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WEEKLY April 11-17, 2020

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Astonishing rise of world's hardest bird

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The three potential paths out of this pandemic

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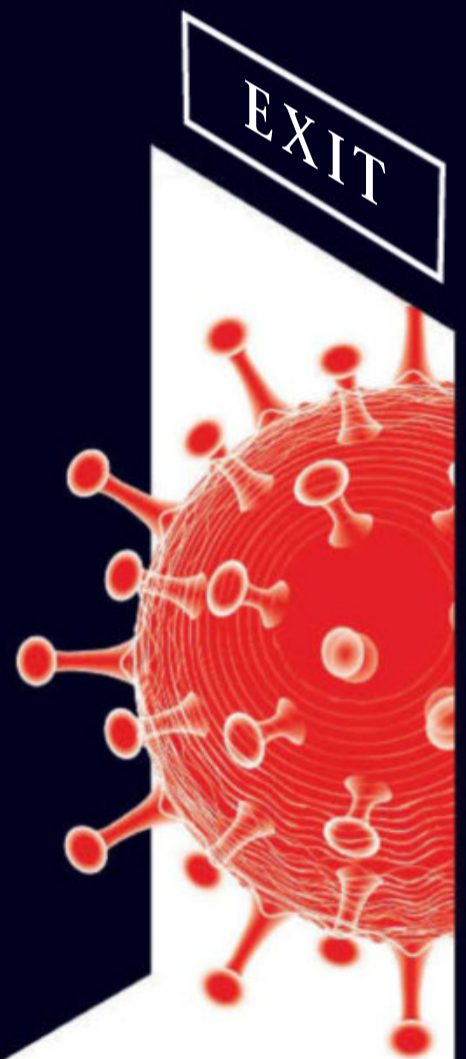
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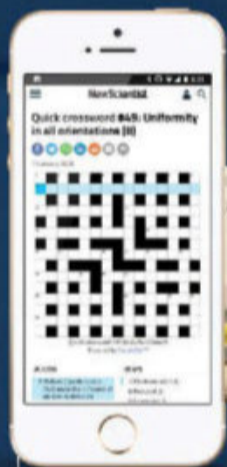
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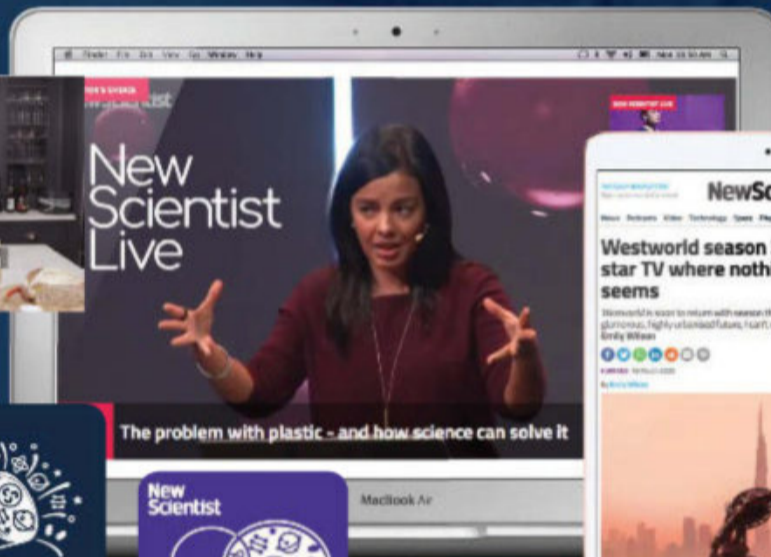
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Endings are hard

Coming out of lockdown will require difficult decisions

ALTHOUGH the UK and many other countries are still on the upward curve in terms of covid-19 cases and deaths, in scientific circles, thoughts are already turned towards how we can end the lockdown and return to a semblance of normality.

It is a crucial endeavour, but it isn't a simple one by any means. The world can't remain in lockdown, yet millions and millions of people remain very vulnerable to the coronavirus. Added to this, a possible vaccine is a long way off, if indeed we ever get one that is useful. So how do we get out of the current situation and resume our former day-to-day lives?

As we report on page 10, there are essentially three ways of achieving this. None of them is risk-free or cheap, and all will require life-and-death decisions:

essentially, who will bear the brunt of a near-inevitable second wave of infections? Another lockdown may well have to be put in place if case numbers start to shoot up again.

The execution of such a strategy is weeks away in the UK, but the decision

"The execution of a strategy to end lockdown is weeks away, but the decision on how to do it needs to be made now"

on which method to pursue needs to be made now, so that adequate preparations can be made. It also needs to be communicated expertly and well in advance – especially the part about the possibility of having to reimpose restrictions if a second wave of infections takes hold.

There is currently no globally agreed exit strategy. Individual countries are largely going it alone. That isn't wrong, because the situation varies from place to place, but some form of global cooperation will be needed: for example, to allow travel and trade to resume.

Meanwhile, the global situation is about to change in ways we can't predict as the virus takes hold in poorer countries. As we explore on page 8, low-income economy countries will face different challenges from those seen in the relatively rich countries hit worst so far. To take one example, Uganda has 0.1 intensive care unit beds per 100,000 people compared with 34.7 in the US. In other nations, slums and refugee camps, where isolation is well-nigh impossible, are a big concern. The full impact of this pandemic has yet to emerge. ■

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A healthcare worker in New York, the worst-hit US state

Imperial College London have estimated the number of missed cases in China based on how many people who were evacuated from Wuhan tested positive. They concluded that the infection fatality rate in China is 0.66 per cent (*The Lancet Infectious Diseases*, doi.org/ggqn5t).

Julien Riou at the University of Bern in Switzerland instead assumes that all covid-19 cases among people over 80 are being detected. His team estimates that the infection fatality rate in Italy is 3.3 per cent, rising from 1 per cent among people aged between 50 and 59 to nearly 90 per cent in those aged 80 or above. For China and Spain, the overall rate is 3 per cent. If half of cases in those over 80 are being missed, it would halve these figures, says Riou.

Jason Oke at the University of Oxford thinks not all of the deaths attributed to covid-19 are caused by it. He points out that while there is an excess of deaths in Italy according to EuroMOMO, a public health monitoring organisation, it isn't as large as that during the last bad flu season in 2016. His team thinks the infection fatality rate could be as low as 0.1 per cent.

But on 1 April, the EuroMOMO website had a highlighted warning against drawing such conclusions based on its data. While that warning has since been removed, it still states that the "number of deaths in recent weeks should be interpreted with caution".

What's more, it has also been reported that one badly hit town in Italy called Nembro has had 158 deaths so far this year compared with an annual average of 35 for the past five years. Only 31 of the 158 deaths were recorded as due to covid-19.

