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WEEKLY February 13–19, 2021

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The handshake: A gripping history

You don't get many handshakes during a lockdown. Some have even suggested they are a thing of the past. Palaeoanthropologist Ella Al-Shamahi thinks otherwise. In this talk, she reveals the true history of the handshake and argues it has a biological purpose that means it is going nowhere. Join us from 6pm GMT on 25 March or watch on demand later. Tickets on sale now.

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Get a grip Ella Al-Shamahi reveals the truth about handshakes

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Your best shot

We can all control parts of this pandemic, even if it doesn't always feel like it

FOR many people, one of the most unsettling things about living through the coronavirus pandemic is the feeling of lacking control – whether it is over our daily lives, the broader situation or both.

Vaccines promised a return to some kind of normality and, with it, a greater sense of control.

But this week has brought sobering news: South Africa has decided to pause its roll-out of the Oxford/AstraZeneca vaccine because of findings that it doesn't offer enough protection against the B.1.351 coronavirus variant first detected in that country (see page 7).

That promised sense of more control may now seem to be slipping through our fingers.

In this week's issue, however, we throw a spotlight on some of the ways in which we can influence our own course through the pandemic – beyond trying to avoid the virus itself as best we can. We also look at some of the many ways in which scientists and doctors have already made big strides towards controlling the impacts of the spread of covid-19.

"We may be able to affect how our bodies respond to a vaccine by simple, everyday actions"

On page 8, we examine how, as individuals, we may be able to affect how our bodies respond to a vaccine by taking measures as simple as getting a good night's sleep or taking more exercise.

Once you have had a vaccine, is there any way you can know whether it is working? Well, there are tests that can tell you, as we explain on page 12.

Meanwhile, on the science front, a great deal of progress is being made.

Innovative new vaccines are in the works (see page 14). These could not only work against new variants, but may also help solve other problems, such as the global inequalities in accessing vaccines.

Then there are the insights that have transformed how medics treat people who have been hospitalised with covid-19, enabling health services to save many more lives (see page 41) than at the start of the pandemic. The interventions that have brought this change may look obvious now, but they certainly weren't early on.

It may not always feel like it, but people's actions are making a real difference in the fight against the coronavirus. We just need to keep on working at it. ▮

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CONTACT US

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General & media enquiries
US PO Box 80247, Portland, OR 97280
UK **Tel** +44 (0)20 7611 1200
25 Bedford Street, London WC2E 9ES
Australia 418A Elizabeth St, Surry Hills, NSW 2010

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People in South Africa wait to receive the Oxford/AstraZeneca vaccine

South Africa vaccination

Vaccine put on hold

South Africa halts Oxford/AstraZeneca vaccine roll-out after evidence it might not be effective against local variant. **Michael Le Page** reports

ON 1 FEBRUARY, there was joy in South Africa when 1 million doses of the Oxford/AstraZeneca coronavirus vaccine arrived. But on 7 February, the health minister announced that the vaccine's roll-out would be put on hold after a small study suggested that it doesn't prevent mild or moderate illnesses caused by the B.1.351 variant responsible for almost all covid-19 cases in the country.

The finding is worrying, not least because the B.1.351 variant is now spreading in several other countries. The number of cases detected outside South Africa remains very low in most places but Austria has found nearly 300, leading the neighbouring German state of Bavaria to threaten to close the border. The UK has stepped up testing to try to halt its spread.

It also seems past infection by other coronavirus variants doesn't protect against mild or moderate infections by B.1.351, said Shabir Madhi at South Africa's University of the Witwatersrand during a video conference revealing the findings. In a study of people given a placebo in a trial of a vaccine made by Novavax, the infection rate was just as high in people who tested positive for antibodies as in those who had none.

That said, it is likely that the Oxford/AstraZeneca vaccine does still protect against severe disease caused by the B.1.351 variant, said Madhi.

South Africa might now roll out vaccines to 100,000 people and then check the hospitalisation rate, said Salim Abdool Karim, who heads the country's covid-19 advisory committee.

Madhi pointed out that some other vaccines have already been shown to be effective against B.1.351. "It's not all doom and gloom," he said.

The Oxford/AstraZeneca vaccine is effective against most other variants, including the fast-spreading B.1.1.7 variant first detected in the UK. Results from ongoing trials in the UK suggest that the vaccine is 74 per cent effective at preventing symptomatic infections due to B.1.1.7, and 85 per cent effective for other variants.

A separate analysis of ongoing trials in the UK, Brazil and South Africa concluded that a single dose of the Oxford/AstraZeneca vaccine is 76 per cent effective at preventing symptomatic infections between 22 and 90 days after vaccination. A second dose 12 weeks or more after the first boosts this to 84 per cent.

Unfortunately, results from one small ongoing trial of the Oxford/AstraZeneca vaccine in South Africa aren't so good. The trial began in June last year, and results from the first months suggest that the vaccine was about 75 per cent effective at preventing mild or moderate cases. There were no severe cases. But once B.1.351 became the dominant strain, there was no significant difference between outcomes in the vaccine and placebo groups. It seems the vaccine isn't effective against B.1.351, but because the numbers are so low – just 1750 volunteers and 42 symptomatic cases – there are huge uncertainties.

> **"Some other vaccines are effective against the South African variant. It's not all doom and gloom"**

The good news is that trials of vaccines made by Novavax and Johnson & Johnson show that even though they are less effective against B.1.351 than against other variants, they are both still around 60 per cent effective at preventing mild or moderate infections.

Crucially, the Johnson & Johnson one-dose vaccine is 85 per cent effective at preventing severe or critical covid-19 in all countries where it is being trialled, with no decline due to B.1.351, said Glenda Gray, also at the University of the Witwatersrand.

The greater efficacy against severe disease may be because while B.1.351 evades antibodies that prevent infection in the first place, it cannot dodge the immune system's T-cells, which help mop up infections.

Immunology

How to give your vaccine a boost

Lifestyle choices around the time of a vaccination can affect your immune response to it. **Helen Thomson** explores how to give it the best shot at success

SIMPLE behaviour changes could improve how your body responds to a covid-19 vaccination and the speed at which you are protected from the coronavirus, evidence from studies on other vaccines suggests. These factors could be so important that some scientists believe that ignoring them could reduce the overall success of the covid-19 vaccine roll-out.

More than 130 million doses of vaccine against covid-19 have been administered at the time this magazine went to press. But not everyone who gets a shot will respond in the same way. Although the majority will build their immunity over the following weeks, a small percentage of

"We know so much about how stress affects vaccine response, I'd be surprised if it didn't apply to covid-19"

people won't become immune at all (see page 12). But even among those who do respond, factors such as age, sex, stress levels and the time of day that you receive a vaccine may affect how strong that immunity is, how quickly you build it, how long it lasts and what side effects you might encounter.

"While you can't change your age, there are psychological, social and behavioural strategies that can substantially impact the immune system's response to any vaccine," says Janice Kiecolt-Glaser, director of the Institute for Behavioral Medicine Research at Ohio State University.

Kiecolt-Glaser's experiments around 30 years ago were some of the first to show the impact we can have on our body's response to vaccination. During a stressful exam period, she and her colleagues vaccinated medical students against the viral disease hepatitis B. Those students who were most stressed took the longest to build up a protective antibody response. Likewise, a study of individuals looking after people with dementia showed that the caregivers had a smaller antibody response to flu shots than non-caregivers, and their immunity declined significantly faster six months later.

Our immune system consists of much more than just antibodies, but they are the best proxy for vaccine effectiveness in studies, says Anna Whittaker, who looks at the effects of lifestyle factors on immune health at the University of Stirling, UK.

Further findings support these initial hints that stress affects our immune response to vaccines: in older people, a positive mood on the day of vaccination is associated with a higher antibody response to a flu shot.

"There is now such a rich literature of how stress can alter your response to vaccines, that I'd be surprised if there were no such effect with covid vaccination," says Kiecolt-Glaser.

Try not to stress

Although stress impacts the immune system in a myriad of ways, one mechanism probably involves adrenaline and cortisol, hormones that increase during stressful periods. Both hormones have a number of functions in our so-called fight-or-flight response. These include raising heart rate and suppressing digestion and the immune system – it is no use diverting precious resources to digesting food or getting rid of a cold virus when you are in a life-threatening situation.

Once the threat has passed, other mechanisms kick in to restore balance. But if you find yourself in a state of perpetual

REUTERS/FABIAN BIMMER

People exercise during the pandemic in Hamburg, Germany

stress, the body is overexposed to these hormones, and immune cells are unable to respond normally. Such chronic stress creates a state in which we are more at risk of infection and experience low-level inflammation that can destroy healthy tissue. Stress can also indirectly impact the immune system via harmful coping methods, such as smoking or drinking more, sleeping less or eating more unhealthy foods.

But is it sufficient, let alone possible, to change our mood on the day of vaccination to improve our response or is a more long-term change in mindset necessary? In Kiecolt-Glaser's study, the students' stress levels and social support as a group had been fairly similar across the academic year, suggesting that their divergent vaccine response was related to the exam period, and stress levels specifically around the time of vaccination.

It may be unrealistic to ask people not to be stressed during a pandemic, but another study may offer more practical advice. It showed that stress levels in the 10 days after vaccination may be more influential for antibody response than stress in the prior two days, and that stress-related sleep loss may be a key culprit.

Evidence for the benefits of sleeping well around a vaccination comes from several directions. For instance, healthy adults who sleep less than 6 hours on average

per night before a hepatitis B vaccination are less likely to mount an antibody response strong enough to fully protect them from being infected, compared with people who typically sleep more than 7 hours.

Likewise, a study that has yet to be published in which people had their sleep restricted for several consecutive nights prior to vaccination against hepatitis A had a lower antibody response compared with people who were allowed to sleep normally.

Slow-wave sleep, otherwise known as deep sleep, is probably involved. During this type of sleep, the brain stores long-term memories and clears out chemical junk that has accumulated during the day. It also creates a chemical and hormonal environment that helps the immune system build a memory for the pathogens it has encountered through the day. There is some evidence that exercise can increase the amount of deep sleep you get the following night, as long as you don't do it just before bedtime.

To try and understand the most influential time to sleep well, Aric Prather at the University of California, San Francisco, looked at sleep over two weeks, pinpointing sleep duration on the two nights before flu vaccination as the best predictor of the immune response several months later. So while it may not be possible to de-stress, try to get some decent sleep around your vaccine. "It makes a whole lot of sense to me," says Kiecolt-Glaser. "I had my vaccine yesterday and I really made sure I slept well the last few nights."

Get friendly

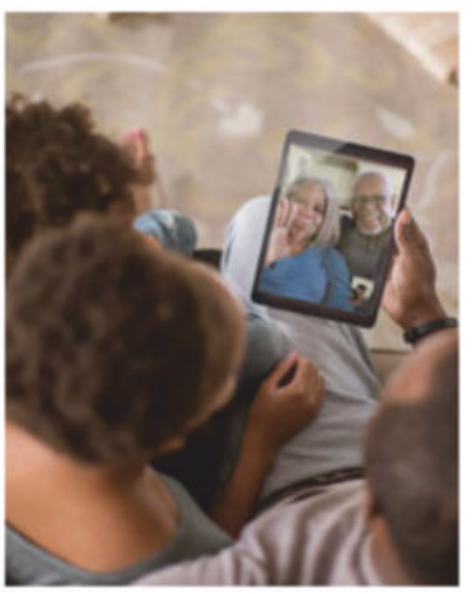
Alongside stress and sleep, you may want to try to mitigate the effects of isolation. Even in young, healthy people, feelings of loneliness have been associated with a lower antibody response to flu vaccination. And having better social support or being married is linked to higher antibody responses to hepatitis B and flu vaccination, while bereavement is associated with lower such responses to the flu vaccine. The mechanism behind this is probably related to the increased levels of stress that can result from a lack of social support.

While it might not be practical for someone to make a bunch of new friends in the middle of a pandemic, you can reconnect and deepen the relationships you already have, says Sarah Pressman at the University of California, Irvine. She and her colleagues showed that social support in the form of hugging is associated with a decreased risk of catching a cold. If you live with others, she suggests that a few extra hugs might not go amiss.

15 mins
of upper body workout can boost the immune response to a flu shot

"Sleep duration on the two nights before flu vaccination is the best predictor of the immune response several months later"

Having strong social support can increase antibodies after a vaccine



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Pressman also recommends organising extra video catch-ups and talking to your family instead of simply "doomscrolling" online news. "Increasing your feelings of being supported will not only reduce your stress, but can also improve how you sleep at night, both factors we know matter for how vaccinations work for you," she says.

Something else you can control is your alcohol intake. In December, Anna Popova, the head of the Russian Federal Service for Surveillance on Consumer Rights Protection and Human Wellbeing, advised Russians to quit alcohol two weeks before their first coronavirus vaccine and to abstain until three weeks after their booster shot. Alexander Gintsburg, head of the Gamaleya National Center of Epidemiology and Microbiology in Moscow, which developed the Sputnik V vaccine, said that drinking alcohol after getting a coronavirus jab can impair the immune response and could even render the vaccine ineffective. Contrary to Popova, though, he recommended refraining from alcohol for three days after each injection.

Currently, there is no advice from the UK or US governments about drinking alcohol around your covid-19 vaccination.

A spokesperson for the World Health Organization said: "We have no specific guidance on this… but current evidence indicates that alcohol use has a clear impact on immune responses in high doses of consumption." Advice is at the discretion of national authorities, the spokesperson added. ›

The effect of heavy alcohol use – six units in one sitting for women and eight for men – on the immune system's response to other kinds of vaccination is well documented. Heavy drinking before and after a vaccine disrupts immune cell function, which can decrease the body's ability to defend itself from a virus.

What about a tipple here and there? A study in macaques shows that moderate alcohol consumption – the equivalent in people of up to two units a day – actually appears to create a more robust response to vaccination using a member of the virus family that causes smallpox in humans. Macaques that drank moderately produced slightly more antibodies and other immune cells in response to the vaccine, compared with macaques that drank no alcohol.

Christopher Thompson, a biologist at Loyola University Maryland, says it is difficult to pinpoint exactly how drinking might impact your immune response to the covid-19 vaccine. This is complicated by the fact that the Pfizer/BioNTech and Moderna vaccines are mRNA-based, a technology that hasn't been used for large-scale vaccination before.

"Women who exercised 45 minutes before a flu shot had a higher antibody response later"

Based on available data, he suggests that moderate alcohol consumption is unlikely to have much of an effect, so if you are an occasional drinker, you probably don't have to change your lifestyle.

However, binge drinking will almost certainly decrease the vaccine's efficacy and should be avoided for four weeks after each injection, says Thompson.

ANDREW MILLIGAN/POOL/AFP VIA GETTY IMAGES

People in Edinburgh, UK, receive their coronavirus vaccines

As it takes about two weeks for an immune response to develop after vaccination, four weeks "gives a bit of a buffer zone", he says.

On top of all that, make sure you are getting enough exercise. Not only will this improve your health more generally, helping to minimise stress and reduce risk factors like obesity and diabetes that can worsen covid-19 symptoms, but exercise is also intimately involved with your body's ability to form an adequate response to a vaccine.

Several studies support this. For instance, people who already have an active lifestyle over the age of 62 have higher antibody responses to flu vaccination than those who are sedentary. People who received a tetanus vaccination after completing a marathon had a higher antibody response than non-runners. And women who used an exercise machine in the 45 minutes before flu vaccination had a higher antibody response a month later than those who did no exercise.

Exercise triggers a transient increase in signalling proteins called cytokines that interact with all the immune cells. Weight training and other forms of resistance exercise also cause tiny tears in muscle, which are thought to activate the immune system in anticipation of these tears letting in possible pathogens.

These effects are generally less pronounced in younger adults, perhaps because their immune systems are already more effective. But in one study, young, healthy adults who performed a 15-minute upper body workout before receiving a flu vaccine saw a stronger immune response than a control group who rested before their shot.

One final benefit is that exercise is a known analgesic. Kate Edwards at the University of Sydney in Australia says recent evidence shows that pain at the site of vaccination and subsequent side effects like swelling, reduced appetite and feeling unwell are all decreased by regular workouts. Kiecolt-Glaser adds that exercise might also help counter general fatigue, which is one of the main side effects associated with covid-19 vaccines.

Clock-watchers

Meanwhile, you may have read that the time of day you receive your vaccine could influence your response. This comes from a study that examined the immune response to flu or hepatitis A vaccine given in the morning or the afternoon. Men vaccinated in the morning exhibited a stronger antibody response to both vaccines than men who got their vaccine in the afternoon. No

difference was seen in women.

The underlying mechanism behind this effect is unclear, but the researchers are investigating the hypothesis that it may be related to rhythmic fluctuations of hormones that affect the immune system and may differ in men and women.

Whittaker, who led the study, says that it was indicative rather than definitive, and that timing hasn't yet been studied with any of the covid-19 vaccines.

"Having a vaccine in the afternoon or night is unlikely to reduce the efficiency of your immune system to be as poor as having no vaccine at all," she says. "Given the urgency and scale of the pandemic, the most important thing is to get vaccinated as soon as possible. Perhaps when we have more answers in the future and the situation is less urgent, then adjusting timing of vaccination is something that could be done."

There are few definitive answers as to what behaviours might affect the success of the covid-19 vaccination drives, and this is understandable, says Thompson. "There was not enough time to assess all of the social, family and medical histories of each patient [in the covid-19 vaccine trials] and correlate that with immunological outcomes. The vaccine companies were tasked to make a safe, effective vaccine as quickly as possible. So this is where their resources were focused."

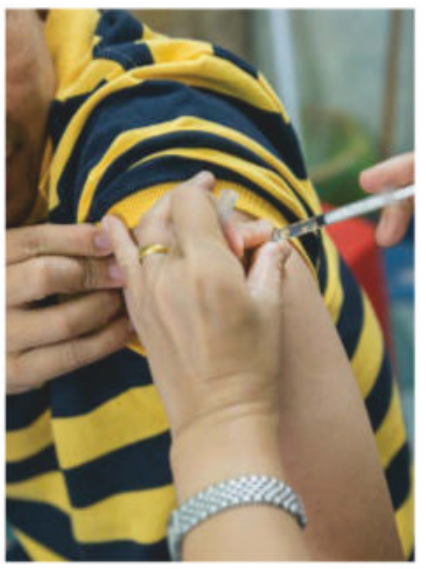
However, others say it is vital to now look at our prior knowledge of how our behaviour has affected other kinds of vaccination. "Past evidence would suggest that not addressing these factors could reduce the overall success of the vaccine roll-out," says Kiecolt-Glaser. ▮

Out of your hands

Some factors that affect our immune response to vaccines are beyond our control

Sex

The evidence is largely consistent on this: overall, women tend to have higher antibody responses to most



SHUTTERSTOCK/DOCTERK

vaccines than men, creating a stronger immune response to dengue, hepatitis A, rabies and smallpox vaccination, among others. Given the early stage of covid-19 vaccine roll-out, it isn't yet clear whether we will see a similar sex difference in response to these shots.

Age

Probably the most well-researched factor here is age. Newborn babies produce low levels of antibodies in response to vaccines, and the antibodies they passively acquired from their mother during pregnancy can interfere with vaccine response, although it isn't well understood why this might be.

The optimal age to start vaccination differs depending on the pathogen you are protecting against. For instance, giving the oral polio vaccine during the first week of life creates an adequate immune response in only 30 to 70 per cent of infants, but giving it after 4 weeks of age leads to immunity in nearly all infants.

Vaccine responses diminish in older people, whose antibodies also wane more rapidly after

4 weeks

The age after which a polio vaccine works best

receiving vaccines. One reason for this is that the thymus, where virus-destroying T-cells mature, begins to degrade in old age.

Microbiome

It is early days, but the make-up of your gut bacteria could play a role. Some small studies have shown that prebiotics and probiotics, which are known to affect our microbiome, might improve the immune response to vaccination, including for diphtheria, hepatitis A and flu.

However, the type used and how long they were taken for

YULIIA CHYZHEVSKA/ALAMY

varied considerably among the studies and it is too early to say how your gut microbes might affect covid-19 vaccination.

Prior infection

Good news for those who have already recovered from covid-19: immunity may last at least six months, with the body mounting a fast and effective response to the coronavirus upon re-exposure, according to a study last month.

Might this mean you also get a more effective response to the vaccine? It is hard to say.

People who have already encountered tetanus, for instance, tend to have a higher immune response after getting a booster vaccination than people who get the shot with no prior infection.

Likewise, people who have naturally encountered members of the flavivirus family, such as the virus that causes West Nile disease, have a higher antibody response to vaccines for other flavivirus diseases, such as dengue fever.

We might see something similar with covid-19, but we don't yet have data on this. What we do know is that the immunity someone gains from having had an infection varies from person to person, and both natural and vaccine-induced immunity can differ, so it is important to get vaccinated even if you have already recovered from the virus. ▮

The jury is still out as to whether prebiotic and probiotic foods help with the immune response

Vaccines

How to tell if your vaccine worked

Some tests for covid-19 antibodies can show if a vaccine has given you immunity

Clare Wilson

TO TACKLE the covid-19 pandemic, we need the most effective vaccines we can get. But even the best vaccines don't work in everyone. How do you know if yours has worked?

All of the vaccines in use against the coronavirus can cause side effects, including a sore arm, fever, chills, headache and nausea, usually in the first two days after a jab.

These are more common after a second dose, and in people who have already been naturally infected with the coronavirus, according to data from the Covid Symptom Study on nearly 36,000 people in the UK who had the Pfizer/BioNTech vaccine.

