEOPLE in the US have been so busy freaking out about the recent presidential election that it was easy to miss a vote in California for a ballot measure called Proposition 22. Gig work giants Uber, Lyft, DoorDash, Instacart and Postmates sponsored the measure, to the tune of \$205 million. Some even converted their apps into propaganda machines, exhorting users to vote “Yes on Prop 22”.

The measure passed, and now California has a new class of worker: “independent contractors”. The result is that there is a special exemption for gig work companies from certain labour laws and benefits, such as those related to sick days and retirement.

Now gig companies want to export this idea of work across the globe. As Uber CEO Dara Khosrowshahi said in an earnings conference call, he and his colleagues will “work with governments across the US and the world to make this a reality”. So, what will that reality be like?

We have to start with some crucial backstory, which is that the state of California recently passed a law called Assembly Bill 5 (AB 5) that reclassified gig workers like Uber drivers as employees rather than contractors.

When the law came into effect, gig companies would have to start paying for their drivers’ health insurance among other benefits. Uber and Lyft flatly refused to abide by AB 5, and put Prop 22 on the ballot to override it.

(Note for non-Californians: we have an unusual system in this state by which anyone with enough signatures can put propositions on the ballot, and as a result we vote on a wide range of public policies.)

Fair enough so far. Gig companies didn’t like AB 5, so they put it to the people of California to vote on the question of whether gig workers are contractors or employees.

But then, the drivers said, the gig companies started playing dirty. Uber and Lyft used their popular rideshare apps to push messages about Prop 22 to California passengers and drivers. When you opened the Uber app, a pop-up ad blocked your access. “Yes on 22,” it read. “Prop 22 is progress.” To get rid of the pop-up, you had to click one of two buttons: “Yes on Prop 22” or “OK”. You couldn’t say no.

“To get rid of the pop-up, you had to click one of two buttons: ‘Yes on Prop 22’ or ‘OK’. You couldn’t say no”

Uber drivers sued the company, claiming that the pop-up was a way of pressuring people to vote yes on the proposition, and that it amounted to coercion and bullying. A judge refused to hear the case. He said there was no evidence that they were being punished for not supporting Prop 22.

Still, for all the passengers who had to look at that pop-up constantly, it was a clear example of the company using its products to push a political agenda.

And the tactic worked. Prop 22 has passed, and the experience was so inspirational for gig companies that they want to recreate it in your state or country, too. It is an obvious win for a company like Uber, which still isn’t profitable.

Now Uber doesn’t have to pay for the same level of worker

protections someone classed as an “employee” would get, although Prop 22 does promise ill-defined “healthcare subsidies” for people who work an average of between 15 and 25 hours per week. But “working” is defined as only those times when a driver is picking someone up or driving them. So all those hours when a driver is fixing their car, or waiting for a passenger, or getting fuel, don’t count.

My favourite part of Prop 22 is a policy “limiting app-based drivers from working more than 12 hours during a 24-hour period, unless the driver has been logged off for an uninterrupted 6 hours”. That sounds safe, doesn’t it? Your driver is invited to sleep for 6 hours between 12-hour shifts, unless they figure out a way to game the app or simply use a different app after the 12 hours have elapsed. This is a very real possibility; many gig workers toggle between Uber and Lyft and DoorDash to pick up more work.

Ultimately, Prop 22 means that people whose jobs are already precarious have even less job security and virtually no healthcare.

But, say the gig companies, they have freedom! They can work whatever hours they want, on a flexible schedule. Of course, they are paid only for a fraction of the time they are actually working, because it is impossible to pick up passengers or deliveries without also waiting around for jobs to roll in.

If gig jobs become the norm, it is easy to imagine that the next trend in employment could be indenture. People will have become so traumatised by their lives under policies like Prop 22 that being housed and fed by companies that own them might feel like an awful sort of paradise. ■

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Editor's pick

Comebacks on the bouncing black holes

31 October, p 30

From Neil Doherty,
Barnsley, South Yorkshire, UK

In his book extract, Carlo Rovelli hits a good note on black holes. A true singularity predicted to have an infinite density at an infinitesimal point is a mathematical anomaly, as maths hates infinities. But here this one has sat, grinning wide – or the inverse thereof, in fact.

My only problem, though, is that when Rovelli's black hole rebounds to become a white hole, tens of billions of years will have passed to those on the outside, due to "the dilation of time... in the rest of the universe". This is a problem because, over this period, trillions of tonnes of material will fall in, past the event horizon. The effect of this raining down on the rebounding black hole must be addressed. I commend Rovelli for this innovative reassessment, however.

From Rollo Reid,
Christchurch, Dorset, UK

Stephen Hawking made a big splash when he forecast Hawking radiation coming out of black holes in such a way that, over time, a black hole could evaporate. Rovelli makes no mention of Hawking radiation in the extract from his book. Is Hawking radiation now dead in the water, being replaced with a more dramatic white hole?

Lockdowns may be a failure of Joe Public

Leader, 7 November

From Stewart Green,
Fareham, Hampshire, UK

To say "lockdowns are an indication of government failure" is disingenuous. The real problem is that many citizens are unable to follow the guidelines, particularly among the 18 to 29 age group.

Other than countries that are very small, have low population densities or are so totalitarian

that they pay no heed to citizens' rights, I can see no nation that has got it "right", but instead plenty – including the UK – that have given it a good shot.

Don't lump us all in with the US anti-vaxxers

31 October, p 8

From Peter Bursztyn,
Barrie, Ontario, Canada

You report that, if a covid-19 vaccine does arrive and is made available at no cost, 54 per cent of people polled in the US will refuse it. Across the border in Canada, we do have anti-vaccination activists, but far fewer than in the US.

In Ontario, Canada's most populous province, take-up of the 2020 flu vaccine has already been much higher than a "normal" year this early in the season. Canadians' willingness to be vaccinated differs markedly from our US neighbours.

My quick personal guide to virus exposure risks

24 October, p 40

From Marjorie McGuirk,
Asheville, North Carolina, US

I tried to give my family a numeric guide to risk for coronavirus exposure to help them figure out which activities were riskier. It is my attempt to quantify exposure risk guidance from the US Centers for Disease Control and Prevention.

Give yourself a score for the following five factors. 1. Time – one point for every 15 minutes of exposure. 2. Mask – one point for a mask, two points for no mask. 3. Groups – one point if one to 10 people are present, plus an extra point for every further group of one to 10 people. 4. Breath rate – one point for talking, three for protests, five for running. 5. Location – one point for outside,

two for inside at 2 metres apart. Finally, multiply the scores.

Example 1: you are talking outside with a friend for 15 minutes or less, with a mask, in a group of one to 10 people. This gives $1 \times 1 \times 1 \times 1 \times 1 = 1$. Example 2: you are protesting for an hour outside with 100 people, half of whom are wearing masks, giving $4 \times 1.5 \times 10 \times 3 \times 1 = 180$ points.

The lower your points, the lower your risk. I am a climatologist, so while I know a bit about probability and risk, I don't know enough to understand the factors of covid-19, which is why I kept this to virus exposure only.

Bean counters are to blame for this rat's nest

7 November, p 44

From Caroline Peters,
Wokingham, Berkshire, UK

As a retired IT professional, I recognised only too clearly the problems with legacy systems described in the article "Code red".

Computer systems have a life in the same way that vehicles do. We replace cars and lorries regularly to pre-empt serious issues, so why not do the same with computer systems? Invariably, the overriding cause of the rat's nest you discuss is short-term cost-cutting and a refusal to invest in preventative maintenance and upgrading or replacement until it is too late.

There is a better way to green our economies

31 October, p 36

From Gareth Ackland, London, UK

Your excellent article on the rewiring of economics after covid-19 drips with hope and the promise of fresh thinking, particularly on the climate and monetary fairness. Among the big ideas, however, there

was a notable absentee.

Last year, many economists signed a letter printed in *The Wall Street Journal* that called for something called Carbon Fee and Dividend (CFD). It is a simple idea: importers and extractors of fossil fuels pay a levy by the tonne, at a rate that rises over time. The money raised becomes a monthly dividend paid to every citizen.

People would then have extra money to cope with price rises that CFD may cause. It is estimated that 70 per cent of us would be better off, with only wealthier high-consumers needing to adapt their habits to avoid losing out.

I have yet to hear of another scheme that can reduce emissions and inequality so elegantly, improving environmental and health outcomes and deftly avoiding the risks of economic pain and public backlash.

Seeing the light: is this the real cause of ball lightning?

24 October, p 46

From Robert Masta,
Ann Arbor, Michigan, US

Your article on ball lightning failed to mention another possible cause: induced hallucination. This was discussed in earlier coverage (22 May 2010).

I suspect that the impact of a bright flash on vision could be enough to trigger the illusion. Recall how apparent reports say the glowing ball follows the person's gaze and has no physical manifestations like heat or odour. This seems more likely than extra-dimensional wormholes.

Incarcerated, yes, but free to choose to fight fires

17 October, p 32

From Christine Wolak,
Dublin, California, US

Your review of sci-fi thriller *The Book of Malachi* mentions that inmates in the US are "used as firefighters". However, I would like to point out that this is a voluntary work programme that prisoners must earn a place in. ■



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When rumours kill

Vaccine misinformation can have a devastating impact. Knowing how to counter it is far from easy, says **Jessica Hamzelou**



Book

Stuck: How vaccine rumors start – and why they don't go away

Heidi Larson

Oxford University Press

RHETT KRAWITT was just 7 years old when he petitioned local lawmakers in California to tighten restrictions on who could avoid vaccinating their children. Rhett had been through years of chemotherapy for leukaemia, so wasn't able to receive the MMR vaccine, which protects against measles, mumps and rubella. This left him, and others like him, vulnerable to these diseases.

But many of the parents of healthy children in the state were turning down the MMR vaccine, using the "personal belief exemption". Such refusal is thought to have contributed to a measles outbreak tied to a Disneyland theme park, which was linked to 147 measles cases across seven states.

The story is one of many that demonstrates how emotions, as well as misinformation and culture, come into play in debates surrounding vaccination. As anthropologist Heidi Larson demonstrates in her new book, *Stuck*, such debates aren't new and crop up continually around the world, and the fact that they are so persistent suggests we need a new approach to them.

The book, largely written before the covid-19 pandemic, is a guide to many of the problems faced by vaccination campaigns. Larson, based at the London School of Hygiene & Tropical Medicine, and who founded the Vaccine Confidence Project to better understand how people feel about vaccines, points out that rumours



JEREMY HOGAN/SOPA IMAGES/SHUTTERSTOCK

have always played a role in the misinformation and fear around vaccines. This has been the case since the first vaccines were introduced for smallpox.

If the thoroughly debunked belief that 5G phone masts were responsible for the covid-19 outbreak sounded familiar, that

"Emotions, culture and misinformation come into play when debates surrounding vaccination come up"

might be because similar ideas linked 3G to the SARS outbreak of 2002-2003, and 4G to swine flu.

Rumours and misinformation may be nothing new, but they can still have devastating effects. And the rising use of the internet and social media has only contributed to their spread, says Larson.

In extreme cases, people administering vaccines have been killed. We have also seen, most

recently with measles, how a drop in vaccination can lead to the loss of herd immunity, and the resurgence of diseases that claim lives.

So how do we tackle them? Larson points out that simply countering misinformation with facts isn't enough. She quotes epidemiologist Stephen Ledder, who wrote that "facts are not rejected because they are seen as being wrong, but because they are seen as being irrelevant". Larson herself describes this as "a near reversal of the Age of Enlightenment".

Instead, it is important to understand the emotions that drive these rumours. A common problem is people feeling that vaccination of their children is something that is out of their control, for example. And it is important to acknowledge that vaccines do have risks, even if the risks of side effects are minimal, says Larson.