For now, we still can't say for sure what the infection fatality rates are. This will start to become clearer if antibody testing can reveal who has been infected in the past, and thus the number of missed cases. ■

Death rate mystery

Knowing the true rate of death from covid-19 will help us fight the pandemic, but for the moment it eludes us, reports **Michael Le Page**

AS FIGURES pour in, the estimates of covid-19's death rate still vary wildly, from as low as 1 in 1000 to as high as 1 in 30.

That is because the risk depends on your age, sex, health and the care you receive. In other words, death rates will vary from place to place and over time.

In the UK, as of 5 April, 4934 people had died out of 47,806 confirmed cases – a crude case fatality rate of around 10 per cent. For Italy, the figure is 12 per cent and for Germany just 1 per cent.

These figures don't tell us how many of those who are infected will die, known as the infection fatality rate. That's because crude case fatality rates don't take into account the fact that some of those

counted in the confirmed case numbers haven't recovered yet and may still die. Early in March, for instance, South Korea had a crude case fatality rate of just 0.6 per cent. That has risen to 1.7 per cent. Among resolved cases – those who have died or recovered – the case fatality rate in South Korea is 2.9 per cent.

Age is a factor, says Melinda Mills at the Leverhulme Centre for Demographic Science in the UK. In South Korea and Germany, the first people to be infected were mostly younger. Based on what is happening in Italy, Mills and her

colleagues calculate that if 10 per cent of people become infected, there would be 302,530 deaths in Italy, with its ageing population of 61 million, but 142,058 deaths in Nigeria, with its much younger population of 191 million.

If lots of infected people with mild or no symptoms are being missed, the infection fatality rate will be much lower than the case fatality rate. For example, the UK is testing only severely ill people and missing mild cases, but South Korea and Germany are testing more widely.

Neil Ferguson and his team at



Coronavirus daily update

The latest news, every weekday at 5pm GMT
[newscientist.com/coronavirus-latest](https://www.newscientist.com/coronavirus-latest)

Low-income economies

An uneven pandemic

Coronavirus will play out very differently in the world's poorest nations

Adam Vaughan

THE coronavirus may prove disastrous for the world's poorest people, including those living in slums and refugee camps.

Cases were slower to appear in low-income economy countries, but as *New Scientist* went to press, almost nowhere had escaped the pandemic. Pakistan is one of the worst hit countries in south Asia, with more than 3000 cases as of 6 April and troops deployed across cities to enforce a national lockdown. Elsewhere, Haiti, the poorest country in the western hemisphere, has reported 21 cases.

In Africa, most cases have been in relatively affluent South Africa and Egypt, but other countries are seeing rises too. Burkina Faso now has more than 300 cases, Senegal 219 and Ghana 205. Across the continent, there are now more than 9000 cases.

The impact of the virus in many low-income economies is likely to be very different to richer ones such as the UK, says Azra Ghani at Imperial College London.

Demographics are one big difference. The world's poorest typically live in households containing more people, with all generations living together in daily contact, in contrast to countries like the UK where older people are to some extent already socially distanced from younger ones.

“Uganda has 0.1 intensive care unit beds per 100,000 people, versus 34.7 in the US”

As a result, infections are likely to be spread more evenly across all age groups. “That in a sense makes everybody more at risk,” says Ghani.

However, as covid-19 seems to hit older people hardest and low-income economies have much younger populations, death rates



MADEEM KAHWER/EPA-EFE/SHUTTERSTOCK

may be lower, she says. “We’d expect more infections in low-income settings but there’d be less severe cases.”

Most of the data we have on the virus is coming from countries like China, Italy and the US. That means we simply don’t know how much the mitigating effect of a younger population in lower income economies will be offset by populations being more malnourished and already handling other diseases, such as malaria, HIV and TB, says Ghani.

In Latin America, countries will have to deal with other overlapping epidemics, including dengue and measles related to migration out of crisis-hit Venezuela, says Alfonso Rodriguez-Morales at the Colombian Association of Infectious Diseases.

In Africa, testing rates are

rising and are now in the tens of thousands, says Kevin Marsh at the African Academy of Sciences, up from around 400 three weeks ago. But he says information is generally scarce.

Ventilation not an option

Treatment will also be different in much of the continent, says Marsh, because ventilation is usually not an option. Uganda has 0.1 intensive care unit beds per 100,000 people, compared with 34.7 in the US, for example.

The prospect of ventilator manufacturing being scaled up in six weeks or hospitals being rapidly built, as has been done in some countries, is unrealistic, he says, so more people, mostly older, will die at home.

Ghani is concerned that the impact of the coronavirus on

A man donates blood in Hyderabad, Pakistan

healthcare in low-income economies will divert resources away from other deadly diseases. She is already aware of malaria bed nets not being delivered in some countries as a result of the crisis, for example. Previous epidemics, such as the Ebola outbreak in West Africa between 2014 and 2016, killed many people indirectly this way.

Lockdowns in low-income economies should cut transmission as they have in higher income ones. But in practical terms, shielding the oldest and most vulnerable will be “very difficult”, says Ghani, due to a lack of space in homes. Low-income economies can also ill afford such stringent shutdowns.

“Extreme population-wide social distancing and travel restrictions, if sustained over a long period, could be very harmful for fragile, export-dependent economies and stretch livelihoods beyond people’s coping ability,” said Francesco Checchi at London School of Hygiene and Tropical Medicine, writing in a blog post.

Some of those people will be the cleaners and security guards commuting on packed minibuses from informal settlements. This week, Dharavi, a slum in Mumbai, India, that is home to more than a million people, reported its first death linked to the coronavirus.

Between 900 million and a billion people are estimated to live in such informal settlements, often in high-density areas. Typically, three to five people share a room, with families sharing one toilet and, in some cases, a water tap.

“Isolation is virtually impossible in those

Risk factors

Does a cell protein explain covid-19 severity?

Jessica Hamzelou

circumstances,” says Diana Mitlin at the University of Manchester, UK. “It’s a pretty terrifying scenario.”

A high risk of the virus spreading extremely rapidly in informal settlements is combined with the fact many people will already have persistent coughs – a key covid-19 symptom – from cooking indoors with charcoal.

Then there is the alarming prospect of the virus entering refugee camps, which house between 8 and 9 million people globally. Paul Spiegel and Shaun Truelove at Johns Hopkins University have modelled what impact that would have on the 600,000 Rohingya people living in a camp in Bangladesh. They found that up to 544,000 could be infected in a year, with potentially more than 2100 deaths.

The youthful population explains the relatively low mortality rate given the high case numbers, but Truelove says this is a best-case scenario. People in refugee camps may already be malnourished and may not be allowed into intensive care units at nearby hospitals, so death rates could be higher.

Social distancing efforts are under way in this camp, says Spiegel, including reducing queues for food distribution. But with high densities and uneven access to water, he fears for refugees and warns that camps aren’t impervious to the virus.

No reports of the virus in camps have reached Spiegel, but he says he wouldn’t be surprised if refugees had already been infected.

“The one positive thing is often refugees are blamed falsely for bringing in diseases, and it’s clear here no one can be blaming refugees and migrants for this particular disease,” he says. ■

DOES a protein on the surface of some of our cells explain why certain people are more at risk from covid-19?