While side effects show your immune system is reacting to the virus, the absence of such signs doesn't mean the jab has failed to work. Even with the second dose, only half of people in the UK study had a sore arm and one in five had a broader effect like fever. "People

"Rapid finger-prick tests could help us get back to normal life, once we get out of this critical phase"

should not be worried if they don't have a reaction," says Deborah Dunn-Walters, chair of the British Society for Immunology's covid-19 task force.

No matter what, it is crucial not to behave as if you are immune to the virus after a vaccine, says Paul Morgan at Cardiff University in the UK. It takes two to three weeks for a vaccine to start taking effect. Even after three weeks, vaccines won't stop all infections, only reduce their severity and number in the population.

It still isn't clear why some people catch the coronavirus after being vaccinated (see "No vaccine response", right). But there is a way

VOISIN/PHANIE/SCIENCE PHOTO LIBRARY

A blood test being used to test for covid-19 antibodies

to know if a vaccine has had an effect on your immune system.

Some antibody tests that are used to detect natural coronavirus infections can also be used to detect antibodies made in response to vaccines three weeks after a shot.

Most tests look for antibodies that recognise the virus's outer spike protein, which the virus uses to latch on to cells in the body, so they can identify people who have had a natural infection or a vaccine. Indeed, they can't distinguish between them. But some identify antibodies recognising a molecule called the nucleocapsid protein, which isn't contained in the vaccines, so wouldn't detect the immune response in vaccine recipients.

And no test is perfect. Antibody tests have up to a 10 per cent rate of false negatives, telling someone they have no antibodies to the virus when they do, according to a review of using such tests in people two to four weeks after a proven infection. The false positive rate is lower, at around 2 per cent.

Current commercial tests give only a yes/no answer – they don't quantify antibody levels, which tend to wane after a natural covid-19 infection. Nor do they give any indication of how powerful antibodies are against the different coronavirus variants.

Long-term testing

Antibodies don't tell the whole story about immunity. We have other parts of our immune system, including memory B-cells – the cells that make antibodies, but can't be detected by an antibody test – and T-cells, which kill virus-infected cells directly.

Tests for T-cells are in development by companies such as UK-based Indoor Biotechnologies and German firm Qiagen. They could shed light on the body's long-term response and help us know how often people will need covid-19 booster shots, says Maria Oliver at Indoor Biotechnologies.

At the moment, any tests, whether for antibodies or T-cells, are being used either for research or personal interest, not as proof of vaccination. Countries such as Sweden and Denmark are developing digital vaccination passports their residents could use to prove they have had a covid-19 vaccine prior to travelling, but this would involve a vaccine certificate, not blood tests.

Rapid finger-prick tests for antibodies against the coronavirus could in future be used at places like airports. They wouldn't prove someone is immune to the virus, but would show they have had the vaccine or a past infection.

Such antibody tests could have a role "in the fullness of time, if we get out of this critical phase when there's so much virus around", says Morgan. "But at the moment it's more important to treat everyone who's immunised as susceptible, and a vector of transmission to others." ▮

No vaccine response

Even the best vaccines leave 5 per cent of vaccinated people susceptible; for some vaccines, that figure is more like 30 per cent. But it is unclear why.

Previous research on diseases such as influenza suggests many possible factors. Age, sex, nutritional status, gut microbes and the state of the immune system may all play a role. In the case of covid-19, we know very little, says John Tsang at the US Center for Human Immunology in Maryland. "It's a complicated issue." Unexpectedly, two factors that usually reduce vaccine efficacy – being older and being male – don't appear to be at work this time, he says.

But baseline immune status probably matters. People with chronic inflammation generally respond worse to vaccines. Obesity can also be a factor, as it causes chronic inflammation, says Tsang.

Notably, clinical trials in lower-income countries, where volunteers may be exposed to higher pathogen and parasite loads, have lower vaccine efficacy rates. Recent exposure to common-cold-causing coronaviruses could also influence the response. A covid-19 vaccine may simply re-activate the immune response to the cold rather than setting up a new one, reducing effectiveness. Graham Lawton

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New vaccines

Tomorrow's vaccines

The world needs new vaccines to beat nasty coronavirus variants, overcome delays and solve global inequality. **Graham Lawton** investigates what's in the pipeline

THE race to develop vaccines against covid-19 got off to a flyer, but with dangerous new virus variants, stark inequalities in access to vaccines and few vaccination options for children, the world still needs all hands on deck. Last week, a virtual meeting run by the New York Academy of Sciences called The Quest for a COVID-19 Vaccine showcased the most promising new candidates.

Codagenix: A nasal spray

So far, all approved covid-19 vaccines have been injectable. Another option is a nasal spray, says Robert Coleman, CEO of biotech company Codagenix, in Farmingdale, New York.

Codagenix's technology uses a live, but weakened, version of the coronavirus that causes covid-19 to provoke an immune response. This approach makes the company the black sheep of the vaccine community, admits Coleman. "They are the most efficacious form of vaccine, they are single dose, they provide broad and

"A vaccine in pill form is in development that could be delivered by post. The vaccine comes to you"

robust immunity, but most people consider them to have safety risks."

The reason? Conventionally, such vaccines are produced by a trial-and-error process in which the virus is grown in animal cells until it acquires enough mutations to make it harmless to humans.

Viruses in such vaccines can occasionally revert back to the dangerous type and start circulating among people, setting off new waves of disease.

However, Codagenix synthesises its coronavirus genome from scratch, and introduces genetic changes that weaken the virus. The enfeebled virus can replicate sluggishly and stimulate the immune response, but doesn't cause disease. The team believes that the genome is so heavily modified – it has 283 mutations compared with the original virus – that there is no risk of it reverting back to being dangerous. "We call it death by a thousand cuts," says Coleman.

One advantage of this approach is that the immune system encounters the entire virus, so mounts a broad response, potentially allowing it to be more effective against variants, although this is yet to be tested.

The vaccine is administered in a single dose dripped into the nose. It is currently in phase I trials (see "Trial phases explained", right). The vaccine will also be tested on children, says Coleman.

Valneva: A whole, inactivated virus

A vaccine developed by Valneva in Saint-Herblain, France, leans on past successes by containing inactivated, whole virus, which cannot replicate but still induces an immune response.

Conventionally, such viruses are inactivated using chemicals or ultraviolet radiation. The inactivated virus is then purified, concentrated and mixed with a substance called an adjuvant, which boosts the response of the immune system. It is a venerable technology and commonly used in many flu vaccines.

They are exceptionally safe, says Thomas Lingelbach, Valneva's CEO, so the vaccine could be given to vulnerable populations such as those at risk of an allergic reaction from other types of vaccine.

The two-shot vaccine is in phase I/II trials, with plans for testing in children.

Inovio: DNA, not RNA

Two of the first crop of covid-19 vaccines – made by Pfizer/BioNTech and Moderna – use messenger RNA (mRNA), which is injected into muscle cells. The cells then translate the RNA's genetic code and make viral proteins that stimulate an immune response.

Both vaccines provide around 95 per cent protection against severe covid-19. But the technique has downsides, not least that the mRNA has to be kept blisteringly cold during distribution and has a short shelf life once unboxed.

That is where DNA can outperform mRNA, says J. Joseph Kim, CEO at Inovio Pharmaceuticals, in Plymouth Meeting, Pennsylvania.

Inovio has synthesised a DNA version of the coronavirus's spike protein gene – which is made of RNA in the actual virus – and inserted it into circles of DNA called plasmids. These are blasted into the skin using a reusable "gun". The DNA is taken up by skin cells and transcribed into mRNA, which is then translated into "massive quantities" of spike protein, says Kim, eliciting a strong immune response.

DNA vaccines don't require frozen storage, and have a one-year shelf life at room temperature and up to five years in a refrigerator. Inovio's vaccine only contains DNA and water, so is also less likely than some other vaccines to provoke an allergic reaction. Inovio's two-dose vaccine is in phase II trials.

CureVac: Natural RNA

Another twist on mRNA vaccines is being developed by CureVac in Tübingen, Germany. Both of the existing RNA vaccines for covid-19 use mRNA that has been chemically modified so that it can evade the defences of the innate immune system, which degrades foreign mRNA on the (usually correct) assumption that it is from a virus. Modification is carried out by adding synthetic nucleotides, the building blocks of RNA, that aren't found in nature.

However, these modifications dampen innate immunity. This is

CLOCKWISE FROM TOP LEFT: VAXART; REUTERS/CHINA DAILY; REUTERS/KAI PFAFFENBACH; CODAGENIX/SERUM INSTITUTE OF INDIA PVT LTD

From top left, clockwise: Vaxart's pills, CanSino Biologic's child-friendly jab, CureVac's RNA vaccine, Codagenix's nasal spray

the first phase of the immune response and is vital to drive adaptive immunity: antibodies that learn to recognise the virus and the white blood cells called T-cells that destroy it.

CureVac uses mRNA built from naturally occurring nucleotides, stabilised in a different way. This induces a strong innate immune response as well as an adaptive one, says Stefan Mueller at CureVac.

The company is also developing a portable mRNA printer, in collaboration with Tesla, to rapidly manufacture mRNA. These printers could be taken to where the vaccine is needed and used to produce vaccines on demand.

CureVac's vaccine is in phase III trials. The UK says it will buy 50 million doses if it is approved.

Vaxart: A vaccine pill

The campaign to vaccinate everyone is a race against time, especially as more dangerous variants of the virus emerge. According to Sean Tucker, chief scientific officer of biotech company Vaxart in San Francisco, one rate-limiting step is getting people to a vaccination centre and injecting them. His solution is to eliminate the needles.

Vaxart is at the early stages of developing a covid-19 vaccine in pill form that could be distributed by post. "The vaccine comes to you," says Tucker.

Vaxart's pill contains a weakened human adenovirus called Ad5 loaded with genes from the coronavirus – both the spike protein and the nucleocapsid protein, which forms the virus's shell – plus an adjuvant. The tablets are designed to break down in the small intestine, stimulating an immune response.

Results of a phase I study announced at the meeting show that the pill elicits a response from T-cells in the bloodstream and antibodies in the lining of the nose. However, it didn't produce antibodies in the bloodstream, raising questions as to its potential efficacy. This news caused the company's share price to crash. However, Tucker points out that the study met its stated goals and says the company will press on.

CanSino Biologics: A child-friendly jab?

Getting news out of China's leading vaccine programmes, run by the companies Sinovac and Sinopharm, has proved difficult. But one Chinese company has revealed its hand. CanSino Biologics, in Shanghai, is developing a vaccine similar to the Oxford/AstraZeneca one.

CEO Xuefeng Yu told the conference that the vaccine is in phase III trials. The vaccine has already been administered to more than 150,000 Chinese military personnel with no reported ill effects, although there is no efficacy data because there are so few cases in China, says Yu.

As part of a phase II trial in Tiazhou, Jiangsu province, 30 children aged between 6 and 12 were given two shots. Yu says the firm is now analysing safety and immunology data.

Trial phases explained

PRE-TRIALS: Studies in the lab
PHASE 0: Studies in animal models of the disease
PHASE I: A drug/vaccine is tested in a small number of people to evaluate safety and dosage
PHASE II: A drug/vaccine is studied in a larger number of people to assess how effective it is and any further safety issues
PHASE III: A study in hundreds or thousands of people to confirm phase II results, assess side effects and compare the drug to already approved medications. The drug is then submitted for regulatory approval
PHASE IV: Monitoring of the drug in the general population

GCVI: Vaccinating the world

As the World Health Organization warns, the pandemic won't end until the whole world is vaccinated.

Peter Hotez at Baylor College of Medicine in Houston, Texas, and his colleagues have now set up the Global Coronavirus Vaccine Initiative (GCVI) to get covid-19 vaccines to the world's poorest people. They have a vaccine in phase II trials in India, and it is "about as straightforward and simple a vaccine as you can imagine", says Hotez. It consists of a vital bit of the spike protein, grown in transgenic yeast and mixed with an adjuvant.

This type of vaccine has a great track record and is similar to a common hepatitis B vaccine. Such vaccines cost about $3 for two doses. Experience suggests that it will be suitable for children.

The GCVI will seek emergency use authorisation in India within months and is negotiating with manufacturers in Africa, Latin America and the Middle East.

Space exploration

A new Hope for Mars

The United Arab Emirates's orbiter aims to chart the Martian atmosphere in detail

Leah Crane

MARS is getting an injection of Hope. An uncrewed craft of that name is the United Arab Emirates' first mission to another world and, as *New Scientist* went to press, was due to enter orbit around the planet on 9 February. The mission aims to build the most complete picture of the Martian atmosphere so far.

"The team has prepared as well as they can... to reach orbit," said Sarah Al Amiri, chair of the UAE space agency and the science lead for the mission, during a press conference late last month.

That preparation is crucial – it takes 11 minutes for a signal from Hope to reach Earth, so the entire operation to enter orbit will be on autopilot. If anything goes wrong, the probe can deal with various problems by itself during the 27 minutes in which the thrusters will fire to put it into a stable orbit.

"By the time we see the start of the burn, it's already almost halfway complete," said Pete Withnell at the University of Colorado Boulder, a programme manager for the mission, during the press conference. "We are observers, and we get to see what's happening, but we do not interact in real time."

The spacecraft's delayed signals make the mission nerve-wracking, says Omran Sharaf at the Mohammed Bin Rashid Space Centre in Dubai, another programme manager. "Firing the thrusters for 27 minutes non-stop is something we haven't done before," he says. "We couldn't test it on Earth because if we did, we could have damaged the spacecraft, so we could only test it for a few seconds." Even the small manoeuvres that the craft has performed on its way to Mars only required the thrusters to fire for a minute or less.

The Hope spacecraft should give us a new way to observe Mars

Once in orbit, Hope will provide us with an unprecedented view of Mars. The six other active craft orbiting the planet follow paths around the equator which line up with its rotation in such a way that they can only see any particular area of the surface at one time of day. Hope, on the other hand, will circle in a way that allows it to get a total picture of the planet every nine Martian days – including every spot on the surface at every time of day.

ALEXANDER MCNABB/MBRSC

The spacecraft carries three main scientific instruments that will allow it to observe Mars's atmosphere in wavelengths from the infrared into the far-ultraviolet. "For the first time, the world will receive a holistic view of the atmosphere," says Sharaf.

The goal is to study how layers of Martian air interact with one another at different times of day and year. This will help us answer the long-standing question of how gas escapes from Mars's atmosphere into space, a process that keeps the planet cold and dry, rather than warm and damp as it may once have been.

If Hope enters orbit safely, the team will spend two months testing the craft and its scientific instruments before starting to take measurements. "Hopefully by September 2021 we will have science data that we can share," says Sharaf. ▮

Chemistry

Making molecules go splat results in precision reactions

BREAKING the chemical bonds in large molecules to form a desired substance can be a fiddly task, but simply chucking molecules at a wall can get the job done.

Stephan Rauschenbach at the University of Oxford and his colleagues made the discovery, which they call "splat chemistry", after accidentally firing a complex molecule called Reichardt's dye at a copper surface.

The team expected the collision to have enough energy to break all the molecule's bonds, but that didn't happen, says Rauschenbach. "Despite this huge energy, it wasn't just chaos, it was very selective."

Using a microscope to investigate the collision scene, the researchers noticed that the result was a systematic crash. The molecule had "fractured" at a specific carbon-nitrogen bond, creating a more spread-out structure. After running the experiment again, they found that the molecule split entirely at this bond to form two separate fragments (*Physical Review Letters*, doi.org/ftjg).

The team created computer simulations of the collision and found that the molecule's final state is based on its orientation as it hits the surface. Striking at a particular angle puts a strain on a particular bond and forces it to break. In contrast, during typical chemical reactions, molecules are heated, randomly distributing the energy without targeting specific bonds.

"Control the geometry of the molecule as it collides and you get controlled chemistry"

"We realised that molecular-surface collisions will divert energy to certain areas, and here we're just exploiting it for a new type of mechanochemistry," says team member Kelvin Anggara at the Max Planck Institute for Solid State Research in Germany.

This technique could create new molecules that can't be made using conventional heating methods. "If someone could control the geometry of the molecule as it collides, you can get a controlled chemistry, and this is the dream for all chemists," says Anggara. ▮

Ibrahim Sawal

Sequencing COVID

By Alison Cranage, Science Writer at the Wellcome Sanger Institute

Every day at the Wellcome Genome Campus, boxes with frozen samples leftover from COVID-19 tests arrive. Couriered from the Lighthouse Laboratories undertaking the tests in communities across the UK, over 17 million samples have been handled so far.

With one of the largest genome sequencing facilities in the world, much of our capacity has been turned over to the SARS-CoV-2 virus, as a sequencing hub of the COVID-19 Genomics UK consortium (COG-UK). Together, the consortium has sequenced over 200,000 virus genomes from the UK.

Virologists around the globe are using the data to understand the spread, and the biology, of the SARS-CoV-2 virus. We spoke to Dr Jeffrey Barrett, Director of the COVID-19 Genomics Initiative at the Sanger Institute, about the work.

DAN ROSS (HTTPS://WWW.DAN-ROSS.COM/)

Genome sequencing is a vital tool in tracking new variants of the SARS-Cov-2 virus

Tracking the spread

Tracking the virus within a hospital, town, country or across the world is possible because genomes mutate. Letters in the genome sequence change as organisms replicate. Individual virus sequences can be placed on a phylogenetic tree, much like a family tree. Researchers can use this data to determine the relatedness of different viruses. The analysis can help identify chains of transmission, super spreading events and fast-growing variants.

To be useful for public health officials, genomic analysis must be available as close to real time as possible. Outbreaks and changes to the virus need to be swiftly identified, and then interventions deployed to contain them.

It is a huge logistical challenge to sequence and analyse thousands of genomes that quickly, every day. In each box from the Lighthouse Laboratories there are hundreds of positive samples among thousands of negative ones. Laboratory, technical, software, logistic, and scientific teams at Sanger have worked to handle the millions of samples, and there is now the capacity to sequence 10,000 virus samples a week. A new £2 million robotic system has just been installed to speed things up even further.

"Researchers in COG-UK use the virus genome data at a local scale, to support public health officials. This crucial work is helping to inform infection control procedures, as well as uncover previously hidden routes of transmission," says Jeff.

"We're also constantly monitoring the national sequence data for mutations that might impact the behaviour of the virus. COG-UK identified a new variant, B.1.1.7, in the South East of England in late 2020. Its prevalence has rapidly increased. This new variant was unlike any others we'd seen – it has many more mutations," explains Jeff.

New variant

Many of those mutations affect the spike protein of the virus, which binds to our cells. Analysis has now confirmed that B.1.1.7 is around 50% more transmissible than previous variants. The increased transmissibility helped explain the rapid rise in cases in the UK at the time.

"We are continuing to work around the clock to sequence and monitor the virus, and we immediately pass information to public health officials and those who need it. The next big question is about vaccines – will the virus mutate to escape? No data so far suggests it can escape the current vaccines. But sequencing will rapidly alert us if it does, plus it will inform the next generation of vaccines, should they be needed."

Jeff re-joined the Sanger Institute in July this year, to lead the coronavirus analysis work. He had previously worked in the Human Genetics department for 10 years. He was then the founding director of Open Targets, before moving to become Chief Scientific Officer at Genomics PLC in 2017. I asked what made him come back.

"I wanted to put large-scale genomics to use in the pandemic," he says. "I wanted to help. It's all anyone wants to do, isn't it?" ▮

Language

Orangutans in zoos create new communication signals

Richard Kemeny

WHAT'S in a somersault, a flap of the lip or a spit of water in the face? More than meets the eye, it seems. They may all be new ways of communicating that orangutans have come up with in captivity. This suggests that such gestural creativity may be ancestral in the great ape line, adding a new piece to the puzzle of language evolution.

Using new expressions to convey things, known as productivity in the field of linguistics, is one of the fundamental building blocks of complex language, and it is rarely reported in the animal kingdom.

Instead, most animals have a fixed set of messages, the meanings of which are determined by the context, such as the arrival of a predator. These signals seem to be innate rather than being learned.

Humans clearly show productivity, but whether other apes do is debated. To explore, Marlen Fröhlich

"Seven gestures and facial signals were used only by orangutans living in zoos"

at the University of Zurich in Switzerland and her colleagues examined whether orangutans held in captivity in zoos have developed new ways to communicate that aren't seen in their wild peers.

Zoos offer orangutans a stable yet different ecological niche. Getting food is less of an issue, as is avoiding predators. In the wild, orangutans tend to live rather solitary lives. In zoos, they live in larger groups in close proximity to one another, with more social interaction. They spend more time on the ground, away from foliage that can disrupt their view of other orangutans. All of these factors may help establish an environment in which productivity can flourish.

RM ASIA/ALAMY

Orangutans use gestures as well as calls to get their message across

Fröhlich's team suggests that zoo living really has made a difference. The group looked at information on more than 8000 examples of non-vocal orangutan communications by 30 individuals in five zoos, and 41 in wild populations in two forests.

After identifying and categorising the full range of signals, the team focused on those seen exclusively either in wild or in captive populations.

Seven signals were used only in zoos, whereas only one was exclusive to the wild. The zoo-only signals include a head-stand and a repeated spit of water in the face.

The results suggest an increase of around 20 per cent in the gestures and facial signals of captive orangutans compared with those in the wild. Most of the zoo signals were used to invite play, or to get food (bioRxiv, doi.org/ftj2).

Fröhlich and her colleagues declined to discuss the work before it has been fully peer reviewed.

"The study provides convincing evidence for innovation with regard to communicative signals in orangutans," says Christine Sievers at York University in Toronto, Canada. She notes, however, that there may have been observational difficulties in the wild habitats, which could have influenced how much innovation was spotted there.