In the book, Larson draws

An anti-vaccination campaigner at a protest in Indianapolis, Indiana

on the need for open dialogue to share information, and the importance of including those who oppose vaccination for whatever reason, and treating them with empathy and kindness. Frustratingly, given her obvious expertise, there is no direct call to action, or clear suggestion for a solution to the problem.

Having highlighted the fatal consequences of vaccine misinformation and avoidance, Larson says "the global vaccine enterprise needs to reboot" and that the scientific community is pondering how to manage people's relationship with information, and misinformation, surrounding vaccines. Larson concludes by writing that she is a "patient optimist", but given what's at stake, this doesn't seem quite enough. ■

Just a small one

Four friends test the effects of constant low levels of alcohol – what could go wrong? **Jon O'Brien** finds out



Film

Another Round

Thomas Vinterberg

Due for release in December

ACCORDING to some reports, Norwegian psychiatrist Finn Skårderud once suggested that humans are born with a blood alcohol level that is 0.05 per cent too low. An unorthodox idea, for sure, and one that is at the heart of Danish midlife crisis drama *Another Round*. The results, it is fair to say, wouldn't stand up to scientific scrutiny.

Directed by Thomas Vinterberg, the film sees four childhood friends – now all teachers – become willing guinea pigs during a 40th birthday meal. Martin (Mads Mikkelsen) is morose, bursting into tears over his stale marriage and a history class that has revolted over his blatant apathy. He throws himself wholeheartedly into a Skårderud-style study: how social and professional performance can be affected by a constant level of inebriation. Thanks to regular top-ups of vodka, Martin soon has both his once-disillusioned students and previously aloof wife Trine (Maria Bonnevie) in raptures.

Psychology lecturer Nikolaj (Magnus Millang) and choir leader Peter (Lars Ranthe) also reap the benefits of day drinking early on, with the latter inspiring a rousing practice between swigs from his secret stash. This motley trio appear to back up a 2013 study that found creative cognition can significantly improve with the buzz of alcohol. Participants just under the US legal limit proved to be quicker problem-solvers than

those who were entirely sober.

Gym instructor Tommy (Thomas Bo Larsen), however, probably isn't the ideal candidate for their haphazard experiment. According to one study from 2000, athletes who drink habitually are twice as likely to be injured, while alcohol consumption can also affect healing times, dehydration levels and performance. Little wonder, then, that the most physically active test subject has the most difficulty adapting.

Yet it doesn't take long for the others' lives to go hopelessly awry too. Walls are bashed into and relationships are torn apart as on-screen blood alcohol levels show just how much they push past that supposed sweet spot of 0.05 per cent into oblivion. Martin may cite under-the-influence high-achievers such as Ernest Hemingway and Winston Churchill to justify the debauchery, but it is pretty clear that the gang isn't going to be penning literary classics or guiding a nation any time soon.

Vinterberg isn't interested in demonising alcohol, though. Sure,

the quartet's issues are exacerbated by a tippie or 10, but as Martin's mid-dinner breakdown proves, they had already risen to the surface before the experiment began.

Like his Oscar-nominated drama *The Hunt*, which starred Mikkelsen as a man accused of child abuse, Vinterberg isn't afraid to lighten the mood with flashes of dark humour. Take when a wasted Nikolaj tries to breathalyse himself with a baby monitor, for example, or an equally sozzled Peter's supermarket meltdown over the lack of fresh cod (incredibly, none of the utterly convincing leads touched a drop of alcohol throughout the shoot).

Offering neither a celebration nor a condemnation of drinking culture, the film's well-balanced narrative may frustrate those expecting a *Leaving Las Vegas*-esque descent into despair. Yet Skårderud's idea doesn't appear to be remotely sustainable in the real world – well, Vinterberg's version of it anyway. ■

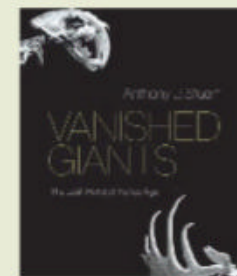
Jon O'Brien is an entertainment writer based in Greater Manchester in the UK



HENRIK OHSTEN

Martin (Mads Mikkelsen) turns to alcohol when he feels stuck in his life

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The film column

Simplicity at its best *Away* is a feature-length animation created entirely by one person. The writing, animation and soundtrack are all uncomplicated, and the storytelling is all the better for it, says **Simon Ings**



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



SUBMINAL FILMS

Away tells the story of a boy pursued by a strange, humanoid figure

physics were necessities. Indeed, the film is structured like a game, with distinct chapters and a plot arranged around simple physical and logical puzzles. The boy finds a haversack, a map, a water canteen, a key and a motorbike. He finds a companion, a young bird, who learns to fly, departs, and returns. The boy runs out of water, then finds more. He wins a major victory over his terrifying pursuer, only to discover it is a temporary one.

But by the end of the film, it is the realistic movies that seem odd, the big budget animations, the meticulously composited Christopher Nolanesque behemoths. Even dialogue feels clumsy and lumpen after 75 minutes of *Away*'s impeccable, wordless storytelling.

The film shows that when everything in the frame and on the soundtrack serves the story, then the elements themselves don't have to be remarkable. They can be simple and straightforward: fields of a single colour, one apposite sound effect, the tilt of a simply drawn head.

Experiments of this sort – ones that change the logistics and economies of film production – are often ugly. The plots of the first films were virtually unfollowable. The first films with sound were dull and stagey. CGI effects were initially so hammy that they kicked viewers out of the moviegoing experience. It took years for Pixar's animations to acquire their trademark charm.

Away is different. In an industry that makes animations whose credits feature casts of thousands, Zilbalodis's exquisite movie sets a very high bar indeed for a new kind of artisanal film-making. ■



Film

Away

Gints Zilbalodis

At selected cinemas, with a digital release in early 2021

Simon also recommends...

Film

Forbidden Planet (1956)

Fred M. Wilcox

Leslie Nielsen is a starship captain investigating a planetary settlement gone suspiciously silent in this reimagining of Shakespeare's The Tempest. The film has its longueurs, but the central idea – a machine that brings dreams alive – is a gripping one.

A BARREN landscape at sun up. From the cords of his deflated parachute, dangling from the twisted branch of a dead tree, a boy slowly wakes to his surroundings, just as a figure appears out of the dawn's dreamy desert glare. Humanoid but not human, faceless yet inexpressibly sad, the giant figure shambles towards the boy, bends and, though mouthless, tries somehow to swallow him.

The boy unclips himself from his harness, falls to the sandy ground and begins to run. The slow, gripping pursuit that follows will, in the space of an hour and a bit, tell the story of how the boy comes to understand the value of life and friendship.

That the monster is Death is clear from the start: not a ravenous ogre, but unstoppable and steady. It swallows, without fuss or pain, the lives of any creature it touches. Perhaps the figure pursuing the boy doesn't represent a physical threat as such, but more the dawning of a terrible idea – that none of us lives forever.

Away is the sole creation of

Latvian film-maker Gints Zilbalodis, and it is his first feature-length animation. Zilbalodis is the film's director, writer, animator and editor, and even composed its deceptively simple synth score – a constant back-and-forth between dread and wonder.

There is no shading in Zilbalodis's CGI-powered animation, no outlining and next to no texture, and the physics is

“When everything in the frame serves the story, the elements themselves don't have to be remarkable”

rudimentary. When bodies enter water, there's no splash. Instead, deep ripples shimmer across the screen. And when a geyser erupts, water rises and falls against itself in a churn of massy, architectonic white blocks.

Away feels nostalgic at first, perhaps harking back to the early days of video games, when processing speeds were tiny, and a limited palette and simplified

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The biggest logistics challenge in history

Making a safe, effective covid-19 vaccine is just the first step. Getting it to enough people to end the pandemic may be a far bigger challenge, finds **Carrie Arnold**

IN KALAMAZOO, Michigan, millions of vials of a covid-19 vaccine may soon be rolling off production lines. There are still many hurdles to leap before that vaccine – the candidate from US drug company Pfizer and its German partner BioNTech – or any other is approved and distributed, but governments, manufacturers and shipping firms around the world have already spent months preparing for what happens next.

That comes down to a simple but easily overlooked fact: a vaccine by itself is useless. “Vaccines don’t save lives,” says Kelly Moore at the Immunization Action Coalition in the US. “Vaccination does.”

When a covid-19 vaccine is approved, it will trigger a staggeringly complex chain of events. These events must occur in perfect lockstep using a global supply chain that needs to reach even the planet’s most remote areas – the same supply chain that left parts of the world in desperate need of things like disposable gloves and protective equipment just months ago.

“The scale and magnitude of what we’re talking about doing is just unparalleled,” says Orin Levine, director of vaccine delivery at the Bill & Melinda Gates Foundation. The list of potential catastrophes has been keeping Levine up at night for months.

But overcoming these logistical challenges is what it will take to end the pandemic. And “the key to overcoming complexity is planning and planning early”, says Levine.

Exactly how many people need to be vaccinated to end the pandemic depends on how effective the vaccine is, and how long the immunity it provides lasts (see page 8). Seth Berkley, head of Gavi, an international group that promotes vaccine use around the world, puts that figure at 60 per cent. Given we now number 7.7 billion, and most of the vaccine candidates in late-stage trials require at least one booster, that is a staggering 9 billion or so doses.

Ramping up production of a newly approved vaccine can take up to a year in normal circumstances, says Julie Swann, a health systems expert at North Carolina

State University. This time, pharmaceutical companies began readying mass production lines well in advance of any results from late-stage clinical trials. Pfizer and BioNTech plan to make enough doses to vaccinate 25 million people by the end of 2020, and 630 million people in 2021. The University of Oxford and AstraZeneca had planned to deliver 30 million doses of their vaccine to the UK government by the end of September, but a delay to their trial forced them to revise that to 4 million by the end of the year.

Making all this vaccine requires a lot of upfront cash, which many countries have provided as a combination of traditional grants and advance purchase orders. These orders give governments the right to buy a given number of doses for a specific price if and when they become available, enabling firms to ensure they will recoup investments in research and manufacturing capacity, says intellectual property specialist Lisa Ouellette at Stanford University in California. Exact details of the agreements, including what money will be paid if a vaccine doesn’t pan out, haven’t been made public, but that’s standard for these contracts, says Ouellette.

According to the US Biomedical Advanced Research and Development Authority (BARDA), the US government has invested ➤

“The fact is vaccines don’t save lives – vaccination does”



\$6.5 billion in covid-19 therapeutics and vaccines predominantly as part of Operation Warp Speed, the country's effort to deliver 300 million doses of a vaccine, with initial doses available by January 2021. That includes at least \$1 billion each to Novavax, the University of Oxford and AstraZeneca, GlaxoSmithKline and Sanofi, and Johnson & Johnson, which owns the pharmaceutical company Janssen. A US government contract with Moderna states that the Massachusetts-based biotech firm could receive as much as \$1.5 billion in exchange for 100 million doses if it hits aggressive deadlines. Pfizer and BioNTech have a similar agreement with the US government for up to \$1.95 billion for 100 million doses. All told, the US government will own more than 700 million doses from at least six different companies.

The UK government has signed similar deals, agreeing to buy a total of 340 million doses at set prices from at least six firms. Australia has invested more than A\$3.3 billion in five different vaccine supply agreements.

For many countries – though notably not the US – some of these payments have been made via COVAX, a 184-nation effort that allows higher-income countries to pool vaccine purchasing power, while subsidising injections for lower-income nations. The goal is to produce and equitably distribute

“The world has no experience administering a vaccine and a booster on this scale”

2 billion doses of vaccine by the end of 2021.