Studies of confirmed cases so far show that people with coronary heart disease or diabetes are more likely to die than other people if they catch the coronavirus. Individuals with lung disorders, such as chronic obstructive pulmonary disease (COPD), and smokers are also at greater risk, says Janice Leung at the University of British Columbia in Canada.

As we begin to understand the virus better, focus is turning to a protein called ACE2. The coronavirus attaches to this receptor protein on the surface of our cells to gain entry to them. The protein is carried by cells in the nose, lungs and gut.

It is possible that variation in how much of this protein people have may help explain why some are more likely to die from covid-19. When Leung and her colleagues looked at lung tissue samples from volunteers, they found that the cells of smokers

and those with COPD make much more ACE2 (medRxiv, doi.org/dqx2).

This may explain why these people are more likely to have severe covid-19 infections, says Leung. “If you ever needed another reason to stop smoking, this would be it,” she says.

People with diabetes also seem to produce more ACE2. But we don’t know yet if ACE2 levels really do have an effect on coronavirus infections.

“People with coronary heart disease or diabetes are more likely to die of the coronavirus”

The link between covid-19 deaths and diabetes and cardiovascular and heart conditions has led to some concern over ACE inhibitor drugs. These drugs, which are used to treat high blood pressure, coronary artery disease, heart failure and diabetes, work by targeting the ACE enzyme – a different protein, but one that works alongside ACE2 to regulate blood pressure.

A study of 106 people with covid-19 by Yong Xiong at Zhongnan Hospital of Wuhan

University, China, and his colleagues found that having hypertension, diabetes or cardiovascular disease was linked to patients clearing the virus from their bodies more slowly.

The team suggests that ACE inhibitor drugs taken by some of these patients may have increased their levels of ACE2, providing the virus with more opportunities to dock onto their cells, although the study didn’t show whether this was the case (medRxiv, doi.org/dqx3).

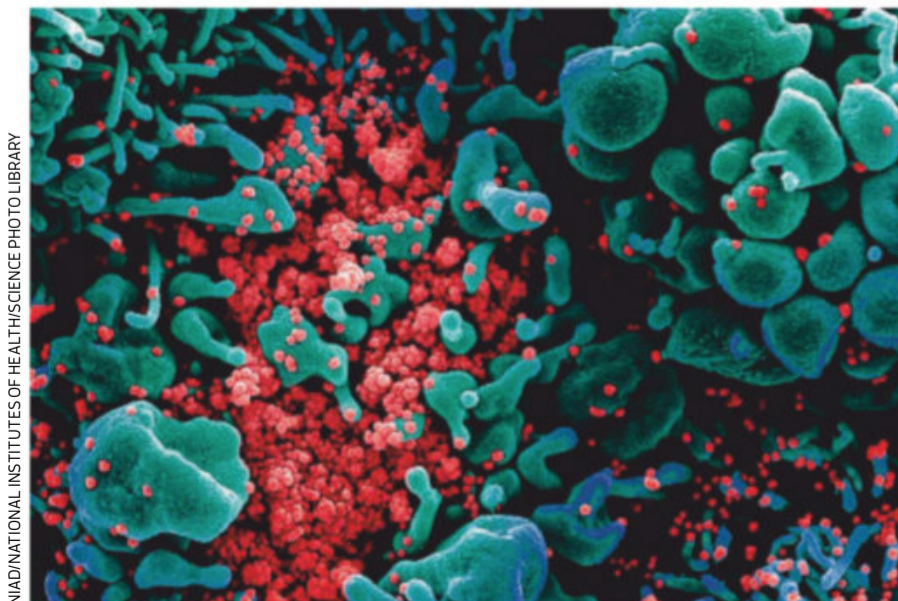
Just as we don’t yet know if ACE2 levels contribute to symptom severity, we also don’t know if taking ACE inhibitors has a negative effect. All we can really say so far is that people with certain conditions are at higher risk of death from covid-19, and that these people are likely to have higher ACE2 levels and also be taking ACE inhibitors.

Because no clinical studies have so far shown that ACE inhibitors raise the risk of covid-19, many organisations, including the American Heart Association and the European Medicines Agency, recommend that those prescribed these drugs continue to take them.

Ultimately, ACE2 might be a good target for drugs to block infection by the virus, but we don’t yet know if interfering with the protein would be safe. Several studies in mice suggest that ACE2 plays an important role in responding to injury in the lungs, so blocking its function might prevent such injuries from healing.

“We know a little bit about ACE2, but we clearly don’t know enough to actually say anything intelligent yet,” says Jose Ordoñas-Montanes at Boston Children’s Hospital in Massachusetts. ■

Particles of the new coronavirus, in red, emerging from an infected cell



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Exit strategies

How do we leave lockdown?

With more than a third of the world living under covid-19 restrictions, it is time to decide what happens next, reports **Graham Lawton**

BANS, curfews and wide-reaching restrictions. For many people worldwide, severe limitations on daily life because of the coronavirus have become the new normal. But as we adjust to these measures, what prospect is there of returning to the old normal? What is the world's exit strategy?

If you are hoping for a return to your old life, there is good news and bad news: it will happen, but not necessarily soon. "It is absolutely the case that government advisers and researchers are considering the question of an exit strategy," says epidemiologist Mark Woolhouse at the University of Edinburgh, UK. But what different nations' exit strategies will look like, how long we will have to wait for them, and whether they will work, are all still up in the air. In addition to this, a lack of coordination at the international level could spell trouble when the time comes.

The lockdowns that many nations are enduring are a short-term strategy to reduce the average number of subsequent infections each covid-19 case causes, in order to stop the rate of infections increasing exponentially. This is known as "flattening the curve". The approach is intended to prevent hospitals being overwhelmed, which should lessen the death count. It also buys time to develop new treatments and better understand the infection.

Lockdown isn't a long-term strategy, however. "We want to get out of lockdown because of all the damage it is doing to society as a whole, economically and psychologically," says Woolhouse. But there is a risk

to lifting restrictions that have successfully flattened the curve: the curve unflattens and the rate of infection returns to exponential growth. "We want to get out, but we don't want the epidemic to take off again," says Woolhouse.

In other words, the two things we want to achieve – a flat curve and an end to lockdown – are incompatible. Devising an exit strategy, then, becomes a question of determining the best time to lift restrictions, and the action to take to keep infection rates under control.

One thing is clear: we can't bank on a vaccine getting us out of this. It will take many months to develop an effective one – if we

manage it at all. "I do not think waiting for a vaccine should be dignified with the word 'strategy'. It's not a strategy, it's a hope," says Woolhouse.

So how do you get out of lockdown without unleashing

"Waiting for a vaccine shouldn't be dignified with the word 'strategy'. It is just a hope"

a dangerous "second wave" of infections among people who weren't exposed to the virus the first time round? A second wave like this is "highly likely", says Susy Hota, medical director of the infection prevention and

control programme at the University Health Network in Toronto, Canada.