Simon Townsend at the University of Warwick, UK, says the study "adds to the growing body of data that indicates signalling in great apes may be more plastic than previously thought, with obvious implications for the evolution of human language, arguably the most productive and flexible communication system in the animal kingdom". ▮

Biology

Ecological research harder due to lack of butterfly collectors

Madeline Bodin

THE decline of butterfly collecting as a hobby is making conservation and ecology research more difficult for entomologists, according to an analysis of 1.4 million specimens held in US museum collections dating from the 1800s.

Although butterfly collecting is often seen as a Victorian-era pastime, Erica Fischer at King's College London and their colleagues actually found that the largest growth in US specimen numbers occurred between 1945 and 1960, showing an 82 per cent increase.

This may have been driven by college-educated veterans who received free tuition after the second world war, the researchers say. The number of specimens collected in the US then faltered in the 1960s, and plunged after 1990, the team found (*BioScience*, doi.org/ftt9).

Fischer says that instead of collecting physical specimens, amateurs these days are more likely to gather observational data, particularly photos posted to online databases. While useful, photos don't let researchers analyse DNA, chemical ratios, internal organs or the pollen found clinging to specimens, says Fischer.

For example, in a 2018 study, Heidi MacLean at Aarhus University in Denmark and her colleagues examined specimens of the Mead's sulphur butterfly (*Colias meadii*) collected over the course of 60 years at Loveland Pass, Colorado, to see how they adapted to climate change by changing colour. "We couldn't have done it without the actual specimens," says MacLean.

Fischer is now studying collections of butterflies and moths in UK museums to see if the same collecting decline holds true and to assess the cultural forces behind the change. "Is it that science has moved away from collections?" says Fischer. ▮

Maths

Breakthrough for 100-year-old knotty maths problem

Leah Crane

UNRAVELLING knots just got easier. One of the biggest problems in the mathematical study of knots is recognising the difference between an actual knot and a piece of string that can be untangled into a single loop. A new algorithm can find this "unknot" far faster than any previous one can.

Mathematically, the definition of a knot is a closed curve – like a piece of string with the ends tied together – that can't be untangled into a simple loop. Anything that can be untangled into a simple loop, no matter how complicated or tangled it appears at first, is called the unknot. "Just like zero isn't a number, the unknot isn't a knot," says Mark Dennis at the University of Birmingham, UK.

Mathematicians have been working on algorithms to tell whether a given knot is actually the unknot for about 100 years, and pioneering mathematician and computer scientist Alan Turing even wrote about it in his final published paper in 1954. Now, Marc Lackenby at the University of Oxford has come up with an algorithm that can make this distinction far faster, which he presented at a recent seminar at the University of California, Davis.

"Although finding the unknot seems quite intuitive because throughout our lives we are untangling wires and pieces of string and headphone cords and things, it turns out that mathematically it touches on much more abstract areas of maths, questions to do with geometry in higher-dimensional spaces," says Dennis. "There are knot diagrams that you need to make more complicated before you can simplify them down," he says, and computers aren't great at recognising when to do so.

"There are knot diagrams that you need to make more complicated before you can simplify them"

The level of complexity of a given knot is defined by the number of crossings it contains. A crossing is the spot at which one part of the string passes over or under another part, and any tangle that can be manipulated so that it has no crossings is the unknot.

"You might expect it not to be a difficult problem, and the issue is that when you start to think about how a computer would actually decide such a question, you realise that you don't have the right tools to even come to a decisive answer about whether a thing is or isn't knotted," says Lackenby.

Other mathematicians have designed algorithms that can find whether a given tangle is knotted or not, but every added crossing doubles the time needed to solve the problem. Lackenby's algorithm can figure it out faster than that. His work relies on defining each knot as representing the edge of a three-dimensional shape.

"You can imagine a round unknot just lying in the plane, well that's the boundary of a disc," says Lackenby. "Or you can imagine taking a strip of paper and gluing it together in a loop with some little twists in it, and the boundary of that strip of paper will be a knot."

If the shape corresponding to a knot can be manipulated and simplified into a disc, that knot is actually the unknot.

Determining whether a knot is the unknot has far-ranging applications, from studying how DNA is tangled up within cells to understanding the loops of plasma that make up stars, so a faster algorithm could be enormously helpful. ▮

Archaeology

Ancient face cream was made from cave 'milk' and animal fat

SOME Chinese noblemen were using cosmetic face cream 2700 years ago. Archaeologists have found an ornate bronze jar containing the remains of a face cream, which was made from a mixture of animal fat and a rare substance called moonmilk that is found in caves.

The discovery is the earliest evidence of a Chinese man using cosmetics, although Chinese women did so earlier than this.

In 2017 and 2018, Yimin Yang at the University of the Chinese Academy of Sciences in Beijing and his colleagues excavated a site called Liujiawa in northern China.

DR. BIN HAN, UNIVERSITY OF CHINESE ACADEMY OF SCIENCES CHINA

The 2700-year-old bronze jar (left) and the face cream it contained (right) were found in northern China

It dates from the Spring and Autumn period (771 to 476 BC) of Chinese history, centuries before the country was first unified by the Qin dynasty. During this period, Liujiawa was the capital city of a state called Rui.

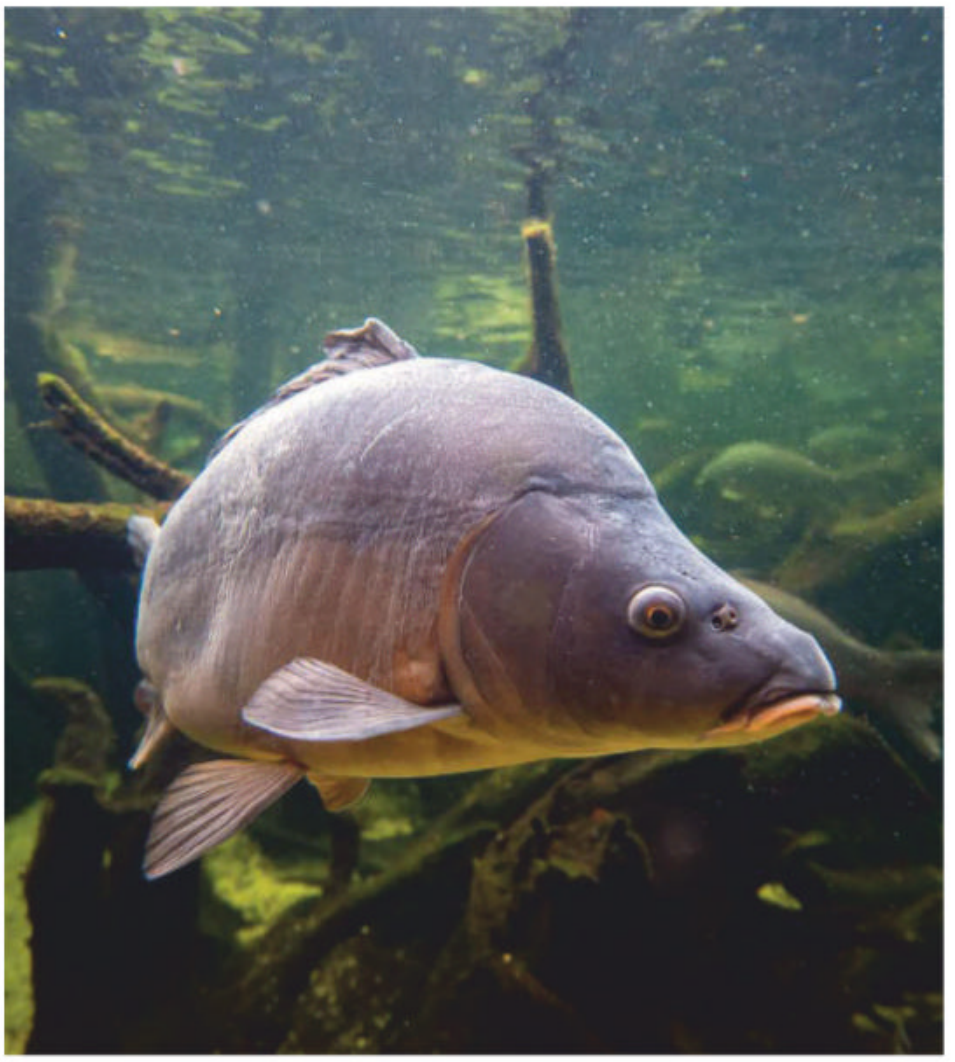
In the 2700-year-old tomb of a nobleman, the researchers found a bronze jar. Inside were lumps of a soft, yellow-white material. They immediately suspected that this was cosmetic cream. Chemical analyses later confirmed this and revealed two main ingredients.

The first was animal fat, which came from a ruminant animal that had been fed lots of grass-like plants.

The second ingredient was a form of watery calcium carbonate called moonmilk. It is a soft, white, creamy substance that forms inside caves. The cream would have made the man's face white, says Yang (*Archaeometry*, doi.org/ftvg).

The face cream is the earliest example associated with a Chinese man. However, evidence of Chinese women using cosmetics goes back further. In 2016, Yang's team studied red cosmetic sticks from 1980 to 1450 BC, which were buried with women in China. ▮

Michael Marshall



VOLODYMYR BURDIAK/ALAMY

Invasive species

Virus could be unleashed to control carp in world first

AUSTRALIA is looking at using a type of herpes virus as a biological agent to cut the number of carp in the country's waterways.

Since its introduction there in the late 1960s, the common carp (*Cyprinus carpio*) has led to a decline in native fish and plants.

Ivor Stuart at the Arthur Rylah Institute for Environmental Research, which is the biodiversity research organisation for the state government of Victoria, and his colleagues have now estimated the size of the problem. They calculated that, in a year with average rainfall, there are roughly 199 million carp in Australia – equivalent to 215,450 tonnes of fish.

"Carp tend to impact the amenity and biodiversity of an aquatic system when they reach 80 to 100 kilograms per hectare," says Stuart. The researchers found that carp pass this threshold for biodiversity impact in 54 per cent of wetlands, 70 per cent of rivers in general and 97 per cent of large, lowland rivers.

The estimate was calculated using a database the team created, based on 574,145 carp caught at 4831 sites between 1994 and 2018, plus the results of 153 research studies (*Biological Conservation*, doi.org/ghtmsm).

While trapping helps control the carp, the Fisheries Research and Development Corporation (FRDC), on behalf of Australia's government, is assessing possible use of *cyprinid herpesvirus 3* as a broader control strategy. This is a highly contagious virus that kills common and koi carp.

"Australia would be a world first in this regard," says Jennifer Marshall at the FRDC. **Donna Lu**

Solar system

We may have solved one Martian mystery

FOR years, researchers have argued about whether strange streaks on the surface of Mars are caused by flowing water or sliding dust. It seems both sides may be right.

Recurring slope lineae (RSLs) are dark stripes that appear to flow down the sides of craters on Mars during the warmest parts of the year. Janice Bishop at the SETI Institute in California and her colleagues were studying the strange behaviour of salty sediments in Antarctica when they realised that similar processes could cause RSLs on Mars.

They used soils similar to those found on Mars to test their idea. When they added a small amount of water, it percolated through the soil and brought salts to the surface. These created a crust with pockets of air beneath it that formed as the salts expanded with water and then contracted again.

"It's like a seasoning mix with salt in it: just a little bit of water and it sticks to everything and gets all crusty and stuck in the shaker," says Bishop.

Recent observations of the Martian surface have shown that RSLs are more likely to occur after dust storms. Dumping dust on thin, salty crusts could cause them to collapse into the air pockets beneath. That could then trigger more dust to slide downhill, causing what we see as RSLs (*Science Advances*, doi.org/ftkn).

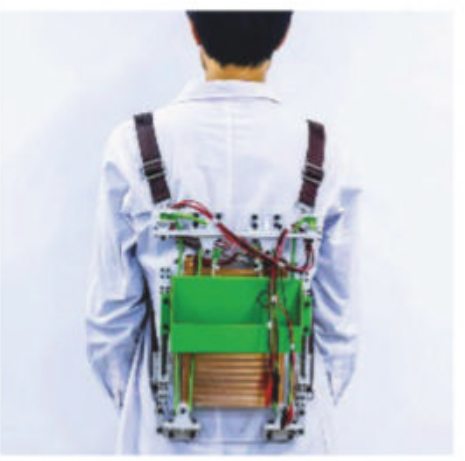
"The whole RSL story is complicated because we are not there and we can't test it," says Bishop. The rovers that have been on Mars can only dig a few centimetres down, so can't tell us anything about the possibilities of processes like the one Bishop and her colleagues suggest could cause RSLs. However, the Rosalind Franklin rover, planned to launch in 2022, will have the capability to dig deeper, so it may be able to solve the mystery. **Leah Crane**

Technology

Moving pack makes power as you walk

A BACKPACK fitted with shock absorbers that generate electricity is easier to carry and can power LEDs and other devices.

The bag is suspended on sliding rails that allow it to move up and down, with a pair of rubber ropes on a pulley system acting like a car's suspension to reduce the impact of the pack as you walk. This reduces the force generated by the contents of the pack jiggling about by around 21 per cent.



ADAPTED FROM ACS NANO 2021

"When we are walking, the mass centre of the body moves up and down," says Jia Cheng at Tsinghua University, China, who developed the prototype with his colleagues. An ordinary backpack moves with this mass centre, but the pulley system cancels that motion out, then uses the relative movement between bag and body to power a triboelectric nanogenerator (TENG) that converts mechanical energy into electricity.

When worn by someone who is walking, the backpack's TENG converts 14 per cent of the bag's movement into 118 microjoules of electrical energy. The team used this to power LEDs, a fluorescent light or a watch (*ACS Nano*, doi.org/ftvb).

The current version is around 3 kilograms – too heavy to be widely used, but Cheng thinks this can be reduced to make it more feasible. He hopes to bring the next version down to 1 kilogram. **Chris Stokel-Walker**

Really brief

KJELL B. SANDVED/SCIENCE PHOTO LIBRARY

DNA clues to recent bird extinctions

North American birds that went extinct last century, including the passenger pigeon (pictured), weren't in genetic decline, suggests a DNA analysis of samples from museum collections. This adds to evidence that humans were responsible for their disappearance (*Proceedings of the Royal Society B*, doi.org/ftdk).

Bats use late-night winds to soar high

By exploiting winds that sweep up south-facing slopes at night, European free-tailed bats in Portugal can reach altitudes of 1600 metres. Birds ride the winds during the day, but until now it was unclear whether bats could do the same at night (*Current Biology*, doi.org/ftks).

Wine analysis backs up idea of 'terroir'

A chemical analysis of Malbec wines from Argentina shows that it is possible to identify the vineyard they came from and the year they were produced. This supports the concept of "terroir", that the combination of climate and wine-making practices can give wines a unique flavour (*Scientific Reports*, doi.org/ftb7).

Ecology

Fairy circles resilient to climate change

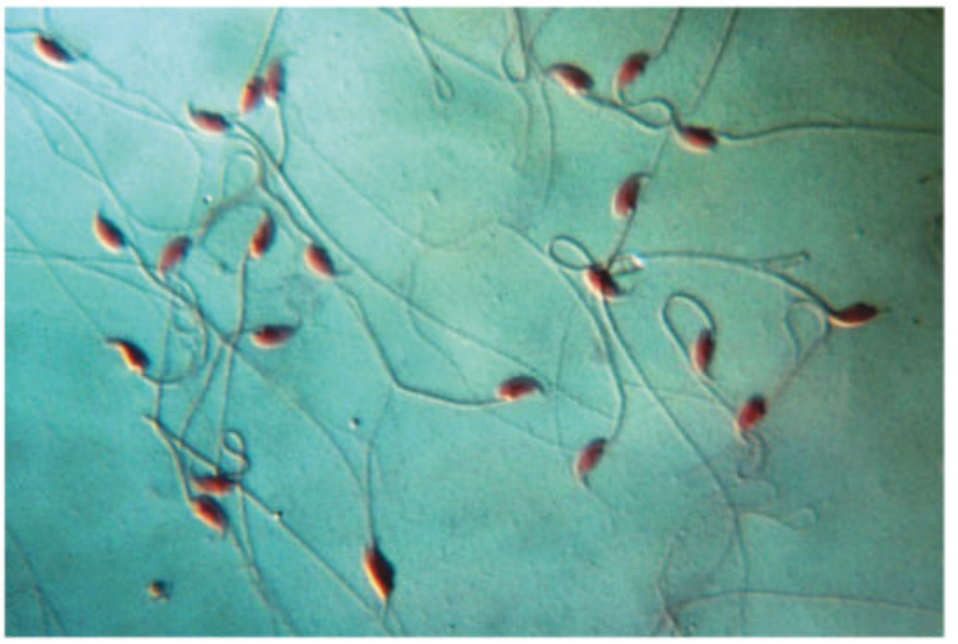
THE most famous so-called fairy circles are grass-ringed patches of barren earth found in Namibia and Australia. Their lesser-known cousins – transient rings of grassy plants found in Chinese salt marshes – could help explain why such patterns naturally form and may indicate ecosystem resilience to climate change.

Li-Xia Zhao at East China Normal University and her team took sediment and plant samples from transient rings, up to 100 metres in size, on salt marshes in Shanghai. Compared with samples from the edge of the rings, those from the centre had higher concentrations of sulphides, which can cause plant death at high levels. The centre samples also had less available soil nitrogen, which can limit plant growth.

These variations are caused by the growth and decomposition of the plants. The team's computer models show that both nutrient depletion and rising sulphide levels would lead the vegetation in the centre to die first, as that is where the plant has been growing for the longest, leaving living rings.

These strange patterns of grass aren't just interesting to look at – they indicate that their environment can bounce back from disruption more easily than others. The researchers' models show that ecosystems with transient rings recover from disruptions like environmental stress – a lack of oxygen in the sediment, for example – to their previous state twice as quickly as those with persistent ring patterns (*Science Advances*, DOI: 10.1126/sciadv.abe1100). **Bethan Ackerley**

Biology



SCIENCE HISTORY IMAGES/ALAMY

Some sperm can sabotage rivals in the race to an egg

SPERM have one goal – to fertilise an egg – and it seems that some mouse sperm cells with a certain genetic mutation may boost their chances by sabotaging rivals.

Previous research has shown that mice with two copies of a genetic variant called the t haplotype are more likely to be infertile. But a new study by Bernhard Herrmann at the Max Planck Institute for Molecular Genetics in Berlin and his colleagues suggests that males with one copy of it make some t haplotype sperm cells that are more motile than those they make without it.

This variant is a "selfish" genetic element, because it can increase its likelihood of being passed on to offspring to higher than the usual odds of 50 per cent. Herrmann and his team have figured out how these sperm gain their advantage.

The sperm with one t haplotype variant produce molecules that are able to disturb other sperm. They make it hard for the rival sperm cells to interact with their environment, blocking various cell signalling molecules that normally provide the sperm with a sense of direction (*PLoS Genetics*, doi.org/ftj8).

Although the t haplotype sperm cells were more motile, the researchers didn't test their ability to fertilise an egg. Karina Shah

Animal behaviour

Spiders bag big prey thanks to silk trick

SOME spiders take on animals that are far larger than they are. To stop such prey from running away, they use their webs as pulleys to lift the doomed animals off the ground.

Gabriele Greco and Nicola Pugno at the University of Trento in Italy watched five captive specimens from the Theridiidae family of common house spiders catch cockroaches up to 50 times more massive than themselves.

They found that the spiders seemed to be using their body weight to tension silk threads to keep them taut before attaching them to the roaches. The spiders then continued to attach more threads until their prey was lifted into the air (*Journal of the Royal Society Interface*, doi.org/ftkr).

"In the end, all these threads create enough tension to lift the prey, and that is when the spider wins," says Greco. The silk's strength is comparable with steel, but it is as elastic as the silk you would use to make clothes.

The behaviour is interesting because you might not expect such a relatively simple animal to know how to catch its prey in such a sophisticated way, says Greco. It may allow spiders to have an outsized impact on their ecosystems. **LC**

Signal Boost

Welcome to our Signal Boost project – a page for charitable organisations to get their message out to a global audience, free of charge. Today, a message from **Harry's HAT**

BRIDGET BAXTER PHOTOGRAPHY

Hydrocephalus is a swelling of the brain caused by excess build-up of cerebral fluid. This leads to an increase in intracranial pressure resulting in serious brain complications. It affects 1 in every 1000 babies born in the UK today and is the most common reason for brain surgery in children.

Despite its prevalence, there is limited knowledge about the condition and limited investment into its management nationally. To reduce the pressure, a shunt is inserted which allows some of the fluid to drain from the brain to another area of the body. There has been very little advance in shunt technology since its co-invention in 1963 by the author Roald Dahl, whose son Theo developed hydrocephalus. Half of all shunts block within the first year, requiring further brain surgery.

Hence, the inception in 2019 of Harry's Hydrocephalus Awareness Trust ("Harry's HAT"). This is only UK charity to focus solely on hydrocephalus with a mission to improve the life and outcomes for children with the condition. Harry's parents founded the charity in response to a need identified following their son's diagnosis with hydrocephalus:

"Harry was just eight weeks old when his shunt was inserted and by his first birthday, he had already endured four brain surgery procedures. We found ourselves isolated by Harry's condition and struggled to access the support and information we needed."

Harry's HAT has the following key objectives:

- To raise awareness of paediatric hydrocephalus.
- To fund training so that front-line workers can learn more about the condition and its management.
- To fund research to improve the outcome for children with the condition.
- To provide quality sign-posting support for families journeying through the condition.