Some of the specialist products that are critical to vaccine production can be harder to come by. These include a substance derived from horseshoe crab blood that is uniquely sensitive to toxins and so used to detect contaminants in vaccines. This precious substance costs more than \$13,000 per litre. There are synthetic alternatives, but they still face regulatory hurdles. So far, suppliers are confident they will meet the surge in demand: the three US providers estimate they can produce enough in a single day to run the tests necessary for 5 billion doses of covid-19 vaccine.

Ahead of time

Some of the vaccine candidates – though currently not any of those using new mRNA technology – will also require adjuvants, which help improve the immune system's response to a vaccine by boosting antibody production. This makes vaccine supplies go further, requiring a smaller dose per person. In May, GlaxoSmithKline announced it had committed to produce 1 billion doses of its ASo3 adjuvant for pandemic vaccines.

Once vaccines have been approved and manufactured at scale, the challenge remains to package, ship and administer them to more people and in a shorter period of time than ever before. While supplies like alcohol swabs, gloves, bins for used needles, pallets, plastic wrap and syringes can all be made by a wide array of manufacturers, the scale of the demand may be hard to cope with. BARDA estimates that the US alone will need up to 850 million syringes for covid-19 vaccination. UNICEF has already begun stockpiling 1 billion syringes in warehouses in Denmark and Dubai as part of COVAX, says Robert Matthews, a contracts manager at the UN agency.

One of the challenges UNICEF faces is that vaccines are shipped by air and can arrive almost anywhere on the planet in one to three days. Syringes, being bulkier and with a shelf life of around five years, are typically sent by boat and truck. They can take two to four months to reach their destination.

The aim is to avoid delays by getting syringes closer to where they will ultimately be needed as far in advance as possible, says Matthews. “This helps mitigate potential supply risks of lockdowns or export bans or shipping congestion around ports, and enables further distribution much more rapidly than we would otherwise be able to do.” Each year, UNICEF provides 800 million

Vaccine front runners

As New Scientist went to press, 53 covid-19 vaccines were being evaluated in 126 clinical trials in 35 countries, according to the COVID-19 Vaccine Tracker from McGill University in Canada.

There are three phases of clinical trials in humans. Phase I is to test for safety in a small number of people. Phase II is to show efficacy in several hundred volunteers. Phase III is to show both safety and efficacy at scale and includes thousands of participants. It is usually the final step before approval.

Twelve candidates from four broad vaccine categories are now in phase III trials.

PROTEIN SUBUNIT VACCINES

These use a small piece of viral protein to trigger an immune response. US company Novavax is working on one (NVX-CoV2373).

MRNA VACCINES

This kind of vaccine takes pieces of the virus's genetic material and surrounds them in protective lipids. The RNA instructs the body's cells to produce small pieces of viral protein, which causes the immune system to make protective antibodies. Pfizer and BioNTech (BNT162b2) and Moderna (mRNA 1273) have candidates in late stage trials.

NON-REPLICATING VIRAL VACCINES

These insert pathogen genes into a different virus that can't copy itself. There are five different vaccines in phase III trials from manufacturers based in China (Ad5-nCoV), Russia (Sputnik V), the US (Ad26.COV2.S), UK (AZD1222) and India (Covishield).

INACTIVATED VACCINES

This technique relies on a killed virus that cannot replicate. Three of the candidates in phase III trials (BBIBP CorV, Coronavac and Inactivated) are from drug companies based in China, while Covaxin is from India.

syringes for various vaccination campaigns. It estimates that covid-19 vaccines could need up to four times that number – 3.2 billion.

Once all of the ingredients are assembled, covid-19 vaccines will be stored and shipped in special glass vials. These are resistant to shattering at temperature extremes and less chemically reactive than standard glass, meaning they are less likely to interact with the vaccine, says Ken Falkowitz at labware manufacturing company DWK Life Sciences.

Earlier this year it was feared that the world would quickly run out of the vials, which are almost exclusively made from borosilicate glass. The main worry is that this glass requires special sand, says Falkowitz, and a breakdown at any point in the chain could bring vaccination efforts to a halt.

Those concerns led to several recent large-scale investments to ramp up production of these vials, which can each hold between two and 20 doses. The world's leading borosilicate glass manufacturer, Germany's Schott, has committed to produce enough vials to hold 2 billion vaccine doses, and says shipments have already gone out to North America, Europe and Asia. Falkowitz says that DWK Life Sciences recently merged with German glass-maker Müller + Müller to bring the new firm's annual production capacity to 600 million vials. BARDA, for its part, has invested hundreds of millions of dollars in US firms to produce an additional 284 million glass vials for covid-19 vaccines, including \$204 million for a new kind of vial from Corning, the firm that makes Pyrex. These measures should be enough to prevent shortages, says Falkowitz.

Once the vials are filled, they will need to be distributed – and quickly. The ailing airline industry is on standby. The International Air Transport Association has estimated that providing a single dose to everyone on the planet would require enough vaccine to fill 8000 Boeing 747 cargo planes.

How they are transported is another challenge: all 12 of the leading vaccine candidates will need to be kept cold to stabilise the sensitive ingredients. Moderna's mRNA-1273 will need to be stored at -20°C, a temperature that can be reached by most household freezers. Pfizer and BioNTech have said that their candidate, also an mRNA vaccine, will need to be far colder: -70°C. That requires special freezers that can reach -80°C, the kind used to store things like bacterial cells in labs or sperm in fertility clinics.

Pfizer has designed new insulated, suitcase-sized containers that will be packed with dry ice to maintain temperatures below

9

billion

The estimated minimum number of vaccine doses needed to end the pandemic

300

million

The number of vaccine doses the US government aims to deliver through its Operation Warp Speed

25

million

The number of people Pfizer and BioNTech aim to provide with vaccines by the end of the year



ANDREW J. MARTINEZ/SCIENCE PHOTO LIBRARY

An extract from horseshoe crab blood is key to vaccine production

-70°C and can keep the vaccine stable for up to 15 days. Each container can hold up to 4875 doses and will need to be refilled with 23 kilograms of dry ice every five days.

But there is reason to hope that mRNA vaccines may not need such a deep freeze. Research by two teams working on vaccines that use this technology but are in early stage trials has revealed that they may be stable for months at 4°C, the temperature of a standard fridge. That would be a game-changer for distribution (see “Keeping cool”, page 40).

However cold the requirements, keeping these vaccines at the right temperature is crucial, says Tinglong Dai, a specialist in operations management at Johns Hopkins University in Maryland. Large shipping companies like UPS and FedEx are already preparing. At some air hubs in the US and Europe, UPS is building freezer farms. Each of the 600 freezers in one of its farms will be able to hold 48,000 doses of vaccine.

Maintaining the cold chain in the air and in warehouses is relatively straightforward, as long as transport companies have the right equipment and a steady supply of electricity. Things get trickier when products are on the road. The World Health Organization has detailed recommendations for everything from the way coolers are packed to how to account for airflow inside freezer trucks. But it gets most difficult in the “last mile”, according to Dai. In low and middle-income countries, drivers on motorbikes typically deliver vaccines and other medical products to villages in remote areas.

Unanticipated shortages

This is why Helen Rees, a vaccine specialist at the University of Witwatersrand in South Africa, is more bullish about the two covid-19 vaccines currently in late-stage trials from Janssen and Novavax. These would be shipped frozen, but manufacturers already know they can be stored at 4°C.

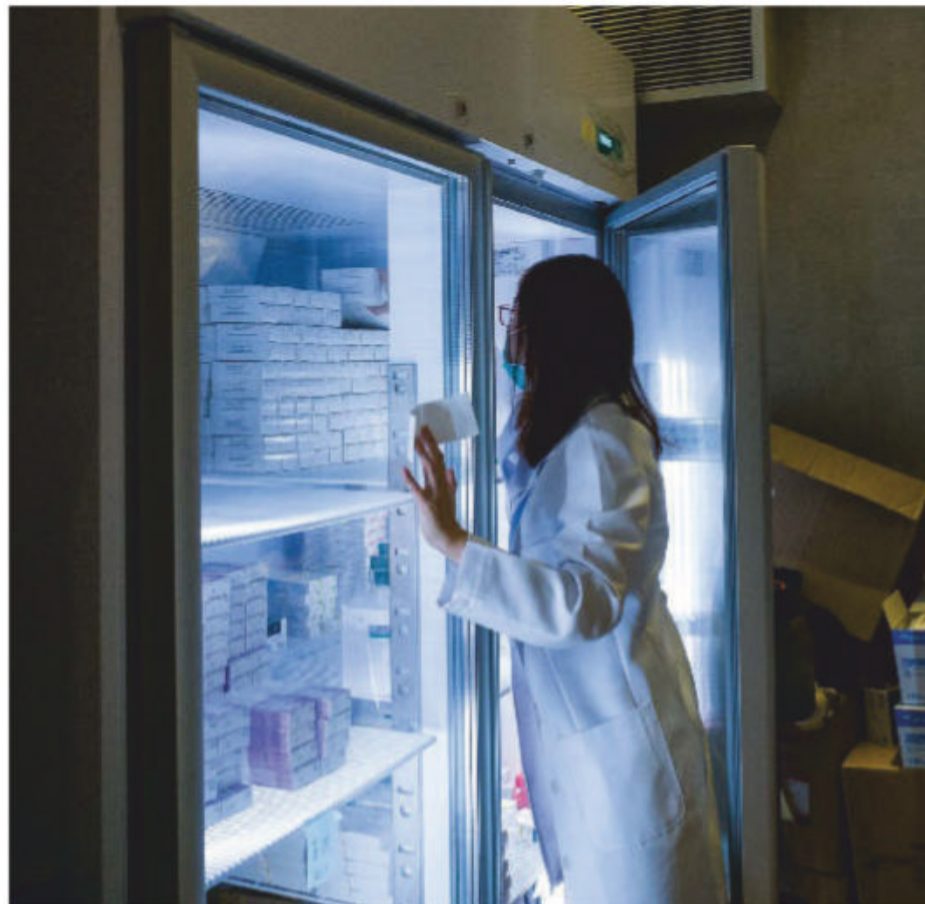
All of these necessary supplies and arrangements are what the world knows that it needs, says Nicolette Louissaint at Healthcare Ready, a US-based non-profit that helps government and hospitals address medical supply chain issues. More worrisome are unanticipated shortages, she says. “There are a lot of hypotheticals and you have to plan and prepare for all of them,” says Louissaint.

Having a distributed global supply chain can be an advantage for manufacturers, says Phil Ashton at 7bridges, a UK start-up that uses artificial intelligence to manage



Keeping cool

The fact that the vaccine developed by Pfizer and BioNTech needs to be stored at -70°C has raised concerns about its distribution. But it may not need to be kept so cold. Anna Blakney's team at Imperial College London found that their mRNA vaccine candidate is stable for months at 4°C . That is also true of an mRNA candidate from CureVac in Tübingen, Germany. It should be the case for the Pfizer vaccine too, says Blakney. "I guarantee that they are doing the exact same studies." All three vaccines encase RNA in droplets of fat, called lipid nanoparticles, made by the Canadian firm Acuitas. Company director Thomas Madden says deciding to store the vaccines at -70°C was due to "an abundance of caution", but that "there's no technical limit". Michael le Page



Keeping certain kinds of vaccines cold may be a huge challenge when distributing doses

supply chains. Mapping out alternatives in advance may be crucial in overcoming inevitable problems. "You need to have the right infrastructure and capacity in place to handle what's going to be a relatively short, sharp shock to the supply system," he says.