Any second wave will probably be less severe than the first, says Woolhouse. "With any newly emerging virus, it's the first wave that is the worst. After that, it will settle down and become much more manageable." For example, since the 2015 to 2016 Zika epidemic, subsequent outbreaks have tended to fizzle out due to the detection and control measures now in place, plus a degree of immunity.

Exit strategies therefore have to include a plan to manage a second wave. Broadly, there are three ways to do this: we can



People applaud health workers in locked-down Madrid, Spain

call them hold, build and shield.

The hold strategy plays the long game: lockdown until the rate of new infections falls close to zero, then lift the lockdown and pivot to an aggressive containment strategy. That means diagnosing second-wave cases as quickly as possible, isolating them, tracing their contacts and isolating them too, if necessary, to cut all new lines of transmission.

That requires building the capacity to do far better containment and contact tracing than most countries managed the first time round. Waiting for the infection rate to be near zero also risks having to impose lockdown for a long time.

Increasing capacity

The second strategy, build, buys time for health services to recover from the first wave and build capacity to deal with the second. In richer nations, health services' limiting factors are intensive care beds and staff. So this strategy involves locking down for long enough to recruit enough of both, then releasing restrictions gradually and dealing with the second wave, hopefully with a much lower mortality rate. But how much intensive care capacity is enough to achieve that? It is a difficult question, and a wrong answer could cost many lives.

Option three, shield, is to end a lockdown abruptly while extensively protecting those who are likely to be most vulnerable to the virus. This means finding ways to ensure the safety of older people and those with health conditions that make them more likely to get seriously ill and die. Pulling this off requires widespread community screening to find out who is infectious – especially

people with no symptoms – and making sure they don't come into contact with vulnerable people.

Another element of this is developing antibody tests to identify medical staff and care workers who have recovered from the virus and may therefore be at a lower risk of infecting others.

The overall effect would be to reduce critical cases and deaths, and hence take pressure off hospitals while allowing herd immunity to build up in the less-vulnerable population. Covid-19 can kill younger people without other health conditions, albeit not often, but if shielding can reduce the number of cases among more vulnerable people, healthcare services should be better placed to treat these.

Choosing between these three strategies depends to a large extent on a few unknowns, particularly how quickly a population crosses the threshold into herd immunity – the point at which enough people have acquired antibodies to the virus to stop it from readily circulating in the population.

We don't yet know if recovering from covid-19 makes you immune to the virus in the long term. But even if immunity is only temporary, once enough people

76 days Expected length of lockdown in the city of Wuhan, China

have encountered the virus, herd immunity will still slow or stop its spread for a while. "Herd immunity will kick in if the infection spreads widely enough," says Woolhouse. "But we need a better understanding of herd immunity to this virus to decide between the three options." If herd immunity builds quickly, then



RICHARD GRAY/EMPHICS

Healthcare workers are given tests for the virus at a drive-through centre in London

option three is perhaps the least worst, for example.

All three strategies may also have to be abandoned or temporarily suspended if second waves get out of hand, which could mean a repeat cycle of lockdown, relaxation, lockdown. "It's certainly possible that once we have released the lockdown we may need to reintroduce it," says Woolhouse.

The UK's deputy chief medical officer, Jenny Harries, recently said she expected the UK to be able to begin lifting restrictions sooner rather than later, but warned that they couldn't be lifted all at once, and may have to be reimposed.

"If we are successful, we will have squashed the top of that curve, which is brilliant, but we must not then suddenly revert to our normal way of living – that would be quite dangerous," she said. "If we stop then, all of our efforts will be wasted and we could potentially see a second peak. We need to keep that lid on and then gradually we will be able to hopefully adjust some of the

social distancing measures and gradually get us all back to normal."

The chances of success for any of the strategies are unknown. They can be assessed using models, but their calculations are only as good as the numbers and assumptions they are based on, and even then can produce highly uncertain results. One recent modelling study of how the UK epidemic might pan out over the next 18 months concluded that "the inherent randomness of societal processes can lead to a wide range of possible outcomes".

"Models are based on major assumptions and often these assumptions are wrong," says virologist Jonathan Ball at the University of Nottingham, UK. "Whilst such models can give an insight into what might happen, they can't tell us what will happen, and the sooner we realise this the better." There is no substitute for on-the-ground research, he says.

Learning from China

For that, many are turning to China, the initial centre of the epidemic. "China was the first country to enforce lockdown," says epidemiologist Caroline Walters at Imperial College London. "So because they're a little bit ahead, I think there will be a lot of eyes on how they are handling the situation."

China has essentially followed the hold strategy, imposing strict social distancing in Wuhan in Hubei province on 23 January, where the outbreak started. This was closely followed by similar measures elsewhere, which appears to have contained the outbreak. On 23 March, the Chinese government announced that, for the first time since the epidemic began, there had been ➤



five consecutive days with no new cases in the country caused by local transmission. Restrictions have now been relaxed, including across most of Hubei, and are due to be lifted in the city of Wuhan on 8 April.

“Early signs suggest that China has to some degree successfully exited stringent social distancing”

“Life is not back to normal, but they started to slowly let people move around a little bit more,” says Walters. “They are not in full lockdown like they were.”

Extensive testing and contact tracing is being combined with some continuing social-distancing practices. China has also closed its borders to everyone except citizens to reduce the number of new cases coming in from abroad.

As a result, economic activity seems to be rebounding, according to a recent study from Imperial College London’s COVID-19 Response Team, of which Walters is a member. The team obtained a data set of the level of movement within major cities in every province of mainland China between 1 January and 17 March, captured by the Chinese search engine Baidu’s location-based services on phones.

“We used movement data as a proxy for economic activity,” says Walters, “and we had data on the case numbers of coronavirus.” Movement is linked to economic activity as it indicates people are shopping and going to work.

They found that, in the early part of the data set, levels of movement were closely correlated with the number of new cases, indicating that people were spreading the virus as they went about their daily lives. But once the containment measures had

been imposed and then relaxed, that correlation disappeared.

“Transmission was staying low, despite people being able to move,” says Walters. “We’re seeing some people being able to return to normal economic activity without the virus returning to the same level of transmission.”

She warns that these results don’t prove anything. “All we’re looking at is a correlation, not causation, we can’t say directly ‘this caused this.’” The team also warns that the results don’t rule out further outbreaks, or predict

half of enterprises had resumed work, although it cautions that China’s economy hasn’t yet returned to normal.

Reports are also emerging that some recently reopened businesses such as cinemas and bars are being abruptly shut again. Authorities haven’t explained these closures, according to a report in *The Washington Post*. But just before they happened,

Children playing in a square in Wuhan, China, earlier this month



XINHUA NEWS AGENCY/PA IMAGES

when activity will fully return to normal. But the study concludes that the results “do suggest that China has successfully exited their stringent social distancing policy to some degree”.