Since its launch, the volunteer-run charity has raised over £62,000, which has enabled paediatric nurse specialists to attend conferences, peer networking forums and workshops to improve their understanding and management of hydrocephalus.

The charity is collaborating with major universities to understand the impact of hydrocephalus on families through patient engagement studies and we are currently embarking on research into antenatal care and the impact of third trimester screening on health outcomes. To this end, we have created a short online questionnaire for UK families to provide feedback: harrys-hat.org/survey

We are also looking for financial support, opportunities to connect medical and scientific experts and we would like people to share our work widely to raise awareness and engagement. It has been over half a century since the invention of the shunt and it is time to advance the treatment of hydrocephalus into the 21st century.

Want to help?

Please do get in touch to help us provide a brighter future for our families touched by hydrocephalus. Thank you. Text to give: Text HYDRO to 70490 to donate £3 (Texts cost £3 plus one standard rate message). Donate online: harrys-hat.org

Views

Comment

Gambling interventions

We now have the fullest picture yet of online gambling's links to financial and social harm, say **Naomi Muggleton** and **Neil Stewart**

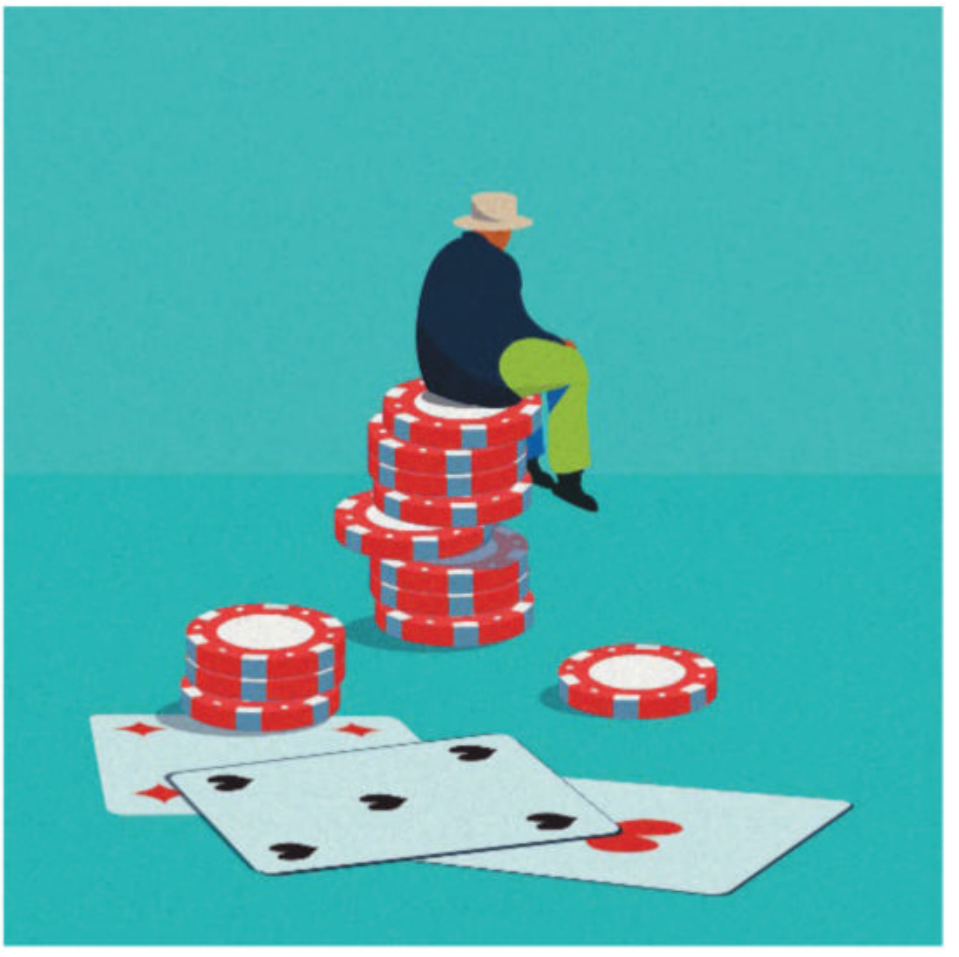
GAMBLING has changed a lot in recent years. Mobile apps give people unlimited access to the global betting market at the touch of a button from anywhere in the world. As the number of gamblers has increased, so too have bookmakers' profit margins and the amount of problem gambling. Yet we still can't say for sure how gambling and financial troubles are linked.

In the UK, the number of active online gambling accounts has risen from around 16 million in 2008 to 30 million in 2019. The Gambling Commission, an industry regulator for England, Scotland and Wales, estimates that up to 300,000 people may be problem gamblers – gambling in a way that is disruptive or damaging to their lives. A similar pattern has been seen in other countries.

As a result, there is some pushback. The Gambling Commission is reviewing current legislation and has announced new restrictions on how online bookmakers can operate. There is talk of banning gambling advertising from sports shirts, reminiscent of when tobacco firms faced a similar outlawing.

But there is still much that we don't know about the impacts of gambling.

As interviewing gamblers is time consuming and costly, much of the existing research relies on surveys of the most extreme gamblers. This is problematic for several reasons. Extreme gamblers are hard to reach and are likely to misremember or distort their gambling habits. Another issue is the assumption that the problems associated with gambling affect just a small proportion of the most extreme gamblers, whereas gambling researchers believe that lower levels of gambling may be harmful too.



MICHELLE D'URBANO

Understanding the societal impact of gambling requires large-scale, objective data into the harms of gambling that, until recently, has been lacking. In a recent study, we looked at anonymised data from a UK bank of around 6.5 million people – of whom 40 per cent gambled – to see what financial, social and health outcomes disproportionately affect those who gamble over a period of seven years (*Nature Human Behaviour*, doi.org/ftj6). While not quite representative of the UK population, this is the fullest picture yet of gambling and its associated harms.

We found that people who gamble, even if it is with a relatively small amount of their monthly budget, experience a small increase in distressing financial outcomes, such as falling behind on their bills and mortgage or using a payday loan, compared with those who don't. This risk rises with higher rates of gambling.

The relationship between gambling and harmful life experiences isn't purely financial. By looking at the time of day that people spend money, we found that those who gamble are more likely to be awake in the middle of the night, a marker associated with poorer mental health. Over the seven year period, gamblers were also more likely to receive disability payments – measured by incoming welfare payments – and to lose their jobs. We also found that all levels of gambling are associated with a higher mortality rate, for men and women, young and old.

Though none of these correlations prove causation, gambling does appear to be closely linked to negative outcomes in people's lives. This suggests that a public health approach – such as an advertising ban – could reduce harm. Targeted approaches, for instance allowing people to enable gambling blocks on current accounts or limiting the amount that can be gambled, would also be beneficial to people with higher levels of gambling. We will only know if these approaches work through a large-scale randomised trial. It is time we found out. ▮

Naomi Muggleton is at the University of Oxford and Neil Stewart is at Warwick Business School, UK

No planet B

A climate tipping point to welcome

The concept of net zero has rapidly taken hold in the public consciousness and it is having a big impact on pledges to cut carbon, writes **Graham Lawton**

Graham Lawton is a staff writer at *New Scientist* and author of *This Book Could Save Your Life*. You can follow him @grahamlawton

Graham's week

What I'm reading
I've just ordered How to Spend a Trillion Dollars *by my* New Scientist *colleague Rowan Hooper.*

What I'm watching
The Great. *It really is.*

What I'm working on
I'm about to fly (virtually) to New York to cover a conference on SARS-CoV-2.

This column appears monthly. Up next week: Annalee Newitz

ONE of the concepts that climate science has bequeathed the wider world is the tipping point: a description of how a complex system can change gradually, almost imperceptibly, then suddenly flip into a new, stable state. Climate tipping points tend to be things we really don't want to go past, such as the irreversible conversion of the Amazon rainforest to savannah or, heaven forfend, the Gulf Stream shutting down. Like in the climate disaster movie *The Day After Tomorrow*. That one ends especially badly.

The existence of climate tipping points and where they lie, however, remain uncertain. Climate scientists have rowed back from the Gulf Stream one, for example, though are increasingly concerned about unstoppable methane release from melting permafrost.

More recently, though, the tipping point concept has found a new application in climate science as a way to explain, and possibly engineer, social change. The way changes in attitude creep along at a glacial pace before suddenly bursting forth to take root across society is a classic tipping point. This process is useful because it moves ideas that were once on the fringes of mainstream opinion rapidly to the centre; ideas such as the need for deep economic and technological changes to avoid a real-life climate disaster movie.

Whether by accident or design, we recently passed one such social tipping point. In narrow terms, it is the sudden, widespread embrace of net zero. In broader terms, it means final realisation from all levels of society that we must take radical action or face dire, possibly terminal, consequences.

A year ago, when I first wrote about it in this column, net zero was creeping into the mainstream. Greta Thunberg was talking about it; two countries – Suriname and Bhutan – had achieved it, and four more, including the UK, had passed laws to aim for it. A dozen or so others were thinking about it.

Today, the picture has changed dramatically. Suriname and Bhutan still stand alone as the heroes of zero, but legislation has been passed or is pending in 21 other countries, plus the European Union. Three of the world's four-biggest emitters – China, the EU and Japan – are in the club. If the US consummates its new relationship with the planet, that will be four out of four. According to the Energy & Climate Intelligence Unit's Net Zero Tracker, the US is one of around 100 countries in which net-zero laws are under discussion. Even Australia, which just four months ago was pushing back, has recanted. Countries on the outside look increasingly like a rogues' gallery of backward-looking petrostates: Brazil, Saudi Arabia, Iran, Russia, Venezuela and Nigeria. You might call them the axis of ev-oil.

"Maybe the power of net zero to win over wider society lies in the fact that it is an easy concept to grasp"

At subnational levels, enthusiasm is spreading too. According to Kaya Axelsson at the University of Oxford's Net Zero initiative, 452 cities, 22 regions, more than 1100 big companies, nearly 50 investment funds and 550 universities have pledged to go net zero globally, with more joining every day. Axelsson says when she goes to talk to private companies, she finds she is pushing at an open door.

Even families can make a pledge at a website called Family Climate Emergency. I will look into this and report back in a later column.

"There's now a big, broad societal consensus about the need to do something about climate change," says Sam Fankhauser at the London School of Economics. "Two years ago or so, you had to make the case for climate action. That narrative has really shifted."

Maybe the power of net zero to win over wider society lies in the fact that it is easy to grasp. The basic concept is actually the simplest part of it, according to one of its originators, Myles Allen at the University of Oxford. In order to keep a lid on global heating at whatever upper limit we choose, we will eventually have to stop adding carbon dioxide and other warming gases to the atmosphere.

A complete cessation is probably impossible, so emissions that cannot be avoided must be offset by planting trees and other nature-based solutions that remove carbon from the air. But these won't be enough, so we also need what Allen calls "re-fossilising": capturing CO_2 released from the combustion of fossil fuels and burying it underground from whence it came. Overall, no new greenhouse gases are added to the atmosphere. Hence "net" zero.

Of course, pledging and achieving are two different things. Three decades of hard graft still lie ahead. We urgently need to speed up emission reductions; only a handful of countries are actually on a trajectory towards net zero. The UK's recent approval of a new coal mine shows how easy it is even for net-zero pledgers to slip back into old ways. But something has tipped, and there is now a fighting chance that the climate won't. Let's face it: we have zero other options. ▮

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Editor's pick

On the hunt for the elusive Dyson sphere

30 January, p 44

From Guy Cox,
St Albans, New South Wales, Australia

The search for alien intelligence by looking for Dyson spheres – vast theorised power plants built to encase and draw energy from a star – is inevitably doomed to fail.

Any civilisation with such a high demand for resources and low respect for the environment is bound to collapse long before it is capable of building a sphere.

The true sign of a highly advanced civilisation would be the mastery of light hydrogen fusion, which would provide virtually limitless energy from the most abundant element in the universe. In principle, we could detect this on a planet by seeing the spectral signature of its product: helium. Unfortunately, since a planet's sun is carrying out the same reaction, this wouldn't be that easy.

From Daniel Kitto,
Norwich, Norfolk, UK

It seems to me that any civilisation needing to build – and capable of building – a Dyson sphere is unlikely to stop at one.

The same drive to ever-greater exploitation of energy and other resources that a Dyson sphere assumes (rightly or wrongly), would also drive such a civilisation to colonise neighbouring star systems and build further spheres.

So perhaps any search for these spheres should look not for individual stars with the infrared signature we would expect of a Dyson sphere, but for clusters of such stars in close proximity.

Can we engineer a solution to the pandemic?

23 January, p 12

From David Aldred,
Elloughton, East Yorkshire, UK

You report that a far less deadly version of the coronavirus will probably emerge naturally, because a relatively benign version in a living human can fulfil its objective to reproduce, whereas a deadly virus in a dying person is more likely to perish with its host.

Would it be possible or practical to engineer a version of the virus that was highly transmissible and highly stable, yet benign? Then it would outperform its more dangerous cousins, and everybody could become infected with it and develop antibodies, thus creating global herd immunity. Or would that be playing with fire?

Burnout is a huge issue for single parents

23 January, p 40

From Eleanor Sharman, Dorrigo,
New South Wales, Australia

I was surprised that the research into parental burnout didn't seem to note whether the families involved were single parents.

My experience is that sole parenting in Western cultures is likely to involve far more personal depletion, responsibility, work and often financial stress. It is possible that sole parents experience less of this kind of stress in traditional cultures in which care and provision for children is shared more widely among extended family and the community.

This means prevention and treatment of burnout for sole parents needs to involve practical intervention and support, not just psychological therapies.

Debate contrarian views, don't just suppress them

30 January, p 12

From Martin Jenkins, London, UK

So someone whose views are moderated or downvoted on social media is more likely to become a conspiracy theorist?

It seems clear to me that having your views suppressed could be construed as evidence of a conspiracy and that this conclusion isn't necessarily an irrational one. I stand by the fundamental scientific principle that you should deal with incorrect views, not by suppressing them, but by winning the argument.

Someone, somewhere, always has to foot the bill

9 January, p 19

From Roger Elwell,
Colchester, Essex, UK

Richard Webb's comment article made the case for free public transport in cities, but this isn't "free" because it needs to be paid for somehow and by someone.

While the environmental considerations may well be fairly clear, apart from the Vienna experiment, Webb doesn't really address how such provision is to be funded. I'm not a city dweller, and I know that I wouldn't be happy to see my taxes pay for free travel in the likes of London. I suspect I am not alone in that.

Rise of gas guzzlers may be a demographic issue

30 January, p 17

From Roy Murchie,
Wivenhoe, Essex, UK

You report that the gains for the climate from greater use of electric cars are being cancelled out by the increase in SUVs. Maybe the reasons why more of the latter are being bought could be explored, especially given the ageing of the population. As an 80-year-old, what I look for in a car is ease of entry and, especially, exit. Can I urge car manufacturers to publish the height of the H point (the point of a vehicle occupier's hip joint) above the road.

When it came to smarts, we were streets ahead

30 January, p 34

From Eric Kvaalen,
Les Essarts-le-Roi, France

Your article on the Denisovans ends by saying that they and the Neanderthals were cognitively not very different from us.

But Neanderthal technology seems to have got no further than string and bone flutes. As far as we know, they never made paintings like those we made in the Chauvet cave, or figurines like the Venus of Brassempouy. They made no permanent buildings, they didn't invent pottery or figure out how to make metals. We may not have been smarter than Neanderthals 50,000 years ago, but I think we're smarter now. They had 300,000 years to try, but they never advanced as far as we have.

Tips for beating those pesky flies

23 January, p 20

From Ann Smith,
Churchdown, Gloucestershire, UK

It was interesting to learn that houseflies have specialised wings known as halteres that make them harder to swat. I find that a very successful way to catch flies in the house is by lowering a cup over them extremely slowly. The flies don't seem to be able to compute low speed.

From Colum Clarke, Wicklow Town,
County Wicklow, Ireland

Halteres or not on your least favourite fly, swatting them leaves a mess and frustration at the misses. I vacuum them up using the basic hose or narrow nozzle. The flies just don't see it coming and you can also easily catch them flying – highly recommended. Success rate 100 per cent.

Want to get in touch?

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For the record

The Dutch study of body language imitation when lying only looked at the behaviour of men (23 January, p 20).

Pool school

Photographer **Shane Gross**
Agency **naturepl.com**

HIDDEN away in a mangrove forest on the island of Eleuthera in the Bahamas, this baby lemon shark (*Negaprion brevirostris*) will spend the first few years of its life searching for food in the small area of underwater foliage where it was born, and learning the ropes to boost its chances of surviving into adulthood.

Mangroves are the only trees that can grow in salt water. Their intricate roots provide ideal places for fish to hide from predators – and a safe nursery for lemon shark pups, which must fend for themselves from the moment they are born. This individual, captured by photographer Shane Gross, will probably make mistakes along the way, as it learns what to eat and how to hunt.

Though adult lemon sharks can grow to 3 metres, newborn pups are only about 7 centimetres in size, allowing them to live comfortably among the mangroves. By monitoring lemon sharks for decades, researchers have found that females will return to the same place they were born to breed.

Lemon sharks are mainly found on the west side of the Atlantic Ocean, from the US to Brazil, but are classified as near-threatened due to the destruction of the mangrove forests that play a crucial role in their lives. In the Bahamas, this destruction is predominantly to make way for human settlements. Globally, more than 35 per cent of mangroves have already disappeared.

Gege Li

For more on shark photography see page 33

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“2021 must be the year to reconcile humanity with nature”

António Guterres,
United Nations Secretary General, Paris, December 2020

The shadow of AIDS

It's a Sin is the perfect snapshot of London's gay scene in the 1980s, while exposing the harsh realities of the rising AIDS epidemic, says **Karina Shah**

BEN BLACKALL/CHANNEL 4

Ritchie (Olly Alexander) and Jill (Lydia West) in *It's a Sin*

TV

It's a Sin

Russell T Davies

Channel 4

AN UNKNOWN virus, misinformation and uncertainty about the future. No, we're not talking about coronavirus for once. *It's a Sin*, a new five-part miniseries on Channel 4, delicately tackles the HIV and AIDS epidemic of the 1980s, with the backdrop of queer London.

Created by Russell T Davies, who was also behind the 1999 series *Queer as Folk*, the show chronicles the lives of three gay men who set off from their home towns to begin new lives at university. A seemingly light set-up, the story takes a turn for the worse as a deadly new virus is on the rise.

It's a Sin opens in September 1981, with an outwardly perfect nuclear family sat around their dimly lit dining table, surrounded by retro lampshades and boldly printed curtains. We are introduced to 18-year-old Ritchie (Olly Alexander), the show's protagonist, who is about to move to the big city: London.

His story really begins when he meets Roscoe (Omari Douglas) and Colin (Callum Scott Howells). As the three young men navigate the capital's gay scene and university life in general, they are introduced to a mysterious disease that seems to disproportionately affect gay men.

In the early 1980s, reports of severe immune deficiency began to rise around the world. Scientists were dumbfounded by this new disease, which worked by attacking the body's immune system, weakening its ability to fight infections.

Navigating an increasingly homophobic society, Ritchie initially responds to the disease with denial. "I don't believe it. I don't believe a word of it," he says in a monologue of denial, while the camera pans to him on the dance floor of Heaven, the iconic gay club in London. As the shadow of AIDS closes in, Ritchie and his friends tackle misinformation and stigma.

The miniseries scarily mirrors our current reality. Much like today's coronavirus, there were many rumours circulating about HIV and AIDS, due to fear of the unknown. One of the most common misconceptions was that only gay people could contract the virus – it was even labelled the "gay plague". This stigma cast a large shadow on the gay community, meaning that many people suffered in silence until their last days of life, as shown in *It's a Sin*.

"HIV and AIDS have claimed the lives of millions of people – this fictional telling doesn't sugar-coat it"

The series presents a candid authenticity that could only be achieved by someone who has lived through and experienced the events themselves, which Davies did. The soundtrack especially gets an honourable mention – it features some of the biggest smash hits of the decade, including tracks by Blondie, Wham! and Queen. Paired with the impeccable acting of the young and upcoming actors, many of whom weren't even alive in the 1980s, we are transported back in time.

Davies preserves the joyous scenes of 1980s London, all while sensitively portraying the realities of the disease's devastating progression. We see how HIV and AIDS affected the individuals themselves, their social circle and even families who discover their son's sexuality through the most haunting circumstances. No spoilers, but keep your box of tissues close to hand. HIV and AIDS have claimed the lives of millions of people across the world – this fictional telling doesn't sugar-coat it.

The mortality rate from HIV is now lower with the development of preventative drugs, such as pre-exposure prophylaxis (PrEP), and antiretroviral therapy. But living with the devastating impacts of HIV or AIDS is still the reality for millions of people, especially those in low-income countries where therapies are hard to access.

It's a Sin serves as a powerful reminder of a chilling chapter that burdened thousands of gay men. It is a poignant love letter to all those lost during the AIDS epidemic of the 1980s, and to those allies who unconditionally supported them. ▮

Learning to love sharks

Valerie Taylor, a shark hunter turned shark lover who shot footage for *Jaws*, is a colourful subject, says **Davide Abbatescianni**

Film

Playing With Sharks: The Valerie Taylor story
Sally Aitken
Wildbear Entertainment

IN JANUARY 1992, Valerie and Ron Taylor notched up an incredible first when they filmed great white sharks without a safety cage or any other protection. Alongside two other divers, they swam among the animals off Dyer Island, South Africa.

Valerie Taylor, an icon and living legend in the diving world, is now in her 80s. She shares some of those memories in *Playing With Sharks*, a documentary about her life, directed by Sally Aitken, which premiered at this year's online Sundance Film Festival.