Back-up plans

The simple fact is, coordinating the administration of a vaccine and booster on a global scale isn't something the world has experience with. "There's no muscle memory to vaccinate people at that scale throughout the world, at levels that are needed to open up society," says Saad Omer, director of the Yale Institute for Global Health. It is the biggest logistics challenge in history. "That's what keeps me up at night. Countries are not ready for this," says Omer.

There will also be political challenges to overcome, not least the willingness of people to actually get vaccinated (see page 12). In a survey of 13,000 people in 19 countries, more than 70 per cent said they were likely to get a covid-19 vaccine. But vaccine hesitancy varied widely by location. While 90 per cent of people in China said they would get one, that was the case for only 55 per cent in Russia. "People have to trust the process and believe that their best interest is being considered," says Marcus Plescia, chief

8000

The number of Boeing 747 cargo planes it would take to transport a dose of vaccine for every person on Earth

4875

The number of vaccine doses that can be transported in each of Pfizer's thermal shipping suitcases

43,538

The number of people in the phase III clinical trial that has shown early, promising results for Pfizer and BioNTech's mRNA vaccine

medical officer at the Association of State and Territorial Health Officials, a non-profit US public health organisation.

There may be other issues too. In the UK, for instance, there are concerns that changing trade agreements under Brexit could delay the transit of vaccines or even leave them stranded at the border. There is also the problem of how to ensure access to vaccines for everyone, not just people in wealthy countries, says Rees. That is why the COVAX partnership was launched in June. Whether it will be enough to overcome the influence of "vaccine nationalism" remains to be seen. A recent report from Oxfam said that the UK has secured enough doses for five injections per person, while Bangladesh only has one dose for every nine people. The US may also wind up with excess vaccine.

However, as this pandemic has shown, we are inextricably connected. This may be to our benefit when it comes to global supply chains. But it will be our undoing if we fail to recognise that countries can't go it alone. "As long as we leave a region or country without access, the virus will come back," says Rees. ■



Carrie Arnold is a science writer based in Virginia. Follow her @edbites



Racism in close up

What can scientific research tell us about the true extent of systemic racism? **Loyal Liverpool** speaks to five researchers on the front line

THE explosion of the Black Lives Matter movement into mainstream awareness has brought the prevalence of systemic racism and anti-Black bias into sharp focus. This isn't confined to individual acts and attitudes. It is racism deeply embedded as normal practice in the systems, structures and institutions that underpin society. And although it remains invisible to some, a growing body of research shows that systemic racism has a hugely detrimental impact on people across the world.

In the US, where the most recent wave

of anti-racism protests began, Black people are far more likely to be arrested and incarcerated than white people for the same crimes. But the issues faced in the US and other countries go far beyond law enforcement. We know that racism is also baked into housing, education, employment and healthcare systems. In the US, UK and elsewhere, for example, the disproportionate impact of the coronavirus pandemic on people from Black and ethnic minority (BAME) backgrounds has put a powerful spotlight on the way societal inequalities

affect health and vulnerability to disease.

And yet researchers are still working to understand how societies hold back and harm BAME communities, running experiments and analysing existing data with fresh eyes to uncover all the manifestations of systemic racism. We spoke to five US-focused scientists who investigate concealed discrimination in various aspects of everyday life, from children's academic development to health and disease in adulthood and interactions with technology.

EDUCATIONAL INEQUITY



Daphne Henry is a developmental and educational psychologist at Boston College in Massachusetts

In the US, Black children tend to get lower scores in reading and mathematics tests compared with white children. But I noticed that in a lot of studies of academic achievement, the majority of the participants from lower-income families were also from ethnic minority groups and the majority who were middle-income or above were white. This risks conflating the effects of socio-economic status with those of race and ethnicity. I wanted to figure out whether the benefits of higher family income led to similar levels of academic achievement for Black children as for their white peers.

My colleagues and I analysed data from a study that followed more than 9000 children across the US who started kindergarten in 1998 until they reached middle school – that is from about age 5 to age 14. We found that higher family socio-economic status was associated with a boost in children's academic achievement, but the size of this boost differed between Black and white children. When family

socio-economic status increases, the academic achievement gap between Black and white children actually grows.

This is counter-intuitive. One of the foundational principles for work that examines achievement disparities is that if you just eliminate socio-economic disparities among African American families, then that will essentially close the achievement gap. My work suggests that doesn't capture the entire story – socio-economic advantage may not bestow the same benefits on Black children that it does on white children.

This really speaks to the structural and social privileges and constraints that exist in US society, and to how those differ for Black and white children at the same socio-economic level. If you take a middle-income African American family and a middle-income white family, they are probably going to have vast disparities in wealth status, in terms of wealth accumulation and assets, as well as in the amount of debt they have. We know that African



ROGELIO V SOLIS/AP/SHUTTERSTOCK

Black children make up 18 per cent of preschool pupils in the US, but comprise nearly half of all suspensions

Source: US Department for Education Office for Civil Rights (bit.ly/2IsNCZs)

TOXIC STRESS



Shawn Utsey is a psychologist at Virginia Commonwealth University

Iwent to graduate school during the tumultuous 1990s. Many people think today, with all of the police-related killings and vigilante killings of Black people, that we have entered a new realm of the Black experience. But that isn't true. In the 90s, we had many killings on a regular basis by the police and by white vigilante groups.

At the time, I was also working as a counsellor in Harlem, New York. I noticed that the items on the life stress scale – a standard measure used by counsellors to assess people – didn't

reflect the lived experiences of my clients. There was no reference to racism or police brutality. So I created my own scale that included those items to try to measure life stress among Black populations.

I wanted to use my scale to investigate how racism and race-related stress impact people's health, because we know that racism is a significant cause of stress among racial and ethnic minority groups and particularly African Americans. Black people in the US die disproportionately from stress-related conditions including

high blood pressure, heart disease and stroke.

People feel stress emotionally, but the real damage is physiological. Through my research, I discovered that people reported experiencing physical symptoms of stress – such as increased heart rate – simply in the expectation of experiencing racism. Even just anticipating that you might be exposed to racism is stressful. My findings are unpublished, but the anticipatory racism connection has also been seen by other researchers.

Indeed, such stress isn't only caused



Americans have to take out more student loans to finance higher education, for example. They are probably going to live in very different neighbourhoods too.

There is also some evidence to suggest that Black and white children in the same school district, or even sometimes attending the same school, may experience differences in the academic instruction that they receive. Teachers may consciously or unconsciously treat Black and white

For African American children, advances in socio-economic status don't always translate to academic achievement

children differently, because everyone – including teachers – grows up in a social context. For instance, stereotypes about who is more or less academically qualified could result in teachers favouring children to go into “gifted and talented” classes based on their race. ■

by overt experiences of racism. Often it is caused by the broader challenges associated with negotiating a racist society while being Black. For instance, Black people will sometimes experience the stress of racism when it happens to someone close to them or when they witness instances of racism through the media, such as videos of Black people being killed by police.

Race-related stress is chronic, and that creates this prolonged activation of physiological stress responses. I think this is a key contributing factor when it comes to racial health disparities. ■

In Philadelphia, African Americans are almost three times more likely to be rejected for home loans than white people

Source: Reveal from the Center for Investigative Reporting (bit.ly/2UngWmC)

THE HEALTH GAP

DR. ROSHNI RAO



Michele Evans is a medical oncologist at the National Institutes of Health in Maryland

In the US, African Americans are 9.4 per cent more likely to have chronic kidney disease than white people, and when you look at end-stage kidney disease – where you need dialysis or a kidney transplant – it is almost a fourfold higher risk. But race isn't a biological construct. So how are social factors putting particular groups of people at an increased risk of disease?

I decided to start looking at social determinants of health as though they were toxic agents. A study I started many years ago follows more than 2000 people in Baltimore, Maryland, through regular health monitoring and surveys. It is a cohort that includes Black and white people both above and below the poverty line.

We discovered that low socio-economic status was associated with a twofold higher risk of chronic

Black people in the US are dying from covid-19 at three times the rate of white people

Source: APM Research Lab (bit.ly/3ksHp44)

kidney disease in African Americans. But when we looked at white people, there was no statistically significant relationship between socio-economic status and chronic kidney disease. So poverty, or low socio-economic status, has a specific detrimental effect on African Americans in terms of their disease risk. It seems there is something unique or different about being both Black and poor when it comes to health.

When I became a medical oncologist, I started to collaborate with colleagues at the University of Maryland to look ➤



at the effect of racial discrimination on health. Racism is a psychological stressor and in the Baltimore study, we had noticed that higher levels of perceived racial and gender discrimination among African American women were associated with a decline in kidney function over the study period.

African Americans are also more likely to develop Alzheimer's-related dementia, so we decided to use MRI to look at white matter lesion volume in people's brains – an early indicator of cognitive decline. We found that, in older African Americans, increases in perceived lifetime discrimination burden were associated with increases in white matter lesion volume. We also discovered that African Americans who reported more perceived racial discrimination tended to have thicker arteries – a subclinical sign of cardiovascular disease.

Research into such health disparities is still in its infancy, because if you look at ethnic minority health in general, in the US we don't collect adequate data on subpopulations, such as Native Americans. We are even in a situation where we are trying to make sure we have populations adequately represented in studies. How can you say that your finding is relevant to everybody when your study includes predominantly white people? ■

A patient receives a check up in Chicago before the pandemic began

Historical violence may influence voter participation today



MICHAEL REYNOLDS/EPA-EFE/SHUTTERSTOCK

VIOLENCE AND VOTING

ECONOMIC POLICY INSTITUTE



Jhacova Williams is an economist at the RAND Corporation in Washington DC

I am a cultural economist. Something I have been working on for years is investigating how historical racial animus continues to influence the voting behaviour of Black people in the US. In the late 1860s, Black men in the US were given the right to vote, and they voted. Voter turnout at that time was nearly 90 per cent among Black men. This caused a lot of animosity and was associated with an increase in lynchings of Black people, which led to a decline in voter turnout. By the 1940s, only 3 per cent of Black men in the South were registered to vote.

These racist and terrorist acts caused a lasting change in the behaviour of Black people. My research shows that Black people who live in areas that historically had more lynchings are less likely to be registered to vote in elections today. They stopped voting, of course, to protect their own well-being, to make sure they wouldn't be lynched, to make sure their family wouldn't be lynched. I believe that this has been passed down from generation to generation, and it has a huge impact on who gets elected.

Two things you always hear people talk about are voter ID laws and gerrymandering. But I think the biggest act of voter suppression is that there is a lack of trust in voting within the Black community. We have to get at why that is. When you see people across the globe looking at George Floyd being killed, imagine what that does to Black people in their psyche. When you see things like that it makes you feel like you aren't a part of society, like you're not actually American even though you were born here and are raising your family here. This was a huge challenge for people working to enfranchise Black voters in the latest US election.

Voting is a social norm. It proves that you have social capital; that's why you are participating. If I don't believe that I am a part of society, why would I vote? ■

FACIAL RECOGNITION



Deborah Raji is a fellow at the Mozilla Foundation, based in Ottawa, Canada, and a fellow at the Algorithmic Justice League

During my first major tech internship, which lasted for a year from May 2017, I was the only Black person and the only woman in the applied machine learning team. I was working on computer vision models, programs that can identify different objects. I noticed that the engineers were making a bunch of assumptions that they weren't aware of. For example, as a team we were asked to build a model to classify hair, and there were 20 different categories of hair textures and only one category for all the afro textures common with Black hair. I know we have more hair textures than that.

Then there was another project I was participating in, developing a model that could filter out inappropriate images, particularly pornography. I realised that the model wasn't performing well for darker-skinned individuals. The pornography being used as examples for the system of what is inappropriate material was more ethnically diverse than the stock images we were using as examples of what is appropriate. Because of the bias in the data sets, the model was filtering out the content of people of colour disproportionately, flagging it as inappropriate.