Lack of coordination

Last month, both sectors of China’s economy, services and manufacturing, reported a return to growth after a major slump in February. China’s National Bureau of Statistics says that more than

National Health Commission spokesperson Mi Feng said “the possibility of a new round of infections remains relatively high”. Epidemiologists say that if a second wave hits China, it will be evident by the end of this month.

So can China serve as a model for the rest of the world? To some extent yes, says Walters, but exit strategies will have to be adapted to local conditions. “Not all countries are going to have the capacity to do the testing or the contact tracing,” she says. Even

within China, exit strategies differ from region to region, according to local circumstances.

The European Union has said it is working on a coordinated exit strategy, but as yet there are no details. Some countries that are still in the early stages of outbreaks, such as Canada, have yet to even start thinking about how to exit, says Hota.

Up to now, exit strategies are being handled at a national or transnational rather than international level despite the outbreak being a pandemic, says Woolhouse. The World Health Organization told *New Scientist* that there is no global exit strategy yet, saying that the organisation is currently focusing on responding to the virus instead.

Whatever exit strategies are eventually put in place, it is likely we will eventually get back to something resembling our old lives. “We have to find a way of living with this virus and still functioning more or less as normal,” says Woolhouse. “I think we are going to be living with this virus for possibly forever but certainly the foreseeable future. So the long-term strategy is, how do we live with covid-19?”

In a year or so, vaccines may become a part of the answer, and improved treatments and some level of herd immunity will play a role too.

“I think that we will get back to our old lives,” says Walters. “Pandemics have happened before. People may end up feeling a bit differently about the world they live in, but what we’re experiencing right now is not forever. It’s a measure brought in to achieve a certain goal, which is the flattening of the curve to protect our health system. We don’t know exactly when it will end. But it will end.” ■

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Astronomy

Supermassive cannibals

Stars may grow huge by repeatedly eating their neighbours

Leah Crane

SOME black holes are bigger than we can explain. They may have formed when supermassive stars collapsed, but we don't know how those formed either. Now it seems the answer could be that many regular-sized stars smash together to create a bigger one.

Astronomers have spotted about 200 supermassive black holes – hundreds of thousands to billions of times the mass of the sun – in the early universe, which we can see by observing light that has travelled for billions of years to reach us. If they formed in the usual way, via a normal star collapsing under its own mass, there is no way they could have grown so large in that little time.

One idea is that they formed from supermassive stars tens of thousands of times more massive than the sun, says Tyrone Woods at the Herzberg Astronomy and Astrophysics Research Centre in Canada. But we don't see any of those supermassive stars now, so we don't know how they form.

Zoltan Haiman at Columbia University in New York and his



MARK GARLICK/SPL/GETTY IMAGES

“With each star that hits the central one, it becomes bigger and puffier, making it easier to grab the next”

colleagues have done modelling studies that suggest dense clusters of stars could be the answer. Star clusters are born when huge clouds of gas fragment into pieces and each piece collapses to become a star. The early universe was much more compact than it is now, so these clouds were probably much denser in the past.

That means that in this scenario, when a cloud of gas forms a cluster, the stars are close together. The biggest of the group would sink to the middle of the cluster and attract the others towards it. With each star that hits the central one, it becomes bigger and puffier, making it easier to grab the next.

“If it just keeps getting bombarded, it'll keep growing,” says Haiman. He and his team found that if the central star devours one of its siblings at least once every few hundred thousand

Stars that form in a dense cluster can clump together and eventually merge

years, it could quickly grow to more than 600,000 times the mass of the sun before collapsing. That is big enough to make one of the supermassive black holes that we see in the early universe and today (*The Astrophysical Journal*, doi.org/dq2v).

Woods and his colleagues have modelled the formation of supermassive stars in a different way, via a gas cloud collapsing to coalesce into a single enormous star. These stars would have to feed on gas rather than other stars, so they wouldn't be able to grow as fast (arxiv.org/abs/2003.10467).

Woods's team found that once these stars reached about 150,000 times the mass of the sun, they would collapse, forming the seed for a supermassive black hole.

They also found that the stars burn for a million years or more before becoming black holes, meaning we might one day be able to find one, says Woods. ■

Palaeontology

Tiny bird-like dinosaur may actually be a lizard

A FOSSILISED skull trapped in amber was recently identified as belonging to a tiny bird-like dinosaur, but it might actually be from a lizard.

Last month, palaeontologists analysed the ancient skull (pictured right) and concluded that it probably came from a tiny bird-like dinosaur that lived 99 million years ago. Now, a different group of researchers has reanalysed the fossil and believe that it actually came from a lizard.

Jing Lu at the Chinese Academy of Sciences and colleagues asked for copies of the CT scans from the original study and reanalysed the data. They argue that certain features of the skull, particularly the structure of the teeth and the shape of the eye socket, are much more consistent with lizard rather than bird or dinosaur anatomy.

Dinosaurs characteristically have teeth that develop in tooth sockets, but the teeth of this creature, named *Oculudentavis khaungrae*, are fused together – a feature much more typical of lizards, according to Lu and colleagues (bioRxiv, doi.org/dq39).



LIDA XING

The shape of the eye socket suggests this may be a lizard, not a bird

The authors of the original paper that described the fossil attributed this to the miniaturisation of the animal, which has a skull measuring a mere 1.4 centimetres across. But Lu's group argues that there is no

evidence to suggest that would lead to these changes.

The structure of the bone behind the eye sockets of *O. khaungrae* is also consistent with eyes of a typical lizard shape, say Lu and colleagues. Labelling the species as bird-like makes its small body size and other features appear extraordinary, they say, but these anatomical features are much less remarkable in a lizard.

Jingmai O'Connor at the Chinese Academy of Sciences, an author of the original study that described *O. khaungrae*, declined to comment until the new analysis has been peer reviewed. ■
Loyal Liverpool

Solar system

Venus may have a secret underground ocean of magma

Leah Crane

VENUS may be hiding a sea of magma under its entire surface that could help us learn about Earth's deep past.

When both planets formed, they were probably molten, with what might have been magma oceans on their surfaces. Over billions of years, their crusts solidified, leaving a layer of magma underneath a stony shell. Earth's magma ocean hardened into rock about 2 billion years ago, but Venus's may remain.

Although our planet has plate tectonics, which cycles cool material from the surface towards its core, Venus doesn't, so its interior should be hotter than Earth's.

Joseph O'Rourke at Arizona State University simulated how Venus's interior cooled over time. "Even though Earth and Venus are made of the same stuff and similar sized, Venus cools down about half as fast because it isn't cycling cold material from the surface down to the interior," says O'Rourke.

Because of this, Venus could still have an underground magma ocean more than 200 kilometres thick – about 2 per cent of the planet's diameter. The research was to have been presented at the now-cancelled Lunar and Planetary Science Conference in Texas.

Venus may now be going through the same process that Earth did billions of years ago, with the magma ocean slowly cooling and solidifying. This should take another 2 billion years at least, says O'Rourke.