It shows her as a shark hunter in the 1950s and early 1960s, then as a world-renowned underwater photographer and, above all, as a passionate conservationist.

Taylor's story is told through archive footage taken over 50 years, recent interviews with her and commentary on her efforts to raise awareness that sharks are endangered, coming from luminaries such as explorer Jean-Michel Cousteau (son of Jacques) and Rodney Fox, a former film-maker and spearfishing champion.

There is a significant narrative shift as we hear how Valerie and husband Ron experienced their epiphany. They were both spearfishing champions and they loved the sea. But after killing five sharks one day, the sight of the carcasses saddened them. Ron realised that killing had become an obsession: he decided to shoot only with his camera. Valerie agreed.

That was the beginning of a long, intense journey, which led them to make documentaries and swim cageless among a school of oceanic white-tip sharks in Peter Gimbel's 1971 film *Blue Water, White Death*.

It is striking to observe how their fear of the predators was gradually replaced by curiosity, mutual respect and admiration.

"We ended up being accepted as other marine animals," says Taylor, while archive footage

"Taylor's journey outlines the scientific story of how our view of sharks changed forever"

shows her in a chain-mail suit, swimming close by the sharks.

***Blue Water, White Death* caught the eye of a young Steven Spielberg, who tasked the Taylors with filming the great white shark sequences for his 1975 thriller *Jaws*. Aitken delves into the emotional response to the film, which, at the time, inspired reckless shark-killing sprees and increased public fear of sharks.**

The director shows the couple's repeated attempts to make amends and explain how their work on *Jaws* was obviously contributing to a work of pure fiction. Valerie Taylor's dismay at accidentally damaging sharks' reputation is plain in one of the film's most painful sections.

After *Jaws*, the couple focused on celebrating sharks, working as underwater photographers and often making the front cover of prestigious publications, including *National Geographic* for that 1992 first with the great white sharks.

The rewarding final sequence of *Playing With Sharks*, set in Fiji, shows how the love for knowledge knows no bounds or age limits. Taylor's life-affirming journey becomes an effective narrative tool for outlining the scientific story of how we changed our view of sharks – from marine monsters to extraordinary, complex animals that should be protected.

Enriched by a powerful score by Caitlin Yeo and impeccably edited by Adrian Rostirolla, *Playing With Sharks* is a must-see for sea lovers and documentary enthusiasts.

Davide Abbatescianni is a film critic based in Cork, Ireland

COURTESY OF SUNDANCE INSTITUTE

Valerie Taylor, making friends with an animal she once hunted for sport

Don't miss

Listen

Octave of Light, featuring soprano Beth Sterling, is an album of exoplanet music by David Ibbett, guest composer at Fermilab in Illinois, and astronomer Roy Gould, who have turned exoplanet spectra into musical chords.

Read

The Raven's Hat by Jonas Peters and Nicolai Meinshausen is a series of engaging games that seem unsolvable – until you translate them into mathematical terms. Hours of fun for anyone who took maths seriously at school.

Watch

Tribes of Europa, a near-future German sci-fi series on Netflix, follows siblings Kiano, Liv, and Elja, who are fighting for their lives on a continent split into warring tribal states. Available from 19 February.

T–B: PAUL SAYED; MIT PRESS; NETFLIX

The games column

Mars was never going to be easy As real spacecraft arrive at the Red Planet, let's celebrate with Mars-based games like *Red Faction: Guerrilla,* which lets you destroy at will, or *Tharsis,* where you captain a doomed spacecraft, says **Jacob Aron**

Jacob Aron is *New Scientist*'s deputy news editor. He has been playing video games for 25 years, but still isn't very good at them. Follow him on Twitter @jjaron

DEEP SILVER VOLITION

A Martian base explodes in *Red Faction: Guerrilla*

THIS month sees a trio of real-life spacecraft arrive at Mars, so in honour of their voyages I thought I'd run through my own jaunts to the Red Planet in game mode.

Mars is a common locale for many first-person shooters, with games in the *Doom*, *Destiny* and *Call of Duty* series all featuring levels on its dry, dusty surface, but they rarely do very much interesting with the setting.

One exception is *Doom Eternal*, which I reviewed last year. As you fight your way through endless demon hordes, it becomes clear you must journey to hell through a portal at the centre of Mars. How? Why, by commandeering a massive laser on Mars's moon Phobos and blasting a gigantic crater into the planet's surface.

Speaking of blowing things up on Mars, the *Red Faction* series makes a selling point of having "destructible terrain", essentially letting you knock down walls and buildings to progress through the game. This is still a rarity in video games, partly because of the technical difficulties in rendering destruction on the fly, but also because letting players destroy everything makes it hard to impose any narrative structure.

My favourite of the series, *Red Faction: Guerrilla*, solves this by throwing narrative structure out of the window, then throwing the window out of the window. You play Alec Mason, a freedom-fighter attempting to overthrow the tyrannical rulers of Mars, but forget all that – what matters here is that you are given mining charges, trucks and a really big hammer and then encouraged to destroy everything in sight. It is incredibly satisfying, even if you are setting the course of Martian settlement back decades.

"*Kerbal Space Program* lets you build pretty much any spacecraft you can imagine; mine tend to blow up"

If you fancy something a bit more constructive, *Surviving Mars*, which I reviewed in 2019, puts you in charge of building a colony from the ground up. I enjoyed the challenges of managing water, oxygen and electricity supplies as I plotted out various domed habitats on the Martian soil. The game is just tricky enough that you feel like you are struggling to survive without it being too disheartening when a bunch of your colonists die in a dust storm.

Offworld Trading Company is similar but puts you slightly further into the future, with Mars settled and corporations vying to exploit its natural resources. The game is ruthlessly capitalist and sees you exploiting markets to get one over on your rivals or make a hostile takeover.

If your dreams of being Elon Musk revolve around building rockets rather than becoming a billionaire, *Kerbal Space Program* is for you. With a bewildering array of capsules, engines and more, you can pretty much construct any spacecraft you can imagine. Whether you can get it off the ground is another matter – mine tend to blow up. Once in orbit, there is a whole solar system analogue to explore, with dusty Duna as *Kerbal's* version of Mars.

Finally, for a darker look at what astronauts heading to Mars might face, there is *Tharsis*. It is set aboard the first crewed ship to the Red Planet, which has been damaged by a micrometeoroid storm, meaning you have to repair the ship and shepherd the crew to safety. Unusually, the game takes inspiration from board games, so you roll virtual dice to achieve objectives such as putting out a fire. This leaves things slightly more up to chance than I would like, making it hard to strategise, but no one ever said getting to Mars would be easy. ▮

Games

Red Faction: Guerrilla
Deep Silver Volition
PC, PlayStation 3 and 4, Xbox 360 and One, Nintendo Switch

Kerbal Space Program
Squad
PC, PlayStation 4, Xbox One

Tharsis
Choice Provisions
PC, PlayStation 4, Xbox One, Nintendo Switch

18+

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BIG IDEAS IN PHYSICS

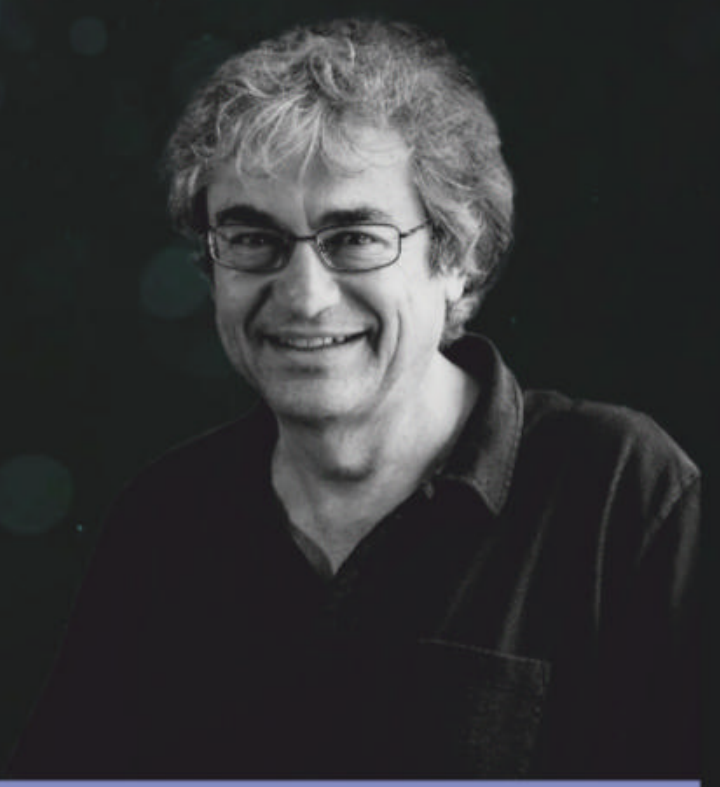
CARLO ROVELLI

MAKING SENSE OF QUANTUM THEORY

Thursday 1 April 2021 6-7pm GMT/1-2pm EST and on-demand

Quantum physics has given us many startling ideas: ghost waves, distant objects that seem magically connected to each other, cats that are both dead and alive. Countless experiments have led to practical applications that shape our daily lives. Today our understanding of the world around us is based on this theory and yet it is still profoundly mysterious.

In this talk, professor Carlo Rovelli, one of our most celebrated scientists, will tell the extraordinary story of quantum physics and reveals its deep meaning: a world made of substances is replaced by a world made of relations, each particle responding to another in a never ending game of mirrors.



For more information and to book your place visit:

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BIG IDEAS IN PHYSICS SERIES
CARLO ROVELLI

Plenty more fish in the sea?

As the world's appetite for seafood explodes, is there really a way to eat it sustainably, asks **Graham Lawton**

THE fish counter at my local supermarket has a chalkboard displaying how many different species are on sale on any given day. It is usually in the 20s, though sometimes creeps above 30. As well as staples such as cod, salmon and mackerel, it often has trout, sea bass, monkfish, langoustines, tuna, scallops, squid, catfish and flatfish.

The chiller cabinet next door has more: jellied eels and cockles in jars, mussels from Ireland, crab from Indonesia, prawns from Ecuador. In the canned goods section I can also find oysters from South Korea, crab meat from Vietnam, anchovies from the Pacific Ocean, sardines from the north Atlantic Ocean and tuna from the Indian Ocean. The freezers have yet more.

This abundance makes my head swim. I don't eat mammal or bird meat, but I do eat seafood, and I want to consume it as ethically and sustainably as possible. But I worry about overfishing and the environmental impacts of salmon farms and shrimp ponds. Most of the products on offer bear a label certifying that they were caught or farmed sustainably, or at least "responsibly". What does that mean? Who checks? Is it even possible? In other words, can I eat fish with a clear conscience?

Seafood is big business. Every year we collectively eat more than 155 million tonnes, about half of it wild-caught and half farmed. To put that in perspective, we eat about 320 million tonnes of land-reared meat a year. Yet consumption of fish is growing faster than that of meat – around 3.1 per cent a year versus 2.1 per cent. Since 1950, human population has grown by about 175 per cent. In that same time, the amount of fish we eat has increased by 750 per cent.

This demand is sustained by a fleet of 2.9 million motorised fishing vessels and a vast and growing fish farming industry. More than half of the world's oceans by surface area are now fished. Despite living on land, humans are a top marine predator.

During recent Brexit negotiations, fishing rights were a major sticking point, despite the fact that this represents a relatively small part of the economy, both in the European Union and the UK. But the importance of the issue underscores the way many feel about an inherent right to the bounty of the sea.

To learn about the impact of our appetite for fish, a good first port of call is a report published every two years by the United Nations' Food and Agriculture Organization (FAO). Called *The State of World Fisheries and Aquaculture* (SOFIA), it is a monumental undertaking. As soon as one edition is finished work starts on the next.

Sea half-empty

The picture that the latest report, published last year, paints of the world's wild marine fisheries is surprisingly positive. Nearly two-thirds of commercial stocks are classed as sustainable. That means there are enough fish to deliver the "maximum sustainable yield", which is the most fish that can be caught now and in the future without the stock becoming depleted. In other words, the annual catch is equal to the annual increase in biomass through growth and reproduction. The FAO monitors just under 500 fish stocks, which produce about 75 per cent of the global catch. Stocks are delineated both by geography and species, for example north-east Atlantic cod. By this reckoning, at least half – two-thirds of 75 per cent – of fish stocks are sustainable. Let's call this the "sea half-full" view.

Stocks of the top 10 most-caught marine species, which together account for a third of all the fish caught at sea, are more sustainable than the average. By mass, 78.7 per cent of seafood that ends up on the market comes from stocks the FAO deems sustainable.

This rather upbeat assessment, however, masks a messier situation beneath the waves. "Many countries do not have research ships to go to sea and monitor the stocks," says Manuel Barange, director of the FAO's Fisheries and Aquaculture Policy and Resources Division. Even when they do, the science is challenging. It requires an estimate of the total biomass of a species within a huge geographical area, and then an assessment of whether that is enough to support the maximum sustainable yield. The margin for error is so large that a stock is considered sustainable even if it is 20 per cent lower than needed for the maximum sustainable yield.

Even with this wiggle room, the FAO says that about a third of the fish stocks it monitors are overfished, and hence on the road to collapse if nothing is done to stop the plunder. In 1974, when the FAO first started counting, 90 per cent of stocks were sustainable. Today, just 65 per cent are. Even if the level of fishing stays the same, stocks will continue declining. This is the "sea half-empty" view. "We cannot allow this to continue," said Qu Dongyu, the director general of the FAO, at the launch of the latest SOFIA report.

The failure to stop or even slow the decline in fish stocks has happened in spite of three global commitments to do exactly that. The first was signed by all 193 member states of the FAO in 1995: the Code of Conduct for Responsible Fisheries. Next came the Aichi ›

ANTONIO SORTINO

BLICKWINKEL/H. BLOSSEY/ALAMY

PHILIPPE LOPEZ/AFP VIA GETTY IMAGES

From top: Aquaculture off the coast of Majorca, Spain; oyster farm in Arcachon Bay, France

Biodiversity Targets (2010) and then the Sustainable Development Goals (2015), which both pledged to end overfishing of wild stocks by 2020 and were adopted by the more than 190 member nations of the UN.

According to Barange, the Code of Conduct was a partial success. It slowed the rate at which stocks were slipping into the "overfished" column. From 1974 to 1995, 20 per cent of stocks flipped from sustainable to unsustainable. In the 25 years since, only another 5 per cent have become unsustainable. "We are flattening the curve," says Barange. "But not sufficiently."

The Sustainable Development Goals, however, have had no discernible impact. They are framed explicitly in terms of managing fish stocks: to end overfishing by 2020 and rebuild by 2030. The 2020 target was missed, and the 2030 one is out of reach. Recovery of an overfished stock takes two to three times the species' life span; an Atlantic cod, which is one of the most overfished species, can live for 25 years, for example. "We are making progress, but it is geographically uneven and not fast enough," says Barange.

As for the Aichi targets, forget it. The 20 goals were supposed to be met by the end of last year, but, to a first approximation, have been completely missed. The specific target for fish set out four aims: end overfishing, put recovery plans in place, eliminate significant negative impacts on threatened species and vulnerable ecosystems, and remain within safe ecological limits. None were met. Some progress has been made on overfishing and recovery plans, but on the other two there has been "no significant change" since the targets were set in 2010.

Conflicting definitions

Even where progress has been made, it is insufficient. Where fish stocks are carefully monitored and assessed and managed with an understanding of how species fit within a broader ecosystem, overfishing has stopped and recovery is under way. But only half of the world's stocks are managed like this. The other half are in poor shape, battered by unregulated, unreported and illegal fishing.

Hang on, you might think, what about the FAO's assessment that two-thirds of stocks are sustainable? There is no contradiction, says Barange. FAO and Aichi use different definitions of "stock". FAO thinks in terms of vast commercial stocks; Aichi in terms of smaller ones defined by ecology. "It depends what units you use," says Barange.

Another major concern is that sustainable doesn't necessarily mean environmentally benign. Large-scale commercial fishing, which began in earnest around 1950, can have many negative impacts on the wider ecosystem, such as the accidental catch of non-target species, called by-catch. Most of the fish, seabirds and other unfortunate creatures that are caught by accident are dead or dying by the time they are tossed back into the sea. By-catch has fallen dramatically, from about 40 per cent of the overall catch in 2000 to about 10 per cent in 2014, but it is still considered "unsustainable" by the Convention on Biological Diversity. A recent study by WWF concludes that it kills more than a million marine mammals, reptiles and birds every year.

Lost or discarded fishing equipment is also a problem. According to some estimates, between 640,000 and 800,000 tonnes of "ghost gear" is cut adrift each year, killing untold numbers of marine animals that get caught up in it.

Certain fishing methods can also take a toll. Bottom trawling, where nets are dragged along the seabed, indiscriminately disrupts and damages marine habitats, possibly even contributing to pollution by undermining the ability of sea-floor microbes to remove harmful sediments.

According to the International Union for Conservation of Nature, which keeps track of the impacts of fisheries on threatened species, fisheries have a net negative impact, and the extinction pressure they create is growing.

Even the concept of sustainability has been questioned. "The word 'sustainable' doesn't mean anything," says Daniel Pauly at the University of British Columbia in Vancouver. "You can actually overfish sustainably – you can reduce the stock to a tiny fraction of its original abundance and fish the rest sustainably. It's like cutting an immense forest, but leaving a few trees standing, which you harvest sustainably." The Canadian cod fishery once yielded 200,000 tonnes a year, for

instance. Then industrial fishing quadrupled the catch, collapsing the stock in 1992. It has since recovered somewhat, and now produces around 20,000 tonnes a year – a number that is considered "sustainable", says Pauly.

"A better question to ask is, how much of the biomass that you had in the water in 1950 is left," he says. By that measure, nearly all of the world's fish stocks are profoundly depleted. "If you look at big fish, the biomass has diminished enormously, on the order of 80 to 90 per cent."

Sustainability also often fails to take into account wider ecological factors. The langoustine fishery in the Firth of Forth in Scotland, for example, is sustainable, but only because so many other species have been fished to extinction and the langoustines no longer have any natural predators, says Pauly.

You also have to consider that fishing vessels are more powerful than they once were, says Pauly. "Even though the biomass has declined, they are able to compensate by finding the few fish that remain, and being able to operate where old trawlers would not be able to," he says. "The fact that our trawlers maintain catches is not an indication that abundance has remained the same."

If that wasn't bad enough, there is also the greenhouse gas emissions of wild fishing operations to consider. According to a recent assessment, per kilocalorie of food produced, wild-caught fish has a bigger global warming footprint than pork, chicken or dairy (see "Carbon costs of food", page 40). Trawler

FREDRIK NAUMANN/PANOS

Bottom trawler fishing disrupts seabed habitats. It is also very carbon intensive

fisheries are the worst, but that is even the case for the lowest-impact wild fisheries. It is because of the huge amount of fuel needed to power long-distance travel over weeks or months, to haul heavy fishing gear, as well as the energy costs of cooling or freezing the fish.

Overall, it is obvious that wild-caught fish come with some hard-to-swallow side orders. "The story of our treatment of the oceans is a shameful one and a very frightening one," says Tara Garnett at the University of Oxford's Food Climate Research Network.

Maybe, then, the answer is aquaculture, aka fish farming. This large and rapidly growing sector already supplies 52 per cent of the fish consumed directly by humans, and is projected to increase as demand for seafood rises but the catch from the wild stays essentially flat.

Aquaculture is the fastest-growing sector of global food production. The vast majority happens in Asia, largely for local consumption. Western consumers mostly encounter it in the form of farmed salmon or shrimp. For those consumers striving to make ethical choices, that can spell trouble.

Trouble on the farm

Fish farming has some well-known and undeniable problems, says Grant Stentiford at the Centre for Environment, Fisheries and Aquaculture Science in Weymouth, UK. Farmed shrimp, for example, mostly comes from southern and South-East Asia and Ecuador, reared in ponds that were created by destroying mangrove swamps. "There has been a loss of habitat and biodiversity in relation to those industries. I don't think anyone can really argue about that," says Stentiford. Add in the environmental cost of feeding the shrimp and freighting them to Western markets, and their calorie-for-calorie carbon footprint can sometimes exceed that of beef.

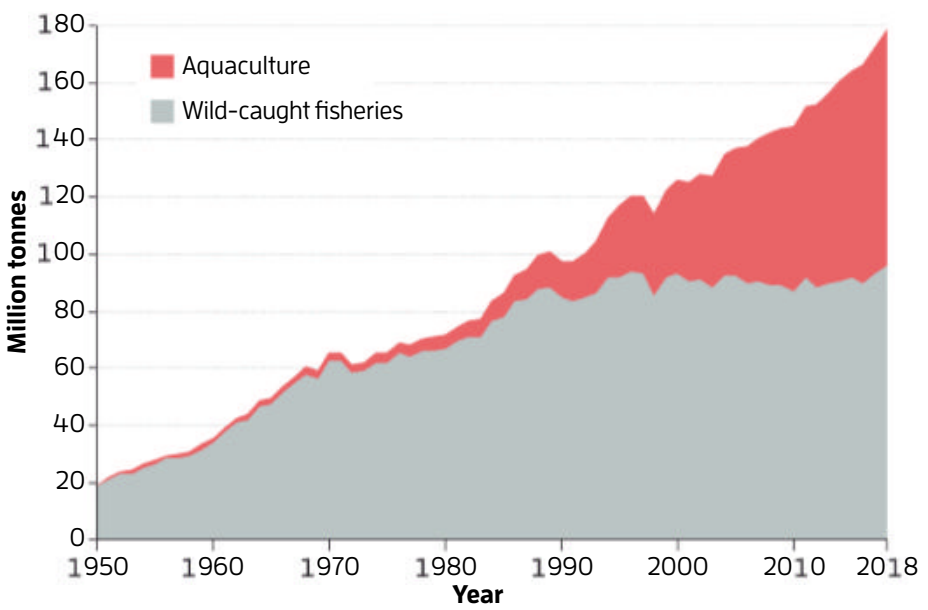
Salmon farming, meanwhile, has well-publicised problems with parasites, the overuse of antibiotics, escaped fish breeding with wild ones – potentially diluting the gene pool of wild fish and in some cases leading to sterile offspring – and pollution of the sea floor underneath the pens. Producers are aware of these problems and are trying to clean up their act, says Stentiford, but there is a long way to go.