Right after my internship ended, I joined Joy Buolamwini at the MIT Media Lab. She had noticed that facial recognition software couldn't detect her face very well, which is a darker-skinned face. We started to collaborate and we discovered that several publicly deployed facial-recognition products developed by companies like IBM, Microsoft and Amazon weren't performing well on darker-skinned individuals. Later, researchers at IBM reported that some 80 to 95 per cent of the faces in the data sets used to develop these systems were from lighter-skinned individuals.

These are the same types of facial-recognition systems that are being used



REUTERS/ANDREW KELLY

The Black Lives Matter movement has raised awareness of systemic racism

by major technology companies. In 2018, we found that Amazon's facial-recognition system, called Rekognition, was failing to accurately recognise the faces of darker-skinned women almost 30 per cent of the time. That isn't a good enough performance for it to be deployed as a product. And definitely not good enough to be pitching the technology to police departments, which the American Civil Liberties Union reported that Amazon was doing at the time. People with darker skin would be more likely to have their faces falsely detected in CCTV footage of crimes they weren't involved in, for example, and potentially even wrongfully arrested because of it.

This June, Amazon finally announced a one-year moratorium on the use of the facial-recognition technology by police departments. IBM had already announced that it would stop developing or selling facial-recognition software altogether. And Microsoft also said it won't allow its facial-recognition system to be used by police.

In addition to lack of representation in the data sets that many models and algorithms are trained on, decisions made by engineers also introduce biases that it is important to pay attention to. The tech industry is very

US job applicants with Black-sounding names are about half as likely as those with white-sounding names to get an interview, even when they have identical resumes

Source: National Bureau of Economic Research (bit.ly/2IsLL6X)

homogenous. You'll go to these tech company campuses and you won't see a Black person for miles. I think that there is ignorance about the fact that, although they aren't necessarily seeing a lot of people of colour in their environment, those people do exist and are actually the ones affected by their technology. ■



Loyal Liverpool is a trainee digital journalist at New Scientist

AI gets emotional

Some say artificial intelligence can now detect your feelings. But even if such machines work, they aren't always a good idea, says **Chris Baraniuk**

RANA EL KALIOUBY was alone in her flat, messaging her husband. "How are you doing?" he typed. "I'm fine," she typed back. Except that wasn't true. The couple had been apart for weeks and she was feeling miserable. Had he been in the room, he could have read the emotions on her face at a glance. But he was miles away.

It is a scene that could easily have played out during a coronavirus pandemic lockdown, when colleagues, friends and even families were cut off from one another. But it actually took place 20 years ago, soon after el Kaliouby had moved from Egypt to the UK to study, leaving her husband behind.

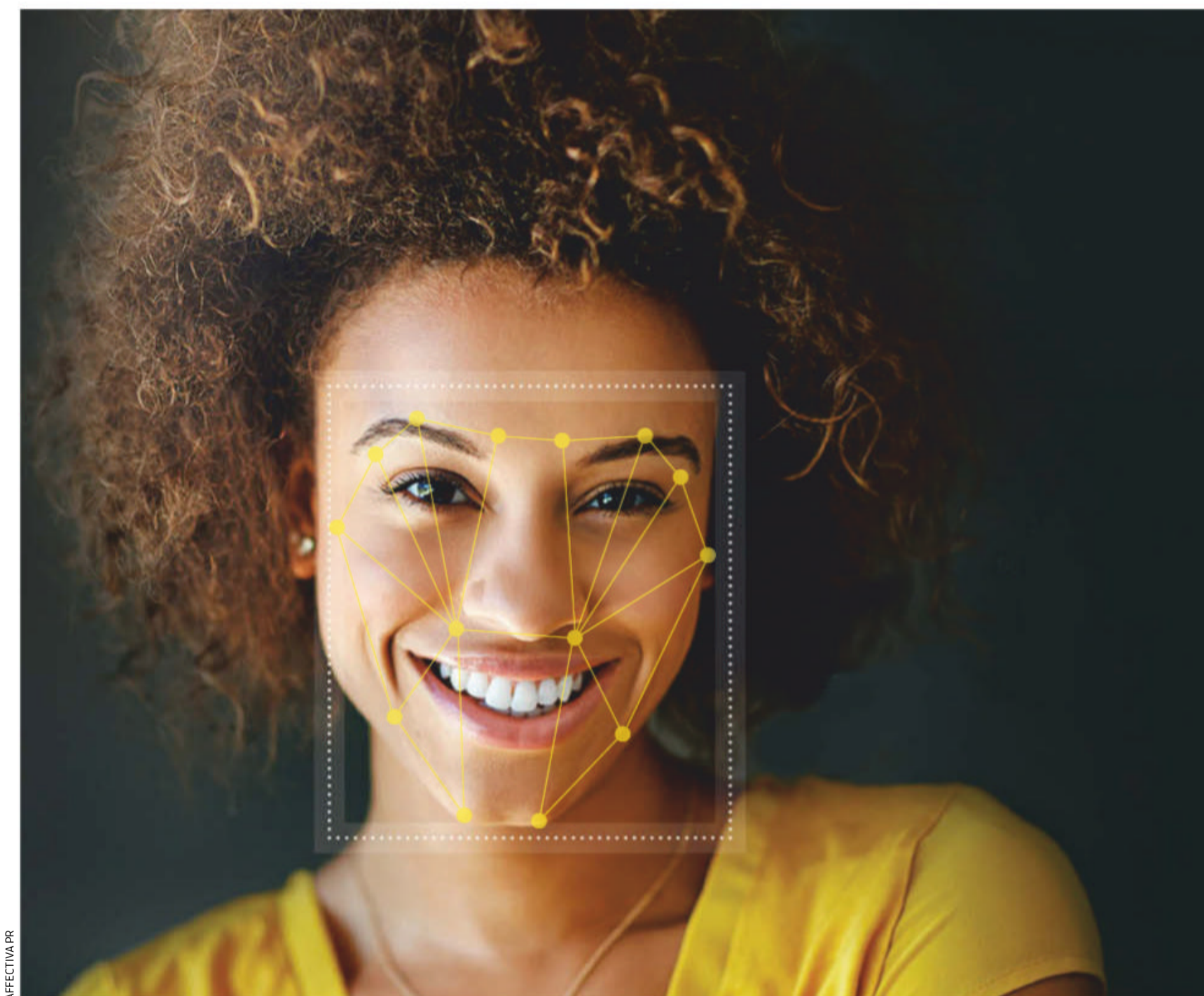
It was in that moment, she says, that she realised how technology was blind to human emotions. Ever since, el Kaliouby has dreamed of building an emotionally intelligent computer – or as she puts it "a mind-reading machine". With so many relationships mediated by text or video call these days, it is a technology that couldn't be more relevant.

These days, the company el Kaliouby co-founded, Affectiva, and others like it, claim to have systems capable of detecting human emotions. The promises they make about the potential of this emotion artificial intelligence (AI) are staggering. Computers, they say, will know if we are distracted while driving, angrily typing an email that we may regret or when our mental health is beginning to slump. In fact, systems like this already exist. But do they live up to their billing? And do we really want machines that know how we feel?

To make her dream a reality, el Kaliouby is relying on AI systems that learn from data how to do certain tasks. Take an AI that recognises cat pictures. It is trained by being shown lots of photos of cats and, in the process, learns what shapes, colours and other features to look out for. To begin with, the system is told whether the pictures contain cats or not. Eventually, given enough examples, it can learn to discern this itself.

Like spotting a cat, recognising a human emotion is a skill that, in principle, could be mastered by AI. Far more is at stake, though, at least for el Kaliouby. "These technologies that interface with us on a day-to-day basis need to know human, they need to understand human," she says. We all know that video calls and messaging apps can't fully replicate the experience of a face-to-face chat and part of that is because it is harder to remotely read other people's emotions. Yet computer-mediated conversations are set to become more common, especially as more of us work from home. One possible application of emotion AI is to help us judge whether an audience is bored, excited or somewhere in between.

The field of affective computing – making machines that can recognise, interpret and simulate human emotions – has been going for years yet is in some ways still in its infancy. We are a long way from machines that can realistically simulate our emotions. But when it comes to machines that can recognise our feelings, we appear to be getting there. ➤



AFFECTIVA PR

Some AIs attempt to identify people's emotions from their facial expressions

FEAR

Since Affectiva was founded in 2009, it has mostly worked with marketing firms to help them understand how audiences react to videos and other marketing content. This is often done by recording videos of people's faces as they encounter a poster, say, or watch an advert. By tracking how facial expressions change when they encounter these things, Affectiva says it can predict how successful an ad campaign will be. It isn't alone. Among others, Realeyes, a company headquartered in London, has also worked with advertisers to measure how attentive viewers are.

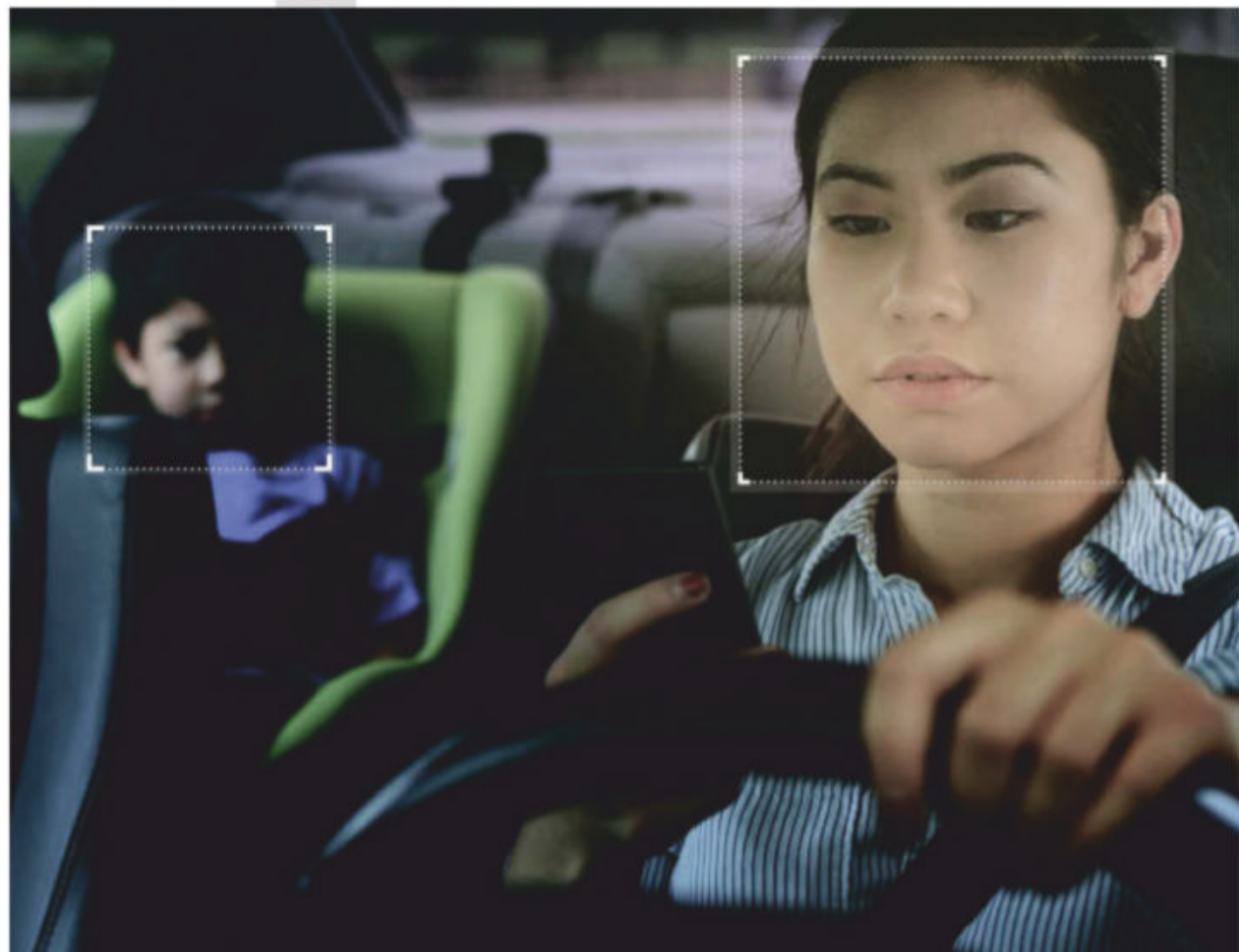
Other companies reckon they can glean insights from the sound of our voices alone. Behavioral Signals, a tech firm in Los Angeles, has developed software to classify emotion based on a speaker's tone. Its algorithm tracks pitch, volume, rhythm, intonation and other features of speech. "We focus on how something is being said," says chief executive Rana Gujral. "Oftentimes we don't even convert the audio into text."