"Venus is sort of the once-and-future Earth," he says. "It looks like Earth did when it was super-hot, and it also might be a preview of Earth in the future if we have a runaway greenhouse effect and all of the oceans boil. If we find a magma ocean on Venus, that will inform how we understand Earth's history." ■

Health

Heated water in the gut may help treat diabetes

Clare Wilson

A BIZARRE diabetes treatment seems to destroy cells lining the gut to change people's hormonal response to food.

The technique involves putting a tube down someone's throat and into the first part of their small intestine, called the duodenum, while they are sedated. Known as Revita, the procedure uses water heated to 75°C to kill the outermost layer of cells.

People with type 2 diabetes, which is linked with being overweight, often have overgrowth of the cells lining the duodenum. This may result from years of unhealthy eating, says Harith Rajagopalan at Fractyl, the firm behind the procedure.

When we eat, cells in the duodenum make a hormone called gastric inhibitory polypeptide (GIP), which triggers several other hormones that control how we metabolise nutrients. GIP production is

Blood sugar monitoring helps people manage their diabetes

enhanced in people with diabetes. Killing some of the excess gut cells should make the person's hormonal response to food more like that of someone without diabetes, he says.

To date, about 300 people in the UK, three other European countries and Brazil have had the intervention. Of these, 34 people have been studied for two years, and their levels of HbA1c, a marker of long-term blood glucose levels, fell from

7.5%
Blood glucose levels after the treatment

8.5 to 7.5 per cent. Despite this improvement, the people would still be classed as having diabetes.

In a randomised 70-person trial, where half the participants had a sham version of the treatment, those who got the real thing had improvements in glucose control and markers of liver health after three months. The figures were due to be presented at the Endo 2020

conference in San Francisco last week, which was cancelled.

The procedure tends to result in a small weight loss of about 3 kilograms, but it won't be marketed as a treatment for obesity. "It's a metabolic reset rather than a weight loss procedure," says Rajagopalan.

If people continue eating an unhealthy diet afterwards, their gut cells may overgrow again but that is likely to take several years, he says. "This procedure could be repeated in time if necessary."

Roy Taylor at Newcastle University, UK, says the mechanism behind the improvement in glucose control is unclear, because it could have resulted from the weight loss. "The jury is very much out."

"It is exciting to see innovative treatments like this in the pipeline, but the research is still at an early stage, and there are many important questions still to answer," says Faye Riley at Diabetes UK. "We look forward to seeing more robust clinical trial evidence, and untangling more about how this approach works."

There is already the option of weight-loss surgery for people who are very overweight and can't slim down through diet and exercise. One method is a gastric bypass, where the stomach is made smaller and connected to the lower small intestine so food avoids passing through the duodenum. Another option is to put a thin sleeve inside the duodenum blocking contact between its cells and food.

Both methods are thought to work by cutting absorption of food, but they may also change the duodenum's release of hormones, says Rajagopalan. ■



MTHIPSORNI/GETTY IMAGES

Human evolution

Closing in on our ancestor

Species that lived at least 800,000 years ago becomes stronger contender

Michael Marshall

TWO studies of ancient humans have shed new light on the last common ancestor we share with Neanderthals.

The insight comes partly from a study of a skull called Kabwe 1, which was discovered in 1921 by miners at Broken Hill in what is now Zambia. It probably belonged to a young male and had a primitive-looking face with “huge brow ridges over the eyes”, says Chris Stringer at the Natural History Museum in London.

Many anthropologists place Kabwe 1 in the *Homo heidelbergensis* species, which ranged across Africa and Europe between about 700,000 and 300,000 years ago. It has long been a candidate for the common ancestor of three later groups: modern humans (*Homo sapiens*), the Neanderthals of Europe and west Asia, and the Denisovans of east Asia.

Until now, however, the Kabwe 1 skull’s age has been a mystery. The normal approach would have been to date the surrounding sediments. But the skull was found by accident and the site quarried, so researchers have no sediments to test. It was assumed that the skull is about 500,000 years old, but it hasn’t previously been possible to analyse the skull without drilling into it, causing unacceptable damage.

Instead, Stringer’s team used lasers to remove fragments a quarter of a millimetre thick. Analysis of these indicates that Kabwe 1 is about 299,000 years old (*Nature*, doi.org/ggqr5s).

Genetic evidence suggests that the last common ancestor of humans, Neanderthals and Denisovans lived about

There are fossils of extinct hominins in Gran Dolina in northern Spain



Homo antecessor offers clues to the appearance of our ancient ancestors

600,000 years ago, so Kabwe 1 is too recent to be a candidate. There is also evidence that modern humans were present in northern Africa 300,000 years ago, about the same time Kabwe 1 was alive. “We reassess it as a separate line of evolution, but one which probably coexisted with the evolution of *Homo sapiens*,” says Stringer.

“We are changing our paradigm for the origins of *Homo sapiens*,” says Shara Bailey at New York University. Instead of a simple progression from one species to



the next, many groups coexisted and sometimes interbred. “This was a process that probably happened across Africa,” she says.

This would suggest that *H. heidelbergensis* didn’t evolve into modern humans, Neanderthals and Denisovans, although it is possible that a small population of the species that existed about 700,000 years ago could have been the common ancestor of the later humans.

A better candidate is *Homo antecessor*, says José-María Bermúdez de Castro at the National Centre for Research on Human Evolution in Spain. These hominins lived in northern Spain between 1.2 million and 800,000 years ago. “*H. antecessor* shows a unique combination of dental and skeletal features,” says Bermúdez de Castro. Its face was quite modern: more like ours than like that of *H. heidelbergensis*.

He and his colleagues have now extracted seven proteins from an *H. antecessor* tooth that is about 860,000 years old. This represents a major breakthrough. “We are able to reliably retrieve ancient human protein sequences over the past 2 million years,” says Frido Welker at the University of Copenhagen in Denmark.

Comparing the *H. antecessor* proteins with those from other hominins shows that the species was closely related to the last common ancestors of humans, Neanderthals and Denisovans (*Nature*, doi.org/ggqr5q). However, the researchers cannot tell if it was the ancestor. “It is too early to conclude this confidently,” says co-author Enrico Cappellini at the University of Copenhagen.

“It’s actually more likely, from the palaeoproteomics evidence, that *H. antecessor* is a sister [group] to Neanderthals, Denisovans and modern humans,” says Lauren Schroeder at the University of Toronto. “That means that we still don’t know who the last common ancestor of all these groups is.” There is also an issue of timing, says Stringer. “If that ancestor lived 600,000 years ago, that’s at least 200,000 years after *H. antecessor*,” he says.

The common ancestor’s age remains uncertain. A 2019 study suggested that it lived more than 800,000 years ago because Neanderthal teeth differ

“Instead of a progression from one species to the next, many groups coexisted and interbred”

from ours, and teeth can only evolve so fast. If so, *H. antecessor* is still a possibility.