Aquaculture is also considered in the Aichi targets, which say that by 2020 it should be "managed sustainably, ensuring conservation of biodiversity". Unsurprisingly, the target wasn't met. Although most artisanal freshwater aquaculture is sustainable, sea-based aquaculture – called mariculture – isn't. According to the latest assessment of these targets, it is responsible for "large-scale loss and destruction of coastal wetlands (especially mangroves), and pollution of soil and water".

Another huge problem with aquaculture is that, paradoxically, it often increases the pressure on wild fisheries. Salmon, tuna, sea bass and many other farmed species are top predators that eat other fish. To meet this demand, around 22 million tonnes of wild ›

Global demand for fish keeps rising

Aquaculture is rapidly expanding to satisfy the world's appetite for seafood



NOTE: EXCLUDES AQUATIC MAMMALS, CROCODILES, ALLIGATORS AND CAIMANS, SEAWEEDS AND OTHER AQUATIC PLANTS

fish are caught each year and processed into fish meal. Most of these are sardines, anchovies and other small fry that are edible for humans. To make matters worse, they are mostly caught in the waters of low-income countries, which often have food security issues, and then exported to richer countries. "This is completely insane," says Pauly. In terms of total biomass, to rear certain species requires more wild fish for feed than you ultimately get farmed fish as a result. "Aquaculture is not a producer of fish, it's a consumer of fish. In part, aquaculture is the reason why fisheries are going down."

The most egregious example is tuna farming in the Mediterranean. "Farming of tuna needs 15 to 20 kilograms [of fish meal] per kilo of tuna," says Pauly. "And when the tuna is fattened it gets a first class ticket to Japan because nobody else can afford it."

Researchers are working on solutions, but they often involve other environmentally problematic sources of protein such as soy.

As a lover of seafood, but also of nature, I was starting to despair. Thankfully, not all aquaculture is so wasteful. There is a category called "non-fed", which includes shellfish such as mussels and oysters that feed themselves and create good habitats for other marine life. "Aquaculture is two sectors that are as separate as growing vegetables and ranching cattle," says Pauly. "The things that don't need to be fed are a net addition to the seafood available to the world. Or you feed 20 kilos of sardines to a tuna to get 1 kilo of tuna."

JAMES D. MORGAN/GETTY IMAGES

Farmed shrimp is becoming more common to meet increased demand

"Not all aquaculture is wasteful – shellfish like mussels and oysters feed themselves"

For all this, fed aquaculture can still be more efficient than land-based meat production, says Stentiford. Fish and crustaceans are cold-blooded and aquatic so don't have to burn energy to heat themselves or to support their own body weight. "There is an inherent efficiency in cold water animals that is not in mammals and birds," he says. Still, in terms of overall greenhouse gas emissions, most aquaculture is roughly equivalent to the production of pork, chicken and dairy.

Trawling the aisles

Farmed molluscs aside, buying fish means stepping into a minefield of environmental destruction and social injustice. Yet it is very hard, verging on the impossible, for consumers to make informed choices.

There are several accreditation schemes for wild and farmed fish, but they are far from comprehensive. One of the best known is the Marine Stewardship Council (MSC), which prides itself on its stringent sustainability standards and tracking of supply chains. "It is incredibly complicated to actually know what you are buying," says the MSC's chief science officer, Rohan Currey. "That is the whole reason we exist."

However, just 16 per cent of the world's wild-caught fish is landed by MSC-certified fleets. The rest may or may not be sustainable, or may not have been assessed by an oversight body. It is impossible to know. And the MSC currently takes no account of greenhouse gas emissions or animal welfare. The overall impact of the MSC divides scientific opinion, with some studies finding that it promotes sustainability, but others that it mostly certifies over-exploited stocks.

So how can we be confident our seafood choices are sustainable? Even fisheries scientists struggle to know what to buy. "Even as somebody who has a fairly deep interest in this area, I don't know the answer," says Stentiford.

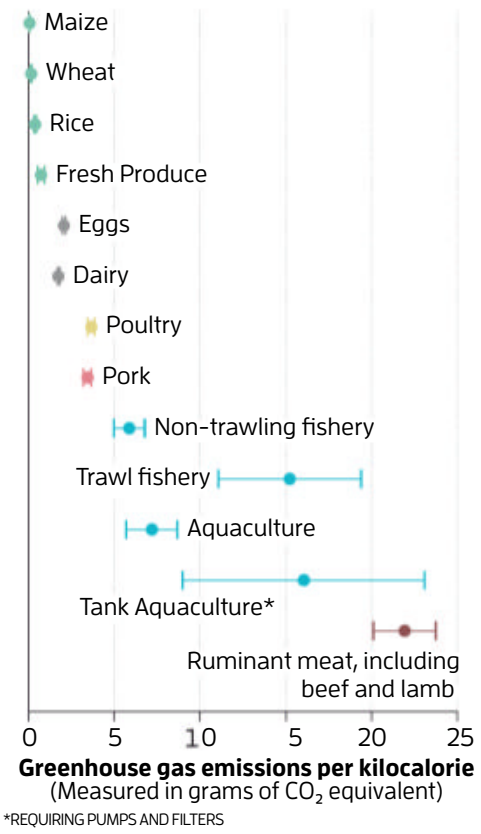
Barange also admits that it is hard, and says he just buys whatever is on the market with reasonable confidence that it is sustainable by FAO standards. Pauly passes on the question. "Frankly, I don't know," he says. It really ought to be the job of governments, not individuals, to decide what is and what isn't acceptable, he says.

Until that happens, we are rudderless, trawling the supermarket aisles with no map. But bear in mind that if you do eat fish, there's almost certainly something fishy about it. ▮

Graham Lawton is a staff writer at *New Scientist*. Follow him @GrahamLawton.

Carbon costs of food

Only ruminant meat such as beef generates more greenhouse gas emissions than farmed and wild-caught fish



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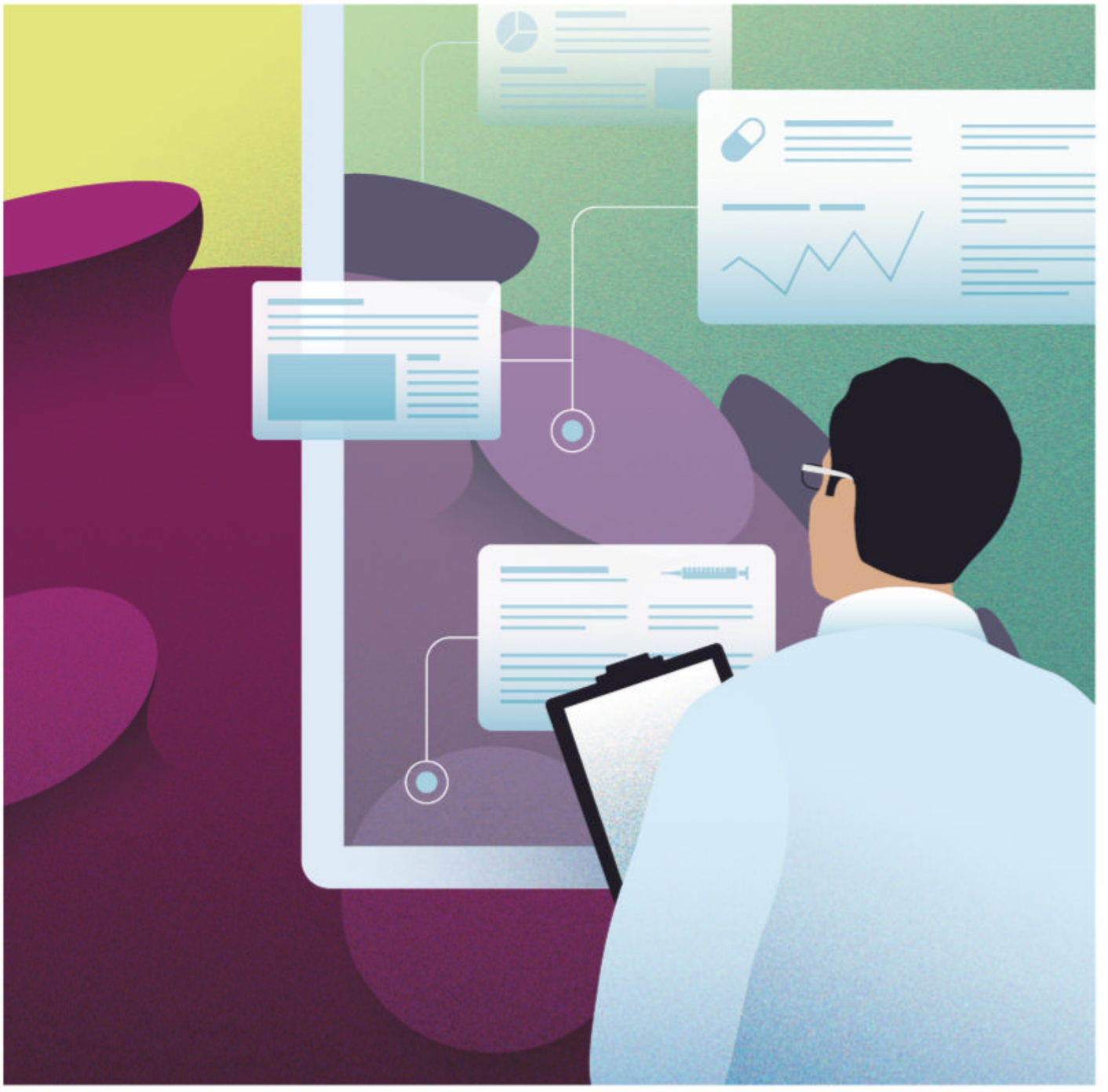


VANESSA BRANCHI

Learning to treat covid-19

Changes in how we deal with serious coronavirus infections are helping more people survive. **Carrie Arnold** reports on what is now the gold-standard hospital treatment

JEFF PACHOUD/AFP VIA GETTY IMAGES

AS MUCH as the gloves and N95 masks, Devan Kansagara's constant companion early last February was a sense of gnawing anxiety. As a physician at the Oregon Health Sciences University, he braced himself for a tidal wave of covid-19 cases. A few weeks later, it arrived. Like doctors around the world, Kansagara found himself having to care for patients with a deadly disease he knew very little about. "Everyone was grasping at straws," he says.

Ideas flooded in from all corners, ranging from the medically plausible to the utterly crackpot. Various clinical insights began to emerge from cities hit early by the outbreak such as Wuhan in China and Milan in Italy. Doctors and researchers had to decide in real time which strategies to pursue and what warranted further testing.

It all happened at a blistering pace. Doctors swapped advice over WhatsApp, Facebook and Twitter, changing clinical practice in hours instead of years. Scientists launched clinical trials, enrolled participants, analysed data and rapidly disseminated results.

Some pinned their hopes on new, life-saving medicines. Yet while thousands of drugs are being tested or are in development, few have yet proven to make much difference (see "Where are the medicines?", page 44).

In spite of this, we have made tremendous progress since those early days. Although outcomes vary by location, and new variants pose new challenges, people hospitalised with covid-19 now are much more likely to survive than they would have been at the start of the pandemic. This is largely thanks to three major changes.

The vast majority of people infected with SARS-CoV-2, the virus that causes covid-19, won't need hospital care, says Anita Simonds, a respiratory physician at the National Heart and Lung Institute at Imperial College London. But about 3.5 per cent will need to be looked after in hospital, according to data from the COVID Tracking Project and the Johns Hopkins University COVID-19 Dashboard.

A wide array of measures, from better protective gear and greater test availability, to improved understanding of transmission and the first roll-out of vaccines, have affected care for those who go to hospital. But there has been a major change in how doctors deliver oxygen. One of the big dangers that covid-19 poses is lung damage, which prevents enough oxygen from reaching the rest of the body. Most healthy people should have an oxygen saturation in their blood of between 95 and 100 per cent. In some people with covid-19, it can dip as low as 50 per cent.

That is why official policies from around the world say that people who show signs of significant hypoxia – which include shortness of breath, headache, fast heartbeat and a bluish tint to the skin – should go to hospital.

Early in the pandemic, the staggeringly low oxygen levels seen in covid-19 patients sent doctors into panic, especially as they noticed that some people could crash into critical illness within minutes to hours, says Lewis Kaplan, a critical care physician at the University of Pennsylvania. So putting patients on mechanical ventilators early in their hospital stay seemed like the best option.

"We believed that we were doing exactly the right thing," says Kaplan. "If you got really sick and were about to die, we would have to rescue you—and we would rather treat than rescue."

With experience, they began to discover that even people with worryingly low oxygen levels can sometimes manage with less invasive kinds of ventilation. Early on, nearly three quarters of patients in critical care were put on ventilators – often very soon after admission. Now it is about half that. Making the shift required many doctors to defy what they knew.

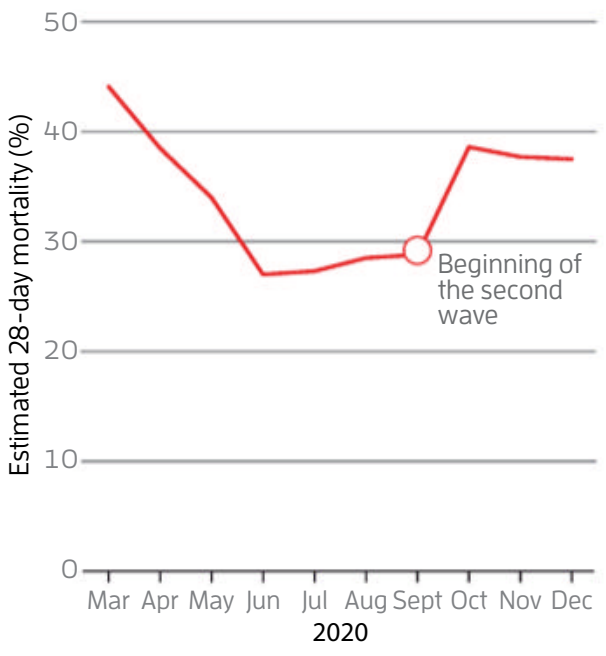
Research suggests that using less-invasive oxygen delivery methods, such as nasal cannulas and continuous positive airway pressure masks, helped doctors to reduce the number of people who needed to be sedated. But perhaps most crucially, it reserved mechanical ventilators for the very sickest ›

"People hospitalised with covid-19 now are far more likely to survive than at the start of the pandemic"

Placing people on their fronts allows oxygen to reach more of the lungs

Reducing deaths

Treatment changes have cut the number of people who die in critical care in England after having had covid-19 for 28 days, but some of those gains were eroded when a second wave of infections swamped hospitals



SOURCE: INTENSIVE CARE NATIONAL AUDIT AND RESEARCH CENTRE

The view from intensive care

Fears about ventilators are costing people their lives, **Alison Pittard** tells Tiffany O'Callaghan

As an anaesthetist and intensive care specialist, Alison Pittard has been on the front lines of the covid-19 pandemic, which she says has forced her profession to rapidly adapt how they develop new practices. As well as concern about burnout and moral injury among her colleagues, she worries that misconceptions about intensive care are driving people to turn down life-saving treatment.

Alison Pittard is dean of the Faculty of Intensive Care Medicine in the UK

Tiffany O'Callaghan: How do you decide if someone needs a ventilator?

Alison Pittard: We take each patient as an individual, look at their blood oxygen levels, their respiratory rate, how tired they are, whether it's becoming difficult for them to breathe, how distressed they are.

We have several non-invasive modes of ventilation, including kinds that help to support breathing by providing a little bit of pressure to help keep the lungs open, rather than just supplemental oxygen, so you don't have to work quite as hard to get that big breath.

If these are not enough or if the patient is becoming really distressed, then we would sedate them and insert a tube down into their windpipe and use a ventilator.

Are you able to talk patients through this?

I think people often get the impression that in intensive care everything is rushed and there are emergencies going on all the time. And it can be like that. But certainly for these types of patients, we're watching them very, very carefully and closely and can start to see when they are getting tired, that they're heading towards needing to be ventilated.

We are speaking to patients all the time, so we can say to them, "This is what we're planning on doing. It doesn't look like you're managing very well." They can often see that they're struggling, they're getting tired. It's very frightening for them. But you can have that conversation and explain what we're going to need to do.

Usually, we can see a steady deterioration and it becomes fairly obvious to us that the only option available is to sedate the patient and put them on a ventilator, because without it they would die.

How difficult are those conversations?

One thing we're finding in intensive care is that people are really scared of being sedated and ventilated because they think that it kills people. That's not the case. The disease kills you.

It's really difficult for staff when you can see a patient in front of you who desperately needs to be sedated and ventilated, but they refuse. They would rather just try and avoid it and they are adamant. And we know that if we can't do that then they're going to die.

My plea is for people to put their trust in us. Allow us to share our knowledge and experience. Take our advice. We don't want to see people die unnecessarily, and if we know that sedating and ventilating somebody gives them a chance of survival, that has to be better than no chance. We only ever want to make people better.

Where are the medicines?

There have been thousands of randomised controlled trials of prospective drugs for covid-19, but so far regulatory agencies have approved only three: the antivirals remdesivir and favipiravir, and the widely used anti-inflammatory dexamethasone (see main story).

Making sure new compounds are safe and effective medicines takes a long time, and the broad strategy has been to focus on three main kinds. This is the progress so far.

IMMUNE MODULATORS should work by reining in the body's potentially dangerous overactive immune response to covid-19, as is the case with dexamethasone. Tocilizumab and sarilumab, already approved for use in autoimmune conditions in the UK and US, have been investigated as treatments for covid-induced pneumonia in 13 countries in people over the age of 50 as part of the REMAP-CAP trial. In January, it was announced that the two drugs together reduced the need for ventilators and intensive care treatment by a quarter.

The University of Oxford's AVID-CC trial began in September 2020 to test adalimumab, which is used to treat inflammatory bowel disease and arthritis. The study was prompted by observations that people with covid-19 in care homes who were already taking adalimumab were less likely to need hospital care. That trial is still under way.

ANTIBODIES are the body's defenders. When we are infected with a pathogen, our immune system produces these proteins, which bind to the invader. This alerts the rest of the immune system to a pathogen's presence and prevents it from multiplying.

It had been hoped that injecting antibodies from people who have recovered from covid-19 might protect those who are newly infected, but trials of this convalescent blood plasma have had mixed results. The UK's RECOVERY Trial stopped recruiting people to test convalescent plasma after preliminary data showed it wasn't beneficial.

Single antibodies have also been synthesised in the lab. These monoclonal antibodies act like the proteins produced by the immune system and are being investigated both for their ability to treat infected people and to prevent infection (see "Covid-19 prophylactics", below).

The US Food and Drug Administration has granted emergency use authorisations for monoclonal antibodies from pharmaceutical firms Eli Lily and Regeneron – and two studies show that these drugs can cut hospitalisations and deaths. As yet, however, both the US National Institutes of Health (NIH) and the Infectious Diseases Society of America say there isn't enough evidence for their routine use.

A trial investigating two monoclonal antibodies synthesised by biotech firm Brii Biosciences kicked off in January to see if they can prevent hospitalisation and death at 28 days of infection. More than a dozen other studies of monoclonal antibodies are under way globally.

ANTIVIRALS work by stopping a virus from replicating. Many early hopes for a quick end to the pandemic were pinned on remdesivir, developed by Gilead Sciences to combat Ebola. Tests had shown it was safe but not effective against Ebola, but maybe would work against covid-19.

In May 2020, early results of a trial, including more than 1000 people hospitalised with covid-19, showed that remdesivir decreased recovery time from 15 to 10 days. In the US, UK and EU, the drug has been approved for hospital patients with severe disease and its use has become fairly routine. However, other trials, such as the World Health Organization's Solidarity Therapeutics Trial, including 11,000 adults in 30 countries, showed no benefit to survival. The WHO doesn't recommend the drug for any patient.

"We're trying to resolve some of these differences in data on the NIH COVID-19 guidelines panel," says Clifford Lane at the US National Institute of Allergy and Infectious Diseases.

Antiviral drugs developed for other diseases are also being investigated. Influenza drug favipiravir has been approved to treat covid-19 in China, Italy, India and Russia. HIV drug lopinavir-ritonavir unfortunately hasn't proven successful in clinical trials.

Still, broad-spectrum antivirals remain a goal. In August 2020, the Corona Accelerated R&D in Europe (CARE) consortium launched to develop monoclonal antibodies and broad-spectrum antivirals over the next five years. Even if it doesn't find anything to help this time, it will help us prepare for the next emerging infectious disease, says CARE co-leader Kumar Saikatendu at biopharmaceutical firm Takeda, a CARE participant.

"The expectation ultimately will be to create not only an effective medicine, but an affordable medicine that can be globally distributed, even to remote places of Africa and Asia," he says.

Covid-19 prophylactics

Vaccines are the best option to prevent covid-19 infections, but they still aren't widely available throughout most of the world. Even once they have been widely rolled out, there will be people who can't be vaccinated. So we need other ways to protect people from infection.