This kind of intelligence could be handy for businesses, not least firms that field lots of phone calls. Behavioral Signals claims to be able to tell within 30 seconds of a call whether a customer will take a particular action, such as commit to paying off a debt.

The company says it has sold its tech to a major European bank, which used tone-of-voice analysis to match callers with staff in call centres. Irrate customers were automatically triaged to especially calm and collected handlers. There was a 20 per cent improvement in call outcomes, says Gujral, which translated into an expected \$300 million, had the bank relied on the system across its business for a whole year.

Hidden signals

But Behavioral Signals is going even further. Gujral says he is working with another company, which he won't name, that hopes to use AI in order to pick up vocal signals associated with depressive symptoms. The idea is to predict the likelihood of someone going on to attempt suicide based on their tone of voice during conversations



AFFECTIVA PR

SADNESS

with a psychologist or caregiver. This is experimental, but "they're actually working on live patients right now", says Gujral.

Clearly, emotional AI could be useful. Can algorithms really grasp human emotions, though? It isn't easy to evaluate the various companies' claims directly because their algorithms typically aren't made public. Even so, the science of emotion recognition can offer some insights.

We know it is possible to classify facial expressions. In the mid-20th century, psychologist Paul Ekman pinpointed facial movements that he argued could be associated with broad emotional states. There are now considered to be seven such emotional states under Ekman's Facial Action Coding System (FACS): anger, fear, disgust, happiness, sadness, surprise and contempt. These are often referred to as the "universal emotions" and well-practised humans can get good at identifying them from facial signals alone, with one study suggesting they get it right 77 per cent of the time.

If a car could recognise its passengers' emotions, it might make driving safer

"Emotion AI could tell us whether an audience is bored, excited or somewhere in between"



But there is a rather large catch: accurately identifying the “anger” state like this doesn’t necessarily mean the person displaying it is angry. One researcher who doubts the usefulness of this approach is Lisa Feldman Barrett, a psychologist at Northeastern University in Massachusetts. She and her colleagues recently completed a large review of existing research to find out whether there was any relationship between specific facial expressions and internal emotional states. The gist of their findings is that the evidence is scant – a scowl can be associated with a wide range of emotions, from anger to confusion to concentration. What’s more, the use of various expressions varies noticeably between cultures. We all like to think we could be as perceptive as Lady Macbeth: “Your face, my thane, is as a book where men may read strange matters”, but fully decoding expressions isn’t so easy in reality.

If humans aren’t perfect, can AI do better? Well, FACS is still an important ingredient in the algorithms designed by AI companies, including Affectiva and Realeyes. This makes Barrett highly sceptical of them. She argues that emotions are more like “episodes”: there is no one brain signal for “anger” and there isn’t one recognisable way of expressing that emotion on the face either.

Similar quibbles plague voice-based emotion recognition. Margaret Lech at RMIT University in Melbourne, Australia, and her colleagues reviewed a series of studies on the accuracy of such systems and found that they were able to correctly identify emotions around 60 per cent of the time on average – hardly a glowing result.

Some proponents of emotion AI accept that this is valid argument and admit that the systems only recognise expressions or intonations, not necessarily the true emotions beneath. Rosalind Picard, who co-founded Affectiva and is now director of the Affective Computing group at the Massachusetts Institute of Technology, is one of them. “I am not proposing one could measure affective state directly, but rather measure observable functions of such states,” she wrote in a 1995 paper.

“A scowl can be associated with a range of emotions, from anger to concentration to confusion

Does the tech we interact with need to understand human emotion?



BSIP/UNIVERSAL IMAGES GROUP VIA GETTY IMAGES

Others see the distinction as a straw man. Barrett’s critique might hold if a person or AI observes a face with no contextual information, they would argue, but that isn’t what happens in real life. Emotion AI is typically used to see how a person reacts to a specific thing, like a funny video clip. In that context, a grin is probably just a grin: an uncomplicated indication of amusement.

Wild feelings

What happens as this technology begins to be used more widely, though? Some companies working in affective computing have made their tech available to study and this has led to the discovery of some examples of bias. Lauren Rhue at the University of Maryland catalogued the results of emotion AIs developed by Microsoft and Chinese tech firm Megvii when the systems were fed pictures of white and black basketball players. “Both services interpret black players as having more negative emotions than white players,” she wrote in a 2018 paper. *New Scientist* asked both firms for a response to these claims. Megvii says that it puts great importance on fairness and doesn’t use its algorithms in scenarios that don’t meet its standards. Microsoft declined to comment.

Such ethical considerations aren’t stopping some police forces from trialling emotion AI in the wild. Lincolnshire Police in the UK recently hit the news because it has received government funding to deploy a system intended to detect the emotions of people captured on CCTV footage. This will, for now, be limited to a trial, and footage will be deleted after 31 days, according to the force.

Researchers at New York University’s AI Now Institute recently questioned how fair it is to use emotion-detecting AI on members of the public without explicit consent. Among the systems mentioned in the institute’s 2019 annual report is one offered by Oxygen Forensics, a US-based, Russian-owned firm that sells software to the FBI, London’s Metropolitan Police and Interpol. Among its products, the company offers facial recognition technology that it claims ➤



CONTEMPT

SURPRISE

can detect emotion. The institute's report argued that there was little to no scientific basis for this technology in general and said its use in areas including criminal justice was "concerning". Lee Reiber at Oxygen Forensics has previously said that being able to detect anger, stress or anxiety can help investigators.

Laughter or despair?

"I don't think we should be using emotion AI broadly in public life, particularly to make decisions that have legal consequence for people," says Jevan Hutson at the University of Washington School of Law in Seattle. Hutson likens emotion AI to phrenology, the discredited 19th-century idea that bumps on people's heads were correlated with personality traits. He says countries should adopt policies and laws to restrict the use of emotion AI in certain areas. Law enforcement, job recruitment, surveillance in public places – all of these applications and more could be deeply problematic if we get this stuff wrong, he says.

Meanwhile, there are plenty of people working to soothe such issues by making emotion AI more accurate. The most obvious

Educational technology might be more effective if it could assess the emotions of the children using it

"I don't think we should be using emotion AI in public life, particularly in decisions of legal consequence"

way to do this is to provide the AI with more context. Imagine an AI trying to work out whether a grimace signifies laughter or despair. If it had the tools to recognise whether a person is hanging out with friends or strangers – perhaps by recognising the other faces nearby – then it could more confidently settle on laughter. This isn't perfect, of course, but in general the more contextual information an AI has, the more likely it is to draw accurate inferences.

Take this to its logical conclusion and we might end up with emotion AI systems that Hoover up information on our voices, our body movements, faces and data about our environment, who we hang out with and what the people around us are doing.

This might sound a long way off, but there is one place where we are already seeing the first steps in this direction: cars. El Kaliouby and her colleagues at Affectiva are among the engineers now developing AI to monitor the behaviour of vehicle occupants. "We've expanded to things like activity detection," she says. "Are you holding a cellphone to your ears? Are the kids fighting in the back seat?"

Ultimately, such a system could form the basis of an autonomous car that even knows when to take control of the wheel. Vehicle maker Toyota is already building a prototype car equipped with an emotion AI system developed by US-based SRI International. Other car-makers are working with Affectiva, el Kaliouby says, and she expects to launch the first commercial versions of the technology in two to three years.

All this leaves computers that can detect our emotions at a pivotal juncture. They still aren't entirely trusted, and yet they are on the cusp of becoming far more widespread. Society hasn't fully grappled with the consequences. But one thing is for sure: we have come a long way since el Kaliouby sent those lonely messages two decades ago. ■



Chris Baraniuk is a freelance science journalist based in Belfast, UK



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Puzzles

Try our quick crossword, quiz and brain-teaser **p53**

Almost the last word

Why people often groan when they sit down **p54**

Tom Gauld for New Scientist

A cartoonist's take on the world **p55**

Feedback

Anachronistic tech and prayers for AI: the week in weird **p56**

Twisteddoodles for New Scientist

Picturing the lighter side of life **p56**

Science of gardening

Future-proof fruit

Blackcurrant bushes struggle with increasingly warmer winters, but there are new varieties that will fare better, says **Clare Wilson**



Clare Wilson is a reporter at *New Scientist* and writes about everything life-science related. Her favourite place is her allotment. Follow her @ClareWilsonMed

What you need

A blackcurrant bush
Garden netting to keep the birds away
A few bamboo canes

IF YOU think your garden or gardening skills aren't up to growing fruit, think again. Blackcurrant bushes are very easy to care for and they take up little space – perhaps a couple of square metres each.

I do little to my own plant, apart from throwing some garden netting over it every summer for a month or so to stop the birds from stealing the crop. I hold the netting away from the fruits with a ramshackle structure of bamboo canes, which can be taken down once the berries are picked.

Blackcurrants' weakness, though, is a potential vulnerability to climate change. If the winter isn't sufficiently cold for long enough, this interferes with flowering and leads to a smaller crop. "If they haven't received enough chill, they still think they're in winter," says Hamlyn Jones at the University of Dundee, UK.

Although the average temperature in the UK has risen by only about 1°C since the 1960s, winters have warmed more than summers. Plus, a small increase in average temperature tends to give a disproportionately large fall in the number of hours spent below 7°C, a common measure of how much winter chilling a fruit crop has had.

Fortunately, some varieties can get by with less winter chilling than others. This year, commercial growers have seen the first harvest from a new variety called Ben Lawers, which has been bred to cope with warmer winters. You can see the "chilling hour" requirements for



IRINA NAUMOVA/ALAMY

many varieties on the Agriculture and Horticulture Development Board website, for example, and it also lets you look up how many chilling hours different regions in the UK experienced last year.

A variety called Ben Hope that is popular with home growers is also tolerant of warmer winters and is ideal for gardens in the south of the UK. But those in cooler regions might be better off with a variety like Ben Lomond, which needs more chilling hours but flowers later in the year and so is less likely to suffer if there are late frosts.

Late autumn and winter is the ideal time to plant a blackcurrant bush, in the dormant season – just avoid doing so if the soil is frozen or very wet. Once in the ground,

brutally lop off all the stems down to a few centimetres. In 18 months, the summer after next, you will have your first harvest.