Either way, the species is probably a better guide to what the common ancestor looked like than *H. heidelbergensis*, says Stringer. “It’s got to be something with a face more like us and *H. antecessor*.”

In other words, the modern-looking face of *H. antecessor* is actually ancient and our species has kept it, whereas Neanderthals are the ones whose faces changed more during their evolution. ■

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Diet

Benefits of popular diets like paleo fade within a year

ATKINS, paleo or Zone – whichever regime you follow, you are likely to only lose a bit of weight, and improvements in blood pressure and cholesterol may disappear within a year. That's according to a comparison of randomised clinical trials looking at the effects of 14 popular diets.

Gordon Guyatt at McMaster University in Canada and his colleagues found 121 relevant trials, together including nearly 22,000 people who were either overweight or obese. Each trial compared the results of adults who were on a diet with others who ate as normal. The team used these to look for evidence of the diets' effect on weight loss and markers of cardiovascular health, including blood pressure and cholesterol.

All of the diets resulted in some

weight loss. Six months after starting a diet, those following regimes were, on average, about 4 kilograms lighter. There were also improvements in blood pressure and cholesterol at this point.

The team noted some small differences in the effects of the diets. The Mediterranean diet appeared to have the biggest impact on cholesterol. The Atkins seemed to result in the most weight loss at six months.

Yet 12 months into a diet, the effects had mostly disappeared. By this point, the volunteers had regained most of their lost weight, and blood pressure and cholesterol benefits had vanished (*BMJ*, doi.org/dqx4). That may be because people struggle to maintain their diets, says Guyatt.

Jessica Hamzelou

Marine biology

Sharks take bite out of biodiversity idea

FISHING vessels are more likely to catch apex predators, including sharks, in cool ocean regions, even though the warm equatorial areas are where marine life is most biodiverse. The finding means biologists need to rethink why the tropics are an ecological hotspot.

More species live near the equator than in temperate or polar regions. For a century, we have suspected that predation helps explain this. The idea is that competition through predation drives evolution among prey species, which in turn encourages evolution among predators. If predation occurs more in tropical seas for some reason, that could be why they have more diversity.

If this idea is correct, then predators should be most active near the equator, and so this is where fishing vessels should catch most of them. But they

don't, according to research led by Marius Roesti at the University of Bern, Switzerland. He and his colleagues collated data from different fishing commissions around the world, covering more than 900 million caught fish.

Even after allowing for the fact that fishing vessels are spread unevenly across the oceans, Roesti and his team found that predatory fish were most likely to be caught in mid-latitudes, roughly between 30 and 60 degrees north and south of the equator. The finding suggests it is here that predators are most active and interact most with prey species (*Nature Communications*, doi.org/dqzt).

Martin Genner at the University of Bristol, UK, says these findings are noteworthy and suggests they could be explained by the different levels of organic matter at different latitudes of the ocean. It is also possible that predator species might be less able to tolerate tropical temperatures.

Jason Arunn Murugesu

Palaeontology

Large sinuses may have doomed bear

HUGE cave bears may have gone extinct in Europe because their skull shape made it hard to adapt their diet as the climate cooled.

Plant-eating cave bears (*Ursus spelaeus*) died out 24,000 years ago in the last glacial maximum. Scientists have speculated that they perished as the cold depleted the food or were driven to extinction by humans. But one mystery is why closely related brown bears

(*Ursus arctos*) survived this era.

Alejandro Pérez-Ramos at the University of Malaga in Spain and his team took CT scans of the skulls of extinct cave bears (pictured) and living bear species, including brown bears, and used them to simulate their chewing styles.

They found that cave bears had large sinuses that shaped their skulls in a way that meant they could only chew with back teeth. The researchers say that, as the climate cooled and plant food ran low, they may have been unable to switch to meat, which normally requires the use of front teeth. Brown bears have smaller sinuses and can use front and back teeth (*Science Advances*, doi.org/dqx6).

Sinuses can store gases that activate hibernation in some bears, so larger sinuses may have enabled cave bears to hibernate for longer as winters worsened. But the bears probably couldn't fatten themselves up enough to survive the longer winters, says Pérez-Ramos. Alice Klein



JUAN AUNIONVALAMY

Really brief

PATRICE LATRON/LOOK AT SCIENCES/SPL



Brain scans reveal stressful decisions

Looking at the brain activity of people as they hunt for actor George Clooney's face in a virtual town has revealed how stress impacts decisions. It seems that when stressed, we focus on what is right in front of us (*Current Biology*, doi.org/dq3n).

Fake news may not be that influential

Fake news may not be as widespread as thought. An analysis of the daily media consumption of people in the US found fake news made up 0.15 per cent of time spent consuming media. The study found traditional news outlets may be a greater source of misinformation than fake news (*Science Advances*, advances.sciencemag.org/content/6/14/eaay3539).

Diet and exercise affect brain ageing

People with certain variants of genes that play a key role in brain ageing seem to respond better to a healthy lifestyle. Some versions of the *SIRT1* gene are affected by amount of exercise and some variants of the *GRB10* gene by whether people eat a Mediterranean diet (*Communications Biology*, doi.org/dq38).

Oncology

Test can spot cancer in samples of blood

A BLOOD test can detect more than 50 cancer types, often before symptoms appear. It is most accurate at spotting 12 especially dangerous cancers, including pancreatic cancers that are often difficult to detect.

Many groups around the world are trying to develop blood tests for cancer. Michael Seiden at US Oncology, a company involved in cancer care, and his team explored several methods of testing based

on sequencing the DNA that cells release into the bloodstream.

They found that looking at methylation patterns in DNA was the most promising way. Methyl groups are chemical tags added to genes to inactivate them, and DNA from cancer cells has abnormal methylation patterns.

Next, they trained a machine learning system using blood from 1500 people with untreated cancer and 1500 with no cancer diagnoses. They then used it to analyse 650 blood samples from people with cancer and 610 without.

The system had a specificity of

99.3 per cent, meaning 0.7 per cent of people were wrongly identified as having cancer. The true positive rate – the proportion of cancers detected – varied depending on how advanced cancers were. For the 12 most deadly forms, the true positive rate was 39 per cent in stage I, 69 per cent in stage II, 83 per cent in stage III and 92 per cent in stage IV. For all the cancer types, the rates were 18 per cent, 43 per cent, 81 per cent and 93 per cent.

The test is now being trialed in a larger group of people (*Annals of Oncology*, doi.org/dqx7).

Michael Le Page

Animal behaviour



STEVE BLOOM IMAGES/LAMY

Male dolphins may call together to attract females

MALE dolphins don't just swim in synchrony, they coordinate their sounds, too. This may mean they work together to attract females.

Stephanie King at the University of Bristol, UK, and her team studied seven groups of male bottlenose dolphins living in Shark Bay in Western Australia between 2016 and 2018. They recorded calls to draw females made by 59 males.

Due to strong competition between the groups, these dolphins usually work together to attract females. Shark Bay males form alliances of up to 14 individuals.