Early findings on monoclonal antibodies called casirivimab and imdevimab from pharmaceutical firm Regeneron have shown that they may prevent disease in people living in the same house as someone with covid-19. Eli Lilly's monoclonal antibody called bamlanivimab showed similar benefits to nursing home residents.

A review of other potential prophylactic drugs currently in trials was less encouraging. It primarily included existing medicines, rather than new compounds being developed specifically for covid-19, but joined the chorus of research concluding that the anti-malarial drug hydroxychloroquine makes no difference to recovery from covid-19, and that there isn't enough evidence for other drugs.

Areas in Africa where the anti-parasitic drug ivermectin is widely used have noticeably lower rates of covid-19 infections, which has inspired hopes that it could be an effective prophylactic. This is now under investigation.

ALAIN JOCARD/AFP VIA GETTY IMAGES

Using more methods to provide oxygen reserves ventilators (left) for the sickest

patients, who have no other option (see "The view from intensive care", page 43).

A second major change was born of desperation. Intensive care specialists had long known that placing sedated, ventilated people face down in the prone position makes it easier for oxygen to reach more of the lungs. Early in the pandemic, in places like Milan there simply weren't enough ventilators to go around. With no other options, doctors had people lie on their stomachs. This "awake proning" hadn't really been done before, and certainly not as a matter of routine.

Buying time

A similar scenario played out at hospitals around the world. At the height of New York's surge in early April, doctors at Columbia University had eight patients who needed mechanical ventilators simultaneously, but only enough staff to do one patient at a time. To buy precious minutes, they placed three patients in the prone position. An hour later, all three saw their breathing improve so much they no longer needed ventilators. Within days, the doctors launched a clinical trial, and other universities followed suit. Studies showed that prone positioning helped keep hospitalised patients on non-invasive ventilation from getting sicker and needing to be admitted into intensive care. It isn't just drugs that have saved lives, says Simonds.

That said, one drug has been a game changer. The third major alteration to care for people hospitalised with covid-19 came last summer in the form of a cheap, readily available steroid first used for rheumatoid arthritis: dexamethasone.

It quickly became clear that what often killed patients wasn't the virus itself, but the body's own immune system trying to fight off the infection. For some people with the coronavirus, an out-of-control immune response could cause deadly collateral damage to the lungs, heart, blood vessels, kidneys and brain. Much of the search for drugs has focused on compounds that might help tamp down this overblown response.

Early on, doctors tried medicines already approved to treat autoimmune disorders. Disappointingly, early clinical trials showed no benefit. Then in July 2020, the RECOVERY Trial at the University of Oxford posted results for the anti-inflammatory dexamethasone. Many immune modulators are precise, switching off specific parts of the immune response. Dexamethasone is a much blunter weapon – more a sledgehammer than a chisel, says Kaplan. But the study found that hospitalised covid-19 patients needing supplementary oxygen or invasive ventilation who also received low-dose dexamethasone were one-third less likely to die.

"It really did completely change everything," says Martin Landray, an epidemiologist at the University of Oxford and co-director of the RECOVERY Trial. "We announced the results at lunchtime, it was NHS policy by teatime, and it was saving lives by the weekend."

> "We announced the results at lunchtime, it was policy by teatime, and it was saving lives by the weekend"

The drug is also cheap and readily available, meaning that nearly every hospitalised covid-19 patient who needs help breathing in most high and middle-income countries is routinely given dexamethasone.

To a casual observer, it might seem that not much of significance has changed in the way hospitals treat covid-19 patients. Far from it, says Simonds. Over time, the cumulative effects of these three changes – and a variety of other small, subtle shifts in patient care – have helped reduce mortality in hospitalised covid-19 patients by about one-quarter. And many of these improvements are within reach for much of the global community. A course of dexamethasone is cheap and widely available, as are nasal cannulas. Prone positioning is free.

Now the goal is to help these standards continue to evolve as we learn more, says Janet Diaz at the World Health Organization. The sheer volume of clinical trials that emerged in the wake of covid-19 have made it challenging at times to sift the high-quality data from the rest. That makes it really difficult to make many definitive statements, says Clifford Lane at the US National Institute of Allergy and Infectious Disease. For now, physicians still rely on clinical judgement and educated guesses far more than he would like. ▮

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

"Contact with intelligent aliens would have dramatic implications for the psyche of the human species"

Harvard astrophysicist **Avi Loeb** has drawn criticism for suggesting that 'Oumuamua, a weird object that passed through our solar system, could be an alien spacecraft. But scientists must keep an open mind, he tells Leah Crane

ROCIO MONTOYA

IN 2017, something strange came hurtling through our cosmic neighbourhood. Astronomers only spotted it once it was already on its way out, so they didn't get a proper look. But from the few observations we did get, it was clear that the object wasn't from around here – its trajectory indicated that it came from another star system. It was dubbed 'Oumuamua, which means "scout" in Hawaiian, and categorised as the first interstellar object we have ever seen in our cosmic neighbourhood.

Not long after 'Oumuamua was spotted, Avi Loeb, an astrophysicist at Harvard University, made waves by proposing that it may be a piece of alien technology. "'Oumuamua may be a fully operational probe sent *intentionally* to Earth vicinity by an alien civilization," Loeb wrote in a pre-print paper.

It is certainly weird. Observations suggested it is likely to be either flat or cigar-shaped, tumbling end over end every 7 hours or so and accelerating at a pace seemingly greater than could be accounted for by gravitational forces alone. Loeb's colleagues have since come up with various natural explanations for what we glimpsed of 'Oumuamua's features, including the idea that it is some sort of giant fractal snowflake. But he is adamant we should at least be open to the possibility that it could be evidence of the existence of extraterrestrial civilisations.

Loeb has now written a book about it called *Extraterrestrial: The first sign of intelligent life beyond Earth*. Here, he tells *New Scientist* about the possibility of advanced alien life and how humans might respond to it.

Leah Crane: You say in your new book that this is your favourite question, so it seems a good place to start – are we alone?

Avi Loeb: Out of modesty, I would say no, because we know that over half of the sun-like stars have a planet of the size of the Earth, roughly the same distance from the star as the Earth is from the sun. If you arrange for similar circumstances, you are likely to get a similar outcome. So, out of modesty, I would say we're probably typical, just like ants on a sidewalk.

As far as I'm concerned, we would be likely to find evidence if we were to search, but if we assume that we will never find anything, obviously we will never discover it.

Do you think we have already seen evidence of alien life and we just haven't been able to understand?

Well, it is possible. There are many stories in the history of science that show that astronomers are very often misguided and overlook observations that they do not understand or that are not in fashionable areas of astronomy. Even though the data might have showed up in papers, in images, people just didn't pay attention, didn't try to explain it. And history repeats itself.

It sounds like the upshot is that there are so many things we have missed, either wilfully or not, that we now know are real, and the same could be true for extraterrestrial life.

Very often prophecies are self-fulfilling – ›

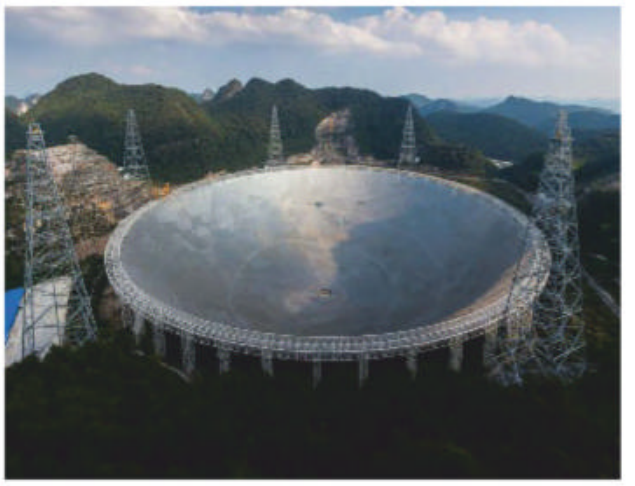
if you put blinders on and you are not checking whether your prejudice is correct or not, you will never discover you are wrong. If you are not judging your convictions by experimental data, by evidence, then you can feel very comfortable.

I remember attending a seminar at Harvard about 'Oumuamua and a colleague of mine was commenting to me: "This object 'Oumuamua is so weird, I wish it never existed." I was appalled by this because it is completely contradictory to the nature of science, where you're supposed to search for anomalies because that's the only way in which you make discoveries. If everything conforms with what you thought, if the future is the same as the past, then, frankly, I would retire very early. You don't learn anything new.

'Oumuamua was something new. Can you tell me about what you think it could be?
You have a pancake-shaped object that appeared to be at the shiny end of all the objects that we usually see from the solar system. Also, the speed of 'Oumuamua is the same as the bulk flow of the galaxy, the speed at which the Milky Way is moving through intergalactic space, almost as if the object was sitting still in the galaxy and we just hurtled through it. It could be artificial, but we know we didn't launch it because it passed by us only for a few months and there was no mission – and we couldn't even launch it at the speed that it was passing by. So, who produced it?

The most important message that I'm trying to convey is that we should be open-minded to the possibility that we might see a message in a bottle. As you walk down the beach, you see mostly seashells that are naturally produced, but every now and then you stumble across a plastic bottle that is artificial. We should be open-minded to the possibility that we'll see something artificial in space. We sent out some space junk, and we sent out Voyager 1 and Voyager 2 and New Horizons, so it's possible other intelligent civilisations have too.

The public response to the idea that 'Oumuamua could be a piece of alien technology has been extremely sceptical. Some of your colleagues have even said that such speculation is irresponsible. How do you respond to that?
It is easy to say it is irresponsible, let's not discuss it. You can make such a statement, but then look at the alternatives: let's look at the evidence and try to explain it. All the natural origins that were suggested are things that we have never seen before, so how can you argue that we should not contemplate one additional possibility that we have never seen before, which is a technological artefact? Why shouldn't that be part of the discussion if all the other possibilities are also things that we have never seen before?



STR/AFP VIA GETTY IMAGES

The new Five-hundred-metre Aperture Spherical Radio Telescope (FAST) in China will listen for signals from intelligent aliens

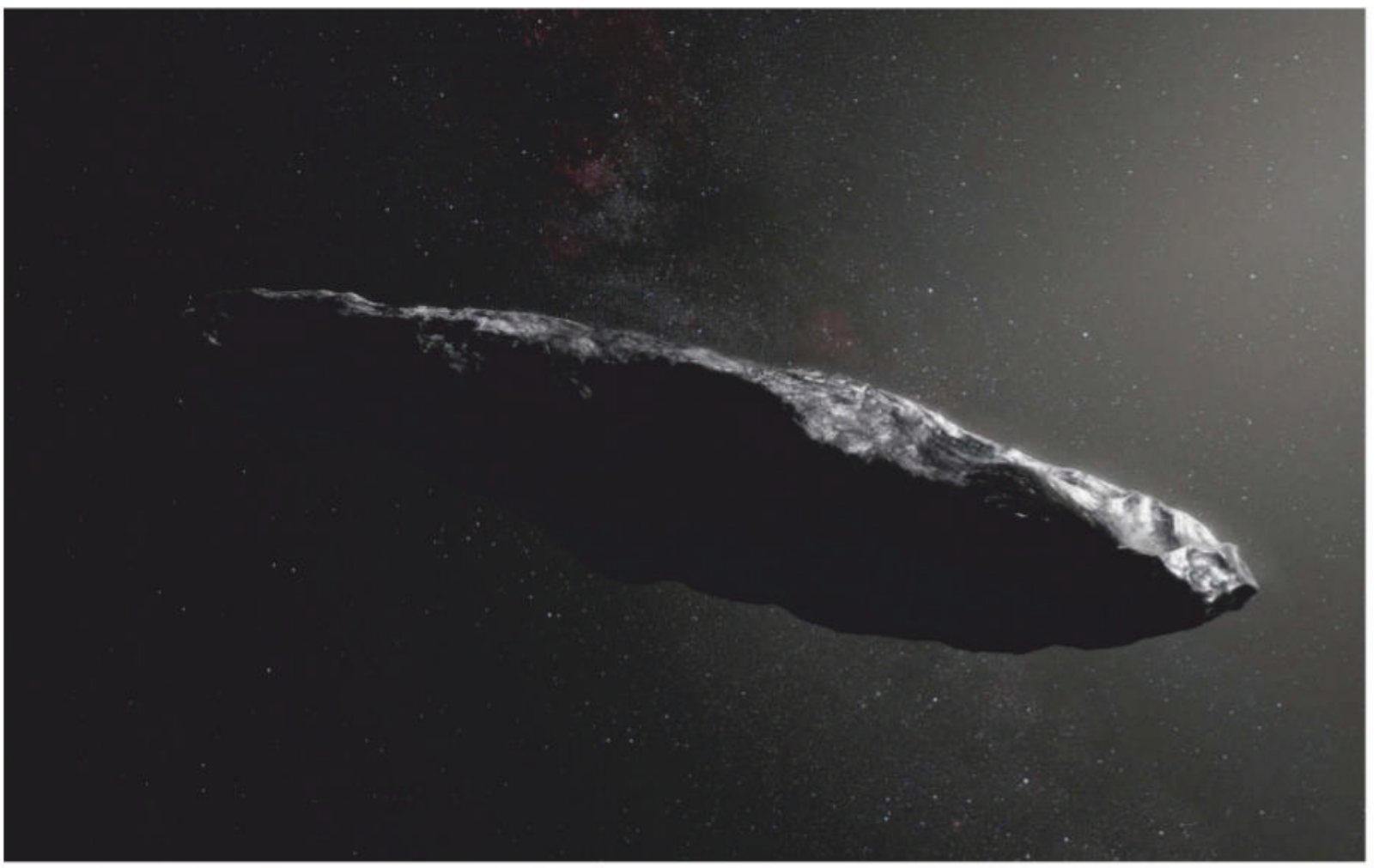
So, you are saying that since it is definitely something weird, the alien hypothesis should at least be one among several options that we are contemplating?
Yes. I don't understand why this option should be out of the vocabulary of the mainstream. In physics right now, there are lots of speculative ideas that are considered part of the mainstream.

People can still stay in their comfort zone and just ignore the anomalies and say, "I don't want to contemplate an artificial origin", but I think that our duty as scientists is to say: "No, we want more evidence, more data on future detection of such objects."

Science should be done out of curiosity, not worrying about taking risks and making mistakes. We should be transparent about it and we should be guided just by evidence and not by prejudice. We should look at the details when we decide whether one interpretation is the correct one, because the devil is in the details and you can't just make blank statements one way or another just to be in your comfort zone.

> "All the natural explanations suggested are things we've never seen before"

Do you think that there is a sense of privilege in that? You are the head of your department and you are tenured, so you can take risks with your reputation that other researchers might not be able to for the sake of their livelihoods.
Well, you might think that, and certainly having tenure is a great advantage because it gives you the freedom to pursue directions that are not necessarily popular. Unfortunately,



EUROPEAN SOUTHERN OBSERVATORY/M. KORNMESSER

An artist's impression of 'Oumuamua, a mysterious visitor from another solar system

if you look at academia, almost all people that get tenure start to worry immediately afterwards about their image, and it is more about promoting themselves than understanding nature. They will not take risks. They will just make their voice sound louder and repeat things that are already known.

Physics, or science more generally, is a dialogue. We have to listen to what nature tells us. It is not a story about ourself. It is not a monologue where we show how smart we are. It is a dialogue and we don't need to show how smart we are. If nature gives us enough clues, we just need to pay attention.

With 'Oumuamua, is it similar to the situation of a tree falling in the forest with no one around to hear it, in the sense that it could have been an artificial object but it was too far away to really know?
I heard it. If we walk on the beach and we find a plastic bottle, it means that there are lots more out there. Of course, we missed an opportunity here because we expected this to be a rock and it doesn't look like the typical rocks we have seen before. Let's admit that. Let's not ignore that. Let's embrace that and therefore search for more objects that look different than rocks. So, unless it is the only object ever to have made it into our solar system from another, and it just came at the right time, there must be a lot of them around.

So, it's not like a tree falling with no one around to hear it. It is more like we saw a log on the ground and now we can say trees fall all the time.
Yes. We should be alert to what we are seeing out there.

There seems to be a difference between how we regard the search for advanced life in the universe versus primitive life, which seems to be a pretty widely accepted scientific goal. Why?
I think there is a psychological barrier. There are several aspects to it. First, the idea that there is advanced life out there touches us at a closer level. If there is something like us or that is even more intelligent, if we are not the smartest kid on the block, if there is something out there, it is a bit frightening and it threatens your ego in some way.

If we were contacted by an intelligent extraterrestrial civilisation right now, what do you think would happen?
I think it would have dramatic implications for the psyche of the human species. First of all, it depends what the nature of that information is. Does it indicate that, indeed, there is a superior intelligence out there that is much smarter than us? Because then we can learn something from it. If we import a technology here to Earth that represents an advance, it may be like copying in an exam, but it could be very beneficial. That could be like a gold mine waiting for us to discover in the sky, if we learn about technologies that we don't possess yet.

Another type of information is if we see dead civilisations that do not exist anymore, we can figure out why they died and perhaps that will teach us a lesson to behave better, to be kinder to each other and to preserve the climate.

In your book, you make the argument that we may not be ready to deal with being visited by intelligent aliens. Can you explain?
One thing I can say by looking at the newspaper every morning is that we are not kind to each other. We do foolish things. We actually waste most of our energy and time and money on fighting each other and in directions that are not constructive.

But I do believe that space exploration offers a better future for humanity overall because it can unify us. If you go to Mars or you go to another star, there is no military threat to anywhere on Earth, so why worry about it? Let's come together. ▮

Leah Crane is a reporter at *New Scientist*. You can sign up for her weekly newsletter about space here: newscientist.com/sign-up/launchpad

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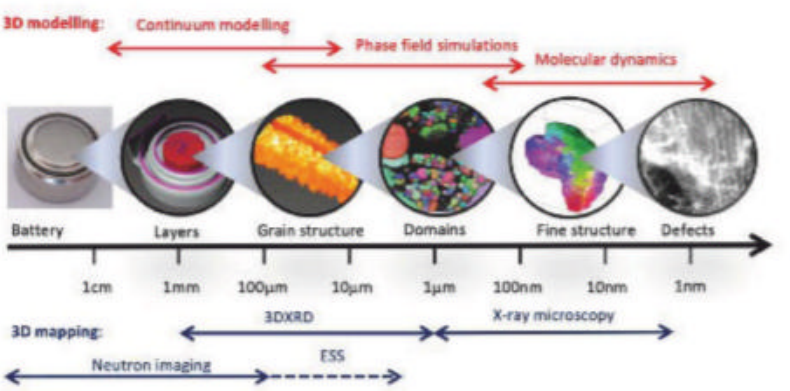

Why Denmark?

English is spoken widely and is the working language in the university. Denmark offers an attractive work-life balance, with work hard/play hard expectations. Research benefits from a deep culture of teamwork, creativity and enthusiasm in solving problems together, where students work side by side with senior scientists.

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We plan to hire 7 PhDs and 3 postdoctoral fellows within the next half year. The openings are listed below but we are open to letters of interest at any time and for future positions. To learn more about the materials, projects and people, and to start your application, we refer to the homepage: **www.solid.dtu.dk**

PhD: High pressure neutron and x-ray studies of liquid structure (Deadline 15 February 2021)

PhD: Semi-supervised learning (artificial intelligence) for volumetric segmentation (Deadline 15 February 2021)

PhD: High-Contrast Neutron Imaging for Visualising Flows in Porous Materials (Deadline 28 February 2021)

PhD: Diffraction-Based Energy-Resolved Neutron Imaging of Li-Ion Batteries under Operation (Deadline 28 February 2021)

PhD: Study plastic deformation in metals using Dark Field X-ray Microscopy (Deadline 8 February 2021)

PhD: Neutron studies of nanofluid characterization (Deadline 5 April 2021)

The back pages

Science of cooking

Marvellous mayonnaise

From eggs to mashed chickpeas, making great mayonnaise means grappling with the chemistry of emulsions, says **Sam Wong**

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

What you need

1 egg yolk
1 tbsp lemon juice
1 tsp Dijon mustard
250 ml vegetable oil

Science of cooking appears every four weeks

Next week

Stargazing at home

OIL and water famously don't play well together. Water is a polar molecule, with a negative charge concentrated around the oxygen atom and a positive charge at the two hydrogen atoms. This means that water molecules attract each other, the hydrogen atoms forming bonds with the oxygen atoms of nearby molecules. Oil, on the other hand, is made from non-polar molecules, which aren't attracted by the water molecules, so it is hard for them to mingle.

If you shake oil and vinegar vigorously enough, you can get the vinegar to be dispersed as tiny droplets in the oil, making what is called an emulsion. But they are likely to separate before long.

Chemicals called emulsifiers can make the emulsion more stable because an emulsifier molecule has one pole (or part) that loves oil and one that loves water so it can form an interface between oil and water. Mustard plays this role well in a vinaigrette, helping ensure the dressing won't separate so readily.

A vinaigrette that isn't well emulsified will make salad leaves wilt quickly, because the oil can get through the waxy cuticle of the leaves. But if the oil droplets are properly dispersed in vinegar, with the help of mustard, the leaves remain crisp for longer.

Egg yolks contain compounds called lecithins that are very effective as emulsifiers. These allow large volumes of oil to be suspended in a relatively small amount of lemon juice to make mayonnaise. Even though

TETIANA VITSENKO/ALAMY

mayonnaise is mostly oil, it doesn't feel greasy because your mouth senses only the so-called continuous phase of the emulsifying process – which is water-based.