Blackcurrants aren't usually sweet enough to eat straight from the bush, but you can boil them up with sugar to make a delicious coulis for ice cream or Greek yoghurt. If I have a good crop, I also make blackcurrant sorbet by straining out the skins and pips, putting it in a tub in the freezer and mixing up the slush three or four times to stop large ice crystals from forming – no ice-cream maker needed. ■

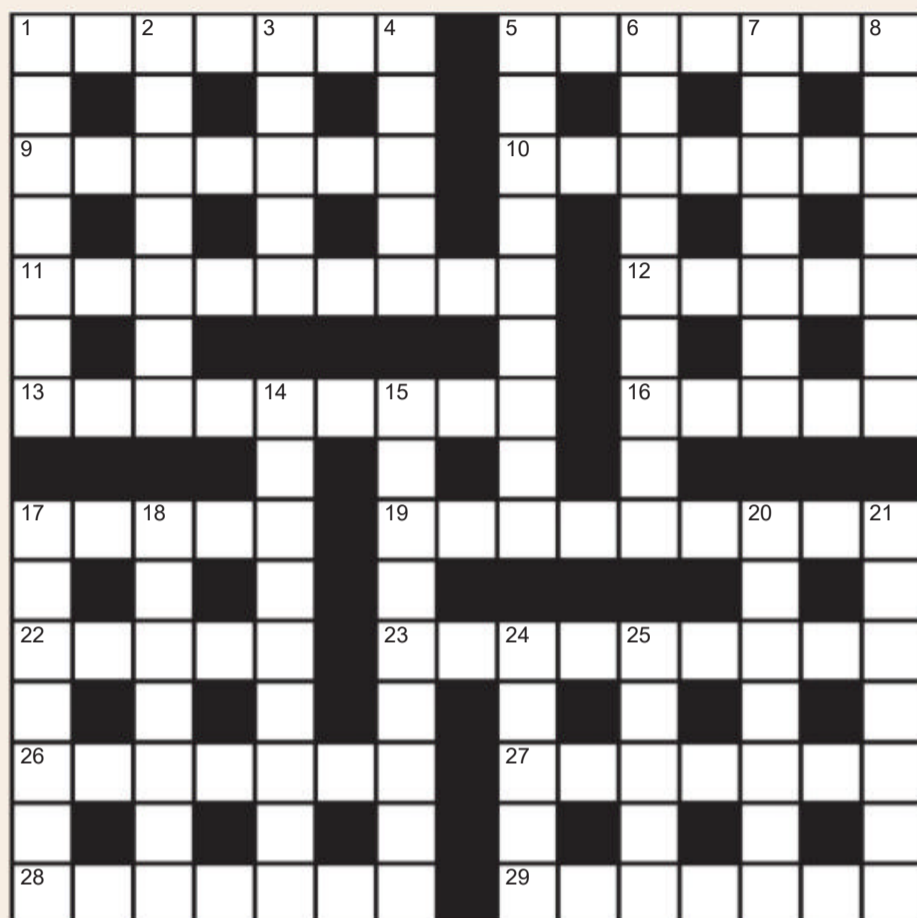
Science of gardening appears every four weeks

Next week

Citizen science

These articles are posted each week at [newscientist.com/maker](https://www.newscientist.com/maker)

Quick crossword #71 Set by Richard Smyth



Scribble zone

Answers and the next cryptic crossword next week

Quick quiz #78

1 The point where the Van Allen radiation belts – rings of charged particles surrounding Earth – come closest to the planet's surface is known as what?

2 When was Andrew Wiles's corrected proof of Fermat's last theorem published?

3 The chalcogens – the elements in group 16 of the periodic table – consist of oxygen, sulphur, selenium, tellurium and what other substance?

4 Name the first virus to be discovered.

5 Where would you find the islets of Langerhans?

Answers on page 55

Puzzle

set by Chris Maslanka

#86 Yam tomorrow

Three shipwrecked sailors discover a crate of yams on the beach. The crate is labelled "100 Yams", but they notice it has been prised open and some of the yams have been pinched, possibly by the monkey they spot nearby. In the night, one of the sailors, Abel, wakes and decides he will take one-third of the yams, but he can only do so in whole yams if he first gives one to the monkey. Later, Babel has the same idea, but again to take one-third in whole yams, he has to first give the monkey a yam; and later still, the same thing happens with Cabel. In the morning, the three sailors, who have all hidden their secret stashes, share out what yams remain equally among them, and this time around the poor monkey receives nothing. How many yams did they each end up with in total?

Answer next week

ACROSS

- 1** Means of providing acquired immunity (7)
- 5** Simple nutriment; pap (7)
- 9** Defrosting (7)
- 10** Part of the skull (7)
- 11** Measure of a rocket's efficiency (4-5)
- 12** Savoury flavour, named in 1908 (5)
- 13** The study of death or deaths (9)
- 16** MacGillycuddy's ____, mountain range in County Kerry, Ireland (5)
- 17** Vestige; faint impression (5)
- 19** Scouring material (5,4)
- 22** Fluid secreted by lachrymal glands (5)
- 23** Mirror, perhaps (9)
- 26** Profession of Agnes Hunt and Linda Richards (7)
- 27** Molasses-like syrup (7)
- 28** Sir James ____, chloroform pioneer (7)
- 29** Bright red (7)

DOWN

- 1** A, B, C, D, E or K, perhaps (7)
- 2** Archetypal (7)
- 3** More frozen (5)
- 4** 2^3 (5)
- 5** Preliminary model, for testing or display (9)
- 6** Bq (9)
- 7** Pierre-Simon ____, "the French Newton" (7)
- 8** Systems or standards of measurement (7)
- 14** EU-US air transport agreement (4,5)
- 15** Female sex hormone (9)
- 17** Lockjaw (7)
- 18** Nag a ram? (7)
- 20** Relating to the eye (7)
- 21** Least small (7)
- 24** Unborn child (US spelling) (5)
- 25** Clyster (5)



Our crosswords are now solvable online
newscientist.com/crosswords

Groan up

Why do some older people groan or say “ohoo” when we sit down, stand up or do pretty much any one-shot physical activity? Is it a cultural convention or is there a physiological reason?

Bryan Simmons

Bratton, Wiltshire, UK

We say “ohoo” when we stand up because bits of our anatomy hurt. It is as simple as that!

Peter Bursztyn

Barrie, Ontario, Canada

I admit it. I am an “older person” and I occasionally vocalise when I move. There is nothing cultural about it. Moving hurts, and this is largely at the start of activity.

Clive McGavin

Horrabridge, Devon, UK

The groan or grunt after a brief physical effort is either the sudden release of pent-up air through the

“In professional tennis, vocalisations can be loud grunts or even shrieks. This habit has caused considerable controversy”

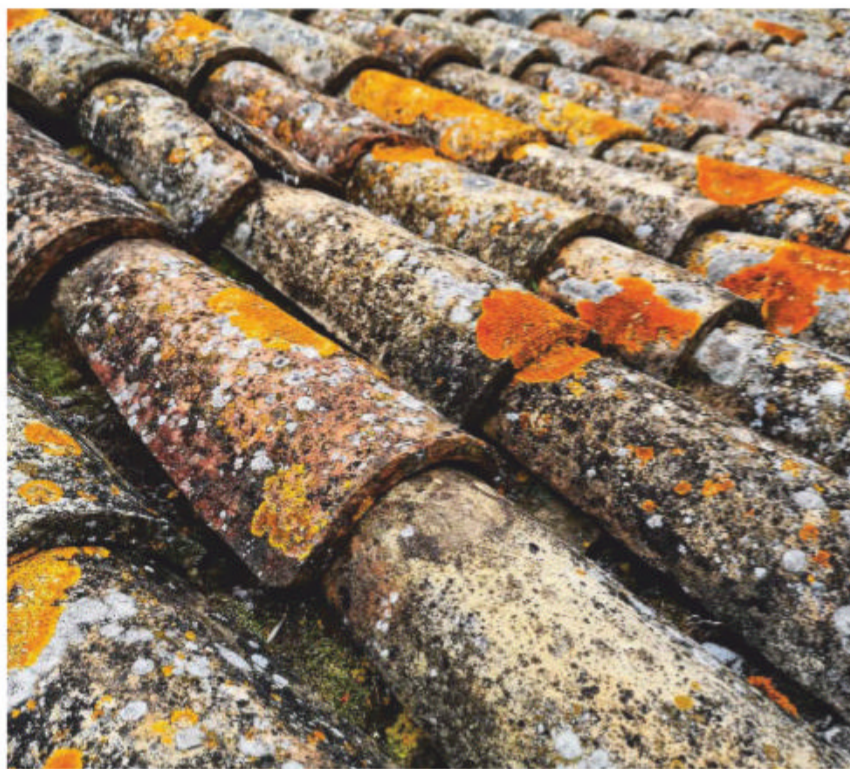
glottis – the space between the vocal cords – or an attention-seeking device to show that we can still stand up without help.

Chris Daniel

Bratton, Wiltshire, UK

The noise that people make when doing anything more than moderate physical movement is the result of breathing out through a constricted airway following instinctive breath-holding prior to the action.

When preparing for physical exertion, it is natural to perform what is known as the Valsalva manoeuvre, which involves taking a deep breath and holding it against a closed glottis. This creates increased pressure in the chest, while the diaphragm pushes down on the abdomen, increasing



ROBERTO PANGIARELLA/EYEEM/GETTY IMAGES

This week's new questions

Sun-baked lichen The tiles on my roof are covered in lichen. In summer, the roof is baking hot and dry as a crisp. How does the lichen survive? *Ross Bowden, Melville, Western Australia*

Bubble trouble In carbonated water, larger bubbles oscillate as they float upwards. What causes this, and why is it only big bubbles? *Jonathan Wallace, Fenham, Newcastle upon Tyne, UK*

pressure there too, so bracing the entire trunk and stabilising the spine. Older or less fit people may have weaker core muscles and this technique gives their trunk additional stability as they perform the task.

While carrying out a movement such as sitting, the breath is exhaled steadily, resulting in a groan or sigh as the air escapes through the vocal cords. For short, explosive actions, notably in professional tennis, vocalisations can be loud grunts or even shrieks as the breath is released rapidly. This habit has caused considerable controversy among players. In 2015, a study found that grunting increases the force of serves and forehand strokes, and other studies have shown increased muscle force while vocalising.

Groaning while exercising can become a habit. A way of avoiding it as you sink into a chair is to exhale slowly through your nose, avoiding activation of the vocal cords.

Roger Taylor

Meols, Wirral, UK

Grunting when standing up isn't confined to older people. At a martial arts-based exercise class I run, beginners of all ages invariably lurch gracelessly to their feet from kneeling with a variety of arm signals and plaintive cries.

I'm not sure why this happens, although perhaps it is endemic leg weakness as outlined in your recent salutary article on how to sit (*New Scientist*, 18 July, p 28). Certainly it is only a habit and I

How does lichen survive being baked to a crisp on a hot, sunny roof?

always take pains to help people deal with it so that they can stand unaided. All it takes is a little patience and persistence to strengthen the lower body and facilitate flexibility and balance, and age is no barrier.

Geoffrey Cox

Rotorua, New Zealand

I am in my 60s and have a number of friends in this age group. None of us groan or say “ohoo” when engaging in one-shot physical action. Since we are all New Zealanders, whereas the questioner hails from the UK, this gives strong, if circumstantial, evidence that groaning is a cultural phenomenon.

Eric Bignell

Fiskerton, Nottinghamshire, UK

I presume that the questioner hasn't reached the point at which he starts making these noises.

As we get older, muscle mass decreases and objects that used to be fairly easy to pick up seem heavier. Our bodies, too, feel heavier, whether they are or not. It was once easy to change position or squat down, but this now requires more effort. Exertion often involves holding your breath. When the exertion is completed, breath is exhaled. It doesn't need to be too audible, but it is also an expression of relief at having completed the exercise.