Proteins can also work as emulsifiers, because they have polar and non-polar parts too. Vegan mayonnaise can be made using a few mashed chickpeas and some of the protein-rich liquid from a tin of chickpeas, known as aquafaba, instead of egg yolk.

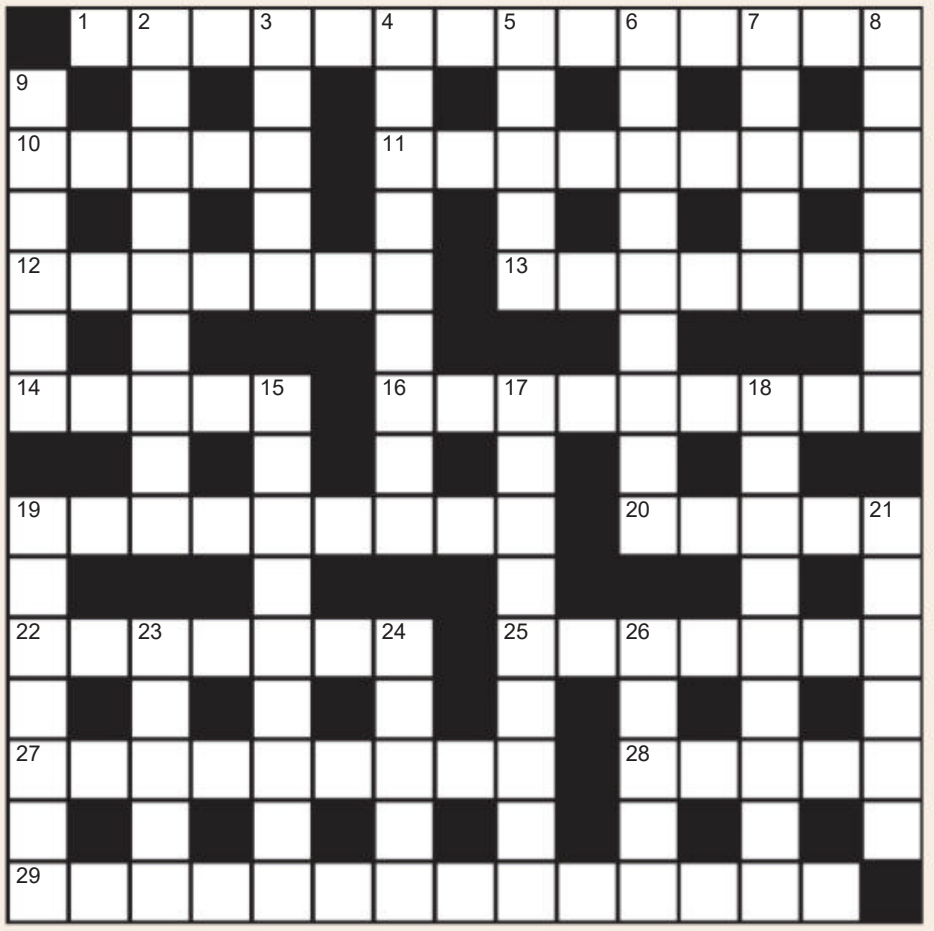
In sauces such as gravy, thickening agents like flour help to create a stable emulsion. They work differently: by increasing the viscosity of water, they prevent fat droplets from moving through the liquid and coalescing.

The traditional way to make mayonnaise starts by whisking egg yolks with a bit of mustard and lemon juice. The oil must be added very slowly and whisked in vigorously so it becomes dispersed as droplets in the water. If oil is added too quickly, it forms a continuous phase on the surface instead of an emulsion.

You can think of mayonnaise as a template for making emulsion sauces from any flavour you like. Add an egg yolk to pureed vegetables, garlic, herbs, miso paste or anchovies, for example, then add oil slowly in the same way. For a fancy finishing touch to your presentation, use a squeezy bottle to put blobs of emulsion sauce on the plate.

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

Quick crossword #76 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

1 Big-headed (14)
10 Stiff (5)
11 Charles Darwin's Kent home (4,5)
12 Part of an aircraft wing (7)
13 Temperature, in metal, of around 550 to 900°C (3,4)
14 = (5)
16 Of fur or skin, dark-pigmented (9)
19 Th, No, U, Ac and Pu, among others (9)
20 Of an angle < 90 (5)
22 Aeroplane personnel (7)
25 Pattern of lines such as those on a telescopic sight (7)
27 Mineral, Fe_3O_4 (9)
28 23, 41 or 89, perhaps (5)
29 Antipsychotic medication (14)

DOWN

2 Phencyclidine or PCP (5,4)
3 Radio-wave detection system (5)
4 Given a cryptic monicker (4-5)
5 P (5)
6 Unable to feel pleasure (9)
7 Female reproductive structure in plants (5)
8 Doubter; rationalist (7)
9 Preliminary assessment, in medicine (6)
15 354 days, 8 hours, 48 minutes and 34 seconds (5,4)
17 Ray emitted through light amplification by stimulated emission of radiation (5,4)
18 Where a road joins another (1-8)
19 Having a low red blood cell count (7)
21 5th example of 28 Across (6)
23 Blue star, ß Orionis (5)
24 Continuous vibratory sound (5)
26 Silicate mineral, $Al_2SiO_4(F, OH)_2$ (5)

Quick quiz #88

1 Which group of conditions was once known as St Valentine's malady?

2 Lovebird is the common name for which genus of parrots?

3 How many petals do most wild rose species have?

4 Oxytocin, the so-called love hormone, is produced in which part of the brain?

5 What is the primary alkaloid found in cocoa and chocolate?

Answers on page 55

Puzzle
set by Rob Eastaway
#100 Late for the gate

This deceptively tricky everyday problem set in an airport was first posed by the US mathematician Terence Tao in 2008.

You are in a bit of a rush to catch your plane, which is leaving from a remote gate in the terminal. Some stretches of the terminal have moving walkways, or travelators, and others are carpeted. You always walk at the same speed, but travelators obviously boost this.

You look down and spot that your shoelaces have come undone. This won't slow you down, but it is annoying, so you decide to stop to tie them. It will take the same amount of time to tie your laces if you are on the carpet or on the travelator, but if you want to minimise the time it takes you to reach the gate, where should you tie your laces?

What if you are feeling energetic and can double your walking speed for 5 seconds? Is it more efficient to run while on a travelator, or on the carpet?

Answers next week

Take a bet

Why do some people like gambling so much? What is the evolutionary root of this behaviour?

Hillary Shaw
Newport, Shropshire, UK
Observing bird behaviour at our garden feeding tray, it seems it may benefit animal communities to have a mix of risk-averse individuals, who will tend to dislike gambling, and risk lovers, who enjoy the thrill of gambling and, importantly, covet the potential gains and tolerate the losses.

When the bird seed is out, robins quickly arrive. Birds that are more timid wait several minutes in case there is a trap or a bird of prey. The robins' safe eating reassures the timid birds. If all were bold, the toll from predators could be higher. If all were timid, less food could be eaten.

In human communities, it benefits everyone if some daring individuals risk injury to access a resource. Either just a daring few will get killed or the timid will see it is safe to access. These mixed communities can collectively access more resources.

"No convincing evolutionary explanation has ever been put forward to explain human stupidity"

Martin Jenkins
London, UK
This question assumes that all human behaviours must have an evolutionary root. Some don't.

Some of our behaviours are based on our ability to make rational decisions, and others, like gambling, on the opposite. The gambler believes that because a bet occasionally gives a large return on investment, they can regularly achieve the same result.

This is an exciting prospect, but, as Samuel Johnson said, it is "the triumph of hope over experience", or, in other words, human stupidity, for which no convincing evolutionary explanation has ever been put forward.

The only people who really like gambling are bookmakers, because the odds are in their favour.

SYBILLE BRINZ

This week's new questions

Ice mystery **I put a bowl of water out for my cats and it froze into a tall spike (pictured). What could have caused it to freeze into this shape?** ***Sybille Brinz,*** *Aberdeen, UK*

Spider abseil **When I nudged a spider, it immediately abseiled to the floor. How did it make a strand of web so quickly, or do spiders have an emergency escape kit in their bodies? When they land, do they cut the cord?** ***Ben Timmis,*** *London, UK*

Motion mystery

Particles are in constant motion. What propels them?

Guy Cox
St Albans, New South Wales, Australia
The answer to this question puts a spotlight on two revolutionary 19th-century scientists.

In 1828, the Scottish botanist Robert Brown published his observation that tiny particles in suspension were in constant motion. His explanation was that they were small enough to be pushed around by the random motion of the water molecules surrounding them.

This, the first demonstration of the actions of individual molecules, was a radical discovery at a time when many scientists didn't believe in the existence of molecules. We now call the effect Brownian motion.

But what moves the molecules? Fifteen years after Brown's report, James Prescott Joule gave his first paper on the mechanical equivalent of heat, outlining that heat is simply the kinetic energy of the molecules in a substance. The higher the temperature, the faster the molecules move.

Why did this spike of ice form in a bowl of water left out overnight?

Joule built various experimental devices to calculate the amount of mechanical energy required to raise the temperature of a given amount of water by 1 degree. His final calculation is close to the figure accepted today.

This, again, was radical, going against the contemporary "caloric" theory of heat, and took a while to gain acceptance, especially since Joule was a wealthy brewer, not a professional scientist.

Eric Kvaalen
Les Essarts-le-Rois, France
Particles on Earth move mostly because of heat. Any material has a temperature, which is related to the energy of the atoms and molecules that make it up.

Due to the conservation of energy, if one particle loses energy, another gains energy. There can be a loss of energy by, for example, thermal radiation, but the sun and radioactive decay keep things warm here on Earth.

Yet even if a substance were cooled to absolute zero, its particles would still be moving. This is called zero-point energy and it is the lowest energy that a quantum system can have, as predicted by Heisenberg's uncertainty principle.

There are also particles in space, moving at high speeds. They just keep going because there is practically nothing to slow them down. They can continue for billions of light years.

Reading matter

Is it better for the environment to read a book or newspaper online or in a paper format?

Mike Berners-Lee
Lancaster University, UK
Reading books is a low-carbon activity, however you go about it.

A typical paperback book has a climate impact similar to that of watching 6 hours of TV, at around

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Questions should be about everyday science phenomena
Full terms and conditions at newscientist.com/lw-terms

Tom Gauld
for New Scientist

1 kilogram of carbon dioxide equivalent (CO_2e). This unit is a measure of carbon footprint, expressed in terms of the amount of carbon dioxide that would have the same impact over a 100-year period.

E-readers are slightly better than paper books, as long as you use them many times. In my book *How Bad Are Bananas?*, I estimate their carbon footprint to be about 36 kg CO_2e, so you have to read the equivalent of at least 36 paperback books (bought new, then recycled) in e-book format before the paper saving outweighs the emissions embodied in the device.

Newspapers are a bit different as there is far more paper produced per hour of reading time compared with books. I calculate that a newspaper such as the UK's *Guardian* has a climate impact of 0.37 kg CO_2e if it is recycled, but this is probably on the low side as it doesn't take into account the footprint of journalism, such as offices and flights taken by writers.

The big weekend newspapers with supplements have a much bigger impact. Getting two of these a week for a year has an impact of around 200 kg CO_2e, similar to a flight from London to Barcelona. Here, online wins. Using a smartphone to access the internet for an hour a day has an impact of 63 kg CO_2e over a year.

"E-readers are better than paper books if used many times so the paper saving outweighs the device's embodied emissions"

It is crucial to recycle newspapers because they emit the potent greenhouse gas methane when they rot in landfill sites, and for each one that isn't recycled, another newspaper's worth of new paper has to be made.

But both reading online or in paper format is a good thing to do if the content helps you become aware of the world, the climate crisis and what we can do about it. And reading itself is a low-carbon activity because it is hard to shop or drive while you read.

Cover-up

When you wash a duvet cover, why does other washing end up in it? (continued)

Keith Macpherson
Clevedon, Somerset, UK
In a previous response (31 October 2020), David Muir showed that, during his washing cycle, an average of 4.6 out of 10 socks migrate into a duvet cover and 5.6 out of 10 escape.

However, his research leads to an even more interesting thought: during a wash, many socks must be transiting in and out all the time and all we see is the final result.

Talia Morris
Cape Tribulation, Queensland, Australia
Previously, Brian King described duvet covers as "textiferous (the textile equivalent of a carnivore)".

Textiferous means bears or carries fabric. The term should be "textivorous" (eats fabric). Trust me, I'm a linguist. ▮

Answers

Quick quiz #88 *Answers*

1 Epilepsy

2 *Agapornis*

3 Five

4 The hypothalamus

5 Theobromine

Cryptic crossword #50 *Answers*

ACROSS 1 Surfactant, **7** Tudor, **8** Burette, **10** Strains, **11** Volta, **12** Enough, **14** Elicit, **16** Avert, **17** Uranium, **19** Tactile, **20** Laser, **21** Permafrost

DOWN 2 Undercover cop, **3** Fermi, **4** Cubist, **5** Arrival, **6** Total eclipses, **7** Tesseract, **9** Elastomer, **13** Gutsier, **15** Eureka, **18** Adler

#99 Around the clock *Solution*

It is 2 o'clock. We don't know how many numbers are in the right position, but we are told that if we did know this, we could work out the time.

There are several orientations in which no number is in the right place. If just one number is in the right position, it could be 1, 3, 6 or 10. If three are in the right position, then those three might be 4,9,11 or 5, 7, 12. However, if two are in the right place, those numbers can only be 2 and 8.

The hour hand is pointing at 2 which is in the correct position, so the time is 2 o'clock. If the pranksters have painted XI and IX upside down, there is still only one pair of numbers that could be in the correct position.

Super spinach

Spinach is a disappointing vegetable. Nana Feedback's early attempts to wean us on to the slimy green stuff by pointing to Popeye as a role model were undermined by our discovery that its iron content has regularly been overstated by a factor of 10, chemist Erich von Wolf having once fatally misplaced a decimal point in the 1870s.

Hence our arched eyebrow at a headline in *Euro News*, "Scientists have taught spinach to send emails and it could warn us about climate change". Indeed, this turns out to be a limp reheating of research from 2016, reported at the time by *New Scientist*, of spinach plants genetically engineered to fluoresce when they encounter certain chemicals in the soil. The emails are sadly not directly typed, but sent automatically by infrared detectors trained on the spinach. Nice try.

Very fun and forward looking, on the other hand, is a recent paper in the journal *ACS Omega* linked to in the *Euro News* story, "Spinach-Derived Porous Carbon Nanosheets as High-Performance Catalysts for Oxygen Reduction Reaction". Xiaojun Liu at the American University in Washington DC and his colleagues used a recipe involving spinach, melamine and salt – oddly, three substances much in use in Nana Feedback's 1970s kitchen – to fabricate porous carbon nanosheets doped with spinach's trace-metal goodness. They suggest the spinach-based sheets could be layered into future metal-air batteries, taking the place of expensive platinum-based catalysts.

We wholeheartedly approve, having read of wider movements to mine precious metals from plants recently in these pages (9 January, p 42). Meanwhile, platinum-based catalysts are just the thing to give that lasagne an added zing.

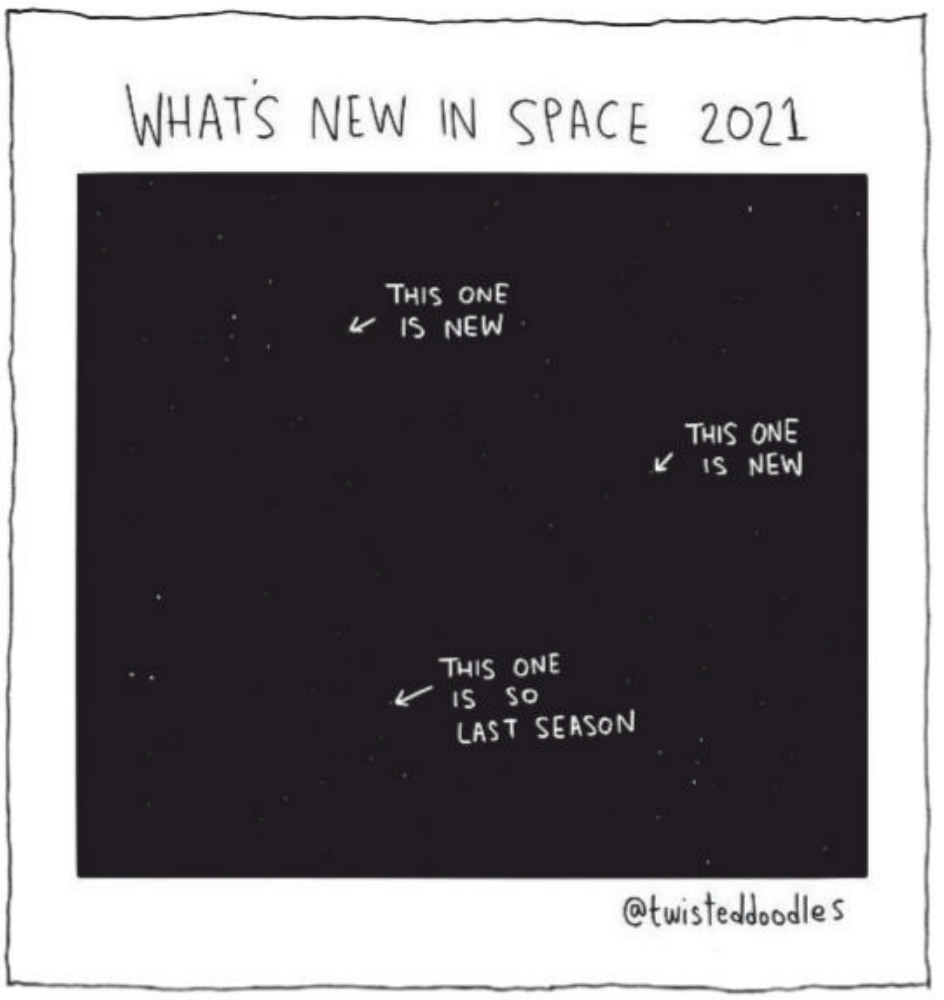
By any other name

As we pick the remnants of that story from our teeth, Simon Goodman from Griesheim, Germany, arrives with dessert, and a story about the chocolate that is too chocolatey to be called chocolate. The confectioner Ritter has produced a new line called "Cacao y Nada" whose sweetness is derived entirely from the mucilaginous pulp that surrounds the beans within a cocoa pod. This falls foul of Germany's notoriously strict food and drink regulations, which stipulate that for a product to be called chocolate, it must contain sugar. So a "cocoa-fruit bar" it is instead.

Admirably consequential, in an inconsequential kind of way. The *Frankfurter Allgemeine Zeitung* quotes Ritter's CEO Andreas Ronken saying: "If sausages can be made of peas, chocolate doesn't need sugar. Wake up! This is the new reality."

Sausages made of peas? That really would be a wurst-case scenario.

Twisteddoodles *for New Scientist*



Got a story for Feedback?

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

Ethical animals

Feedback recently expressed confusion as we tried to envisage Australian printer cartridge waste expressed in multiples of northern hemisphere blue whales (30 January). As a magazine-backwards reader, we weren't to know of the byzantine analogies being served up just a few pages further on.

In a "Green and Ethical Checklist" advertorial, Jan Rossiter points out, payment provider EML committed to cut plastic consumption in payment cards by "the weight of 56 elephants, 10 humpback whales, 1,250 lions and the height of 5,000 giraffes across its global portfolio".

Giraffes don't tessellate well in our recollection, and we join Jan in straining to picture 5000 of them stacked up. Moreover, while accepting the portfolio is global, we consider it neither feasible nor wise to bring all those animals together in the same place at the same time.

This big boulder

Linda Jared draws our attention to a no-nonsense approach to matters of scale adopted by the San Miguel sheriff's office in Telluride, Colorado. "A large boulder the size of a large boulder is blocking the southbound lane Hwy 145 mm28 in Stoner Creek area of Montezuma County," the office tweeted on 5 February. "Expect delays. #largeboulder."

We note this follows on from the same account tweeting on 27 January of a "Large boulder the size of a small boulder" blocking the same highway some 80 kilometres further on. Fortunately, there is a picture of the offending rock with a sheriff's car parked close by for scale. Although we are unsure whether it's a large or small sheriff's car. That rather depends on the size of the boulder.

Wandering whale

London-based singer Ebony Buckle has garnered acclaim from the likes of *Earmilk* and *Atwood Magazine* to name a few, and we reject the assertion that we aren't cool enough to know that and are just reading from a press release.

Buckle's latest work, *Wonder*, is inspired by the story of Whale 52, the "world's loneliest whale". Its distinctive, unique 52-hertz song was first heard in the north Pacific in 1989 – although the last time we checked in on the story, age and the slackening of vocal cords had lowered the call's frequency to 47 hertz (19 March 2016, p 35).

We are unqualified to assess Buckle's spine-tingling vocals, floating delicately atop minimalistic, ethereal melodies, creating an almost hypnotic effect. But the visuals of an intergalactic floating whale searching for its home planet truly did, as advertised, transport us to another dimension and leave us there. What we'd really like to know, however, is how big the whale is. ▮

New Scientist Podcast

New Scientist Escape Pod

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

This lockdown podcast doesn't include any references to coronaviruses or other unpleasant happenings on the planet below. The Escape Pod is pure, well, escapism. Sit back, relax and let hosts Rowan Hooper, Anna Demming and Timothy Revell whisk your mind away to worlds of inspiration and distraction.

And when you're ready to come back down to Earth and hear about what's going on in the world, don't forget the *New Scientist* Weekly podcast – your audio guide to all the essential science news of the week.

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