Stephen Alexander

London, UK

I groan on movement because I am 76 and have generalised osteoarthritis, and am on the blood-thinning medication warfarin. This precludes many analgesics and the only treatment is joint replacement or paracetamol – one rather drastic and the other not effective for me.

We have made astonishing strides in science and technology, but arthritis is still widespread and groan-inducing.



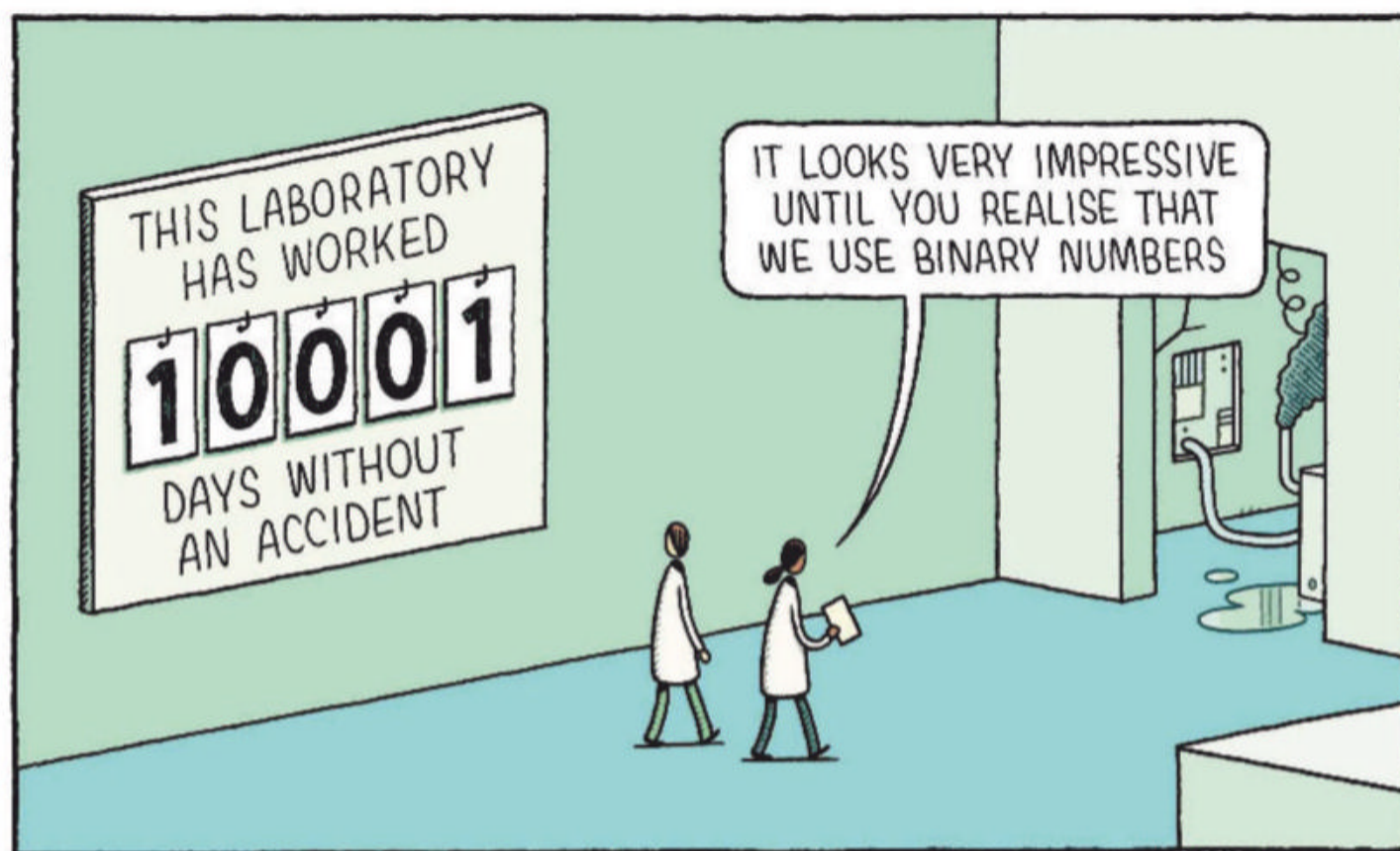
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Tom Gauld
for *New Scientist*



Going potty

If plants and trees can communicate via their root system, do they get lonely in pots?

Sebastian Leuzinger
Auckland University of Technology, New Zealand

Plants don't have "feelings" as we know them, because they don't have a nervous system. Yet it would be presumptuous to assume that we have a full understanding of all aspects of plant life, particularly how plants communicate.

Plants will definitely experience something like being "lonely" in pots because they miss out on underground connections. The majority of plants form symbioses with fungi underground, via their roots. Physical connections between the roots of different plants are rarer, although probably more common than once thought. Carbon, nutrients and water can be exchanged through those connections, but a pot plant can easily be given these resources in

"Tree stumps without leaves can be kept alive by neighbouring trees that provide water and nutrients via their interconnected roots"

its container. However, if plant hormones or chemical signals are also being exchanged through this root network, the story looks different. Research on this is still in its infancy.

It is difficult to characterise exactly what an "isolated" plant is missing out on. However, we know that some tree stumps without any green leaves are kept alive by neighbouring trees from the same species that provide water and nutrients via their interconnected roots. This is something that is definitely out of reach for a solitary plant in a pot.

So, while plants are easily pleased when they have access to sunlight, carbon dioxide, water and nutrients, we are far from understanding some of their secrets.

Awful eaters

Foxes have the most repulsive smell, alive or dead. We often see dead foxes on our farm and they just decompose in situ. So, does anything eat foxes? (continued)

Len Winokur
Leeds, UK

Various carrion feeders, including the golden eagle and buzzard, have been observed eating fox carcasses. But let us not forget about foxes themselves.

Foxes are opportunistic omnivores, whose diet includes rodents, berries and carrion. A study of the scat and stomach contents of road-killed specimens (to assess whether cannibalism could explain the transmission of a parasite) indicated that their diet includes cadavers of their own kind.

Foxes may smell hideous to us, but smell and taste are subjective. After all, some human cultures eat fermented raw meats and fish. Quite how they stomach it leaves the rest of us foxed. ■

Answers

Quick quiz #78

Answers

- 1 The South Atlantic Anomaly
- 2 1995
- 3 Polonium
- 4 Tobacco mosaic virus
- 5 In the pancreas

Cryptic crossword

#44 Answers

ACROSS 1 Acai, 3 Bitterns, 8 Evolved, 10 Abode, 11 Deadline, 14 Tribal, 15 Mutate, 17 Conscience, 20/23 Amino acid, 21 Ignites, 22 Honeybee

DOWN 1 Anecdote, 2 Aromatic, 4 Iodine, 5 Transfusion, 6 Roof, 7 Seed, 9 Volcanology, 12 Magnetic, 13 Deceased, 16 Aspire, 18 Hash, 19 Kiln

#85 Chopping board Solution

Let's start from the end. If the board gets down to the two most senior members, they will certainly survive, as member 2 (numbered from most senior to newest member) will vote to retain themselves. Thus, member 3 won't be happy if the board comes down to just members 1, 2 and 3 because members 1 and 2 would eject 3. It follows that with just members 1, 2, 3 and 4 left, the board would be stable: member 3 would vote nay to prevent the board being reduced to three members, and member 4 would vote nay to save themselves immediately. Similarly, members 1 through 8 would constitute a stable board. Since members 1 to 8 are a majority and are safe from further reduction, they will eject 9 and 10, leaving eight as the ultimate size of the board.

Paper chase

Feedback's mind was recently blown by an unlikely source – the annual report from the UK's National Cyber Security Centre. The interesting bit wasn't the headlines that it now has to combat malicious emails disguised as coronavirus updates. No, the most surprising news was that until this year, the cryptographic keys sent to military bases were in the form of spools of punched paper.

That's right – the same method that was first developed as an input tool for programmable looms in the 18th century, taking the term "legacy IT" to a new level. Apparently, the punched paper keys were hard to replace because they had such a crucial function in a wide range of infrastructure.

But watch out, cybercriminals! After years of effort, keys are now sent out in Top Secret, electronic form – and that doesn't mean a floppy disc with the password stuck on the side. Military cryptographers will presumably be glad to see the back of the old punched-paper versions, with one industry source describing them to *Computer Business Review* as "all a bit 1960s really".

Fax axe

Speaking of anachronistic tech, 2020 was supposed to be the year that UK hospitals stopped using fax machines. For younger readers, sending a fax was like sending an email if you first had to print it out on a sheet of paper, then slowly feed it into a moaning typewriter. It was all the rage in the 1980s, but so were shoulder pads.

Two years ago, the world's biggest purchaser of fax machines were the UK's various National Health Service bodies. The country's politicians often claim the publicly funded healthcare system is world-beating, but this probably isn't what they meant.

When UK health secretary Matt Hancock – who is such a big fan of modern tech that he has his own app – learned of the state of affairs, he banned English hospitals from

Twisteddoodles for New Scientist



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buying any more fax machines. NHS trusts would also be monitored quarterly until they were "fax free".

Yet it is hard to break a habit. A report last year said many hospitals weren't phasing out fax machines fast enough to meet the target of April this year, and two had even enlarged their fax machine collection. With hospital managers now presumably busy with other matters, there doesn't seem to be much hope things will improve.

Feedback would love to hear readers' experiences of having to reply on anachronistic tech. The most ridiculous will get a prize – delivered by carrier pigeon.

On me'ed

New technology sometimes creates new problems, though. When lockdown stopped fans attending

football matches, Inverness Caledonian Thistle Football Club in Scotland proudly announced that it would livestream the team's games using an automatic camera with AI-driven ball-tracking technology.

Unfortunately, the high-tech system was foiled in a recent match in which one of the assistant referees was, er, follicularly challenged. The man's bald head was confused for the football and the camera repeatedly cut away from the action to zoom in on his pate, causing a crucial goal to be missed.

Pixellot, the firm that makes the camera system, says it happened because the camera angle made it seem like the man's head was inside the pitch. The Verge helpfully explained that problems like this can arise because AI is "brittle", which means it sometimes malfunctions in unexpected ways.

Praying for help

Not too unexpected, we hope, or – depending on our religious inclinations – pray. Folks on Twitter were bemused to see that no less a personage than Pope Francis has taken an interest in machine learning. Each month, @pontifex asks the world to join in prayers for a specific goal. This year, for instance, subjects have included help for migrants and world peace.

Unusually, the hot topic for November was AI. "We pray that the progress of robotics and artificial intelligence may always serve humankind," he said. Feedback can sympathise. When the antiquated computer system in the stationery cupboard starts malfunctioning, we often feel like praying too. But the Pope's choice of words left some wondering: what does he know about AI progress that the rest of us don't?

Timing is everything

The announcement this month of promising early results for Pfizer and BioNTech's coronavirus vaccine led to widespread rejoicing in most quarters – but not all.

Some in US president Donald Trump's campaign were suspicious of the timing, with the findings being released a few days after the election on 3 November. During his campaign, Trump said a vaccine may arrive before voting day, so an earlier announcement could have boosted him. "Nothing nefarious about the timing of this at all," tweeted his son Donald Trump Jr, once again demonstrating the pressing need for a universally accepted sarcasm emoji.

Compared with some of the other baseless conspiracy theories about the coronavirus, it is hardly the wackiest. But if Trump Jr is right, it would be the first time, to Feedback's knowledge, that a pharmaceutical firm has been accused of suppressing research findings about its products that are positive. Big Pharma is usually accused of bending the truth in the other direction. ■



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