The researchers towed underwater microphones through

the bay. They found that the animals synchronised their calls, matching each other's tempo and starting and ending together (*Proceedings of the Royal Society B*, doi.org/ggqpgd).

King thinks that this acoustic coordination could apply to other populations of dolphins too, such as those in Florida that are allied in pairs.

However, it isn't yet clear whether coordinating these type of sounds results in more reproductive success, says King. It may instead be an important way for male dolphins to maintain social bonds and reduce stress, she says. Gege Li

Nanotechnology

Tiny bots mop up mercury in water

TINY robots made using pollen could one day be used to clean contaminated water.

Waste water from some factories contains mercury, which is toxic. It can be removed in treatment plants, but this is time-consuming and expensive.

Martin Pumera at the University of Chemistry and Technology, Prague, in the Czech Republic and his team are working on a low-cost alternative. Pollen grains adsorb mercury, so the researchers are seeking ways to turn them into tiny mercury-removing robots.

They used pollen from a range of plants, including dandelion, lotus, poppy and cattail. They cleaned and purified pollen, then stuck particles of platinum to one side of each pollen grain.

They added the modified pollen to water laced with 0.2 per cent mercury by mass. They also added hydrogen peroxide to the water, which reacts with the platinum to form a chemical motor that helps the pollen move in the water.

After 2 hours, all pollen types had adsorbed at least 80 per cent of the mercury. Cattail adsorbed the most mercury – around 90 per cent (*Advanced Functional Materials*, doi.org/dqzd). JAM



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The columnist
Annalee Newitz
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Comment

Children and covid-19

Children will face many hidden negative effects from the new coronavirus – it's not too late to avert them, says **Paul Ramchandani**



THE direct impact of covid-19 on children seems to be less severe than on adults, but indirect and hidden consequences will have a lasting effect. The choices we make now can stave off some of the worst of these.

Across much of the world, schools are closed and families are largely restricted to their homes. The associated uncertainty and anxiety is a real concern, with disruptions to children's education as well as to their time with friends, for exploration and play.

These disruptions won't be fairly shared out. Children from more prosperous homes will have more space, greater access to toys and learning opportunities, greater support from their schools

and better access to resources on the internet. We must ensure that those who have the least in society don't end up being more adversely affected.

There are, and will continue to be, clear effects of the coronavirus on children's education, social life and physical and mental health. For children in key development stages, such as the very young and those in adolescence, disruption of many months will have a larger impact on social development.

These effects will be pernicious and sustained. Though they are hidden from view, we can act now to tackle them. There are many examples, but here are three.

First, the very youngest children (including those yet to be born) are

potentially the most vulnerable to family stress and anxiety. Effects on them may not be immediately apparent, but there is a large body of research showing that depression and anxiety in either parent is linked to a greater risk of mental health problems in children. This isn't set in stone, so intervention and support now, such as psychological therapies for parents, would be transformative for many families.

Second, confinement to home seems to lead to a rise in domestic violence. Children experiencing or witnessing violence in the home are at a much higher risk of psychological difficulties in their lives. Many local authority and school staff are doing an amazing

job at supporting vulnerable children and families during the pandemic, but as schools close and home visits by health and social care staff are reduced, more children in this situation will go unheard and unnoticed.

Third, and probably the largest in terms of children's future health and opportunities, is the impact of an economic downturn. In the UK over the past decade, the burden of economic pain was felt widely, with a stalling of life expectancy. Policies enacted to tackle the recession had the greatest impact on families from the poorest communities, with 30 per cent of children living in poverty and a large and sustained increase in the number of families using food banks. The next economic shock may be larger, but choices can be made about how the challenge is shared. Children shouldn't bear the brunt this time.

The coronavirus crisis is already affecting the lives of children, but perhaps more concerning are these hidden ways in which they will be affected in the months and years ahead. We can mitigate these effects if we make the right choices.

A crisis is a time of great uncertainty and anxiety, but is also a time when new options become possible. Now is the time to plan for the future we want. ■



Paul Ramchandani is LEGO Professor of Play at the University of Cambridge

This changes everything

Apps for a crisis The new coronavirus has many of us stuck at home. The result could fundamentally reshape how we use the internet, writes **Annalee Newitz**



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

Annalee's week

What I'm reading

A Song for a New Day by Sarah Pinsker, which is about a post-quarantine world where people are learning to go out and enjoy live music again.

What I'm watching

The cult Scottish pandemic flick Doomsday, which includes gladiators, motorcycle gangs, cannibals and Malcolm McDowell.

What I'm working on

Taking long walks and birdwatching.

This column appears monthly. Up next week: James Wong

AS THE coronavirus pandemic shuts down public life on the streets, a new kind of life is opening up online. Many people who are lucky enough to still have their jobs are working from home, often experimenting with video chats and virtual offices for the first time. Students are attending classes and visiting friends online, too. Covid-19 could change the internet as profoundly as it is changing our handwashing habits.

Our arsenal of must-have apps has already started to shift. Almost overnight, the videoconferencing app Zoom has gone from obscurity to necessity. People are using it to hold meetings with colleagues, teach university classes and have quarantine-compliant cocktail hours with friends. For those who don't want to be "Zoom-bombed", where an unwanted person joins the video call by exploiting bugs in the app, there are video features you can use in Skype, Google Hangouts and Discord.

Popular streaming service Twitch, typically used to watch gaming live, has also had a rise in fortunes. It has suddenly become an all-purpose performance space, with musicians, writers and comedians all using it to broadcast live shows that they have had to cancel – and thanks to Twitch's tipping and subscription functions, they can get paid for it, too.

There is an app for almost every kind of social event, and I am using as many of them as I can. My Dungeons & Dragons group now meets on Roll20, which lets us share a virtual game board. I used to set up extra chairs around the dining room table every Sunday evening, where my friends and I would spread out our maps, dice and snacks. Now most of the

chairs are empty, and the table is covered in laptops instead: two for myself and my partner, and one for the Zoom session with our fellow adventurers.

To replace the experience of inviting people over for a movie night, there are countless apps for watching media online with friends – though my pals and I simply fire up Hangouts with the sound off, texting and making faces at each other during painful scenes. Though it isn't as good as an in-person visit, these gatherings have eased my loneliness and made the days more bearable.

“More and more, we'll expect people in online spaces to behave like they would in an office or a park full of families”



Though we have had online video chat for years, it has always been a sideshow of most social media platforms. Now it is moving to the centre of our internet experience because it is connecting us with people we would ordinarily see in our day-to-day lives.

We want to feel like we are in the room with people we love and depend on, and seeing their faces

makes the encounter feel more official and real. And in the age of coronavirus stay-at-home orders, many of us are seeing our doctors via video too.

Until recently, the internet was mostly a place of leisure. We went there for entertainment, news and catching up with friends, both distant and imaginary. Yes, it has always been a workplace for some of us, but now millions more people are using apps like Slack and Asana to talk to colleagues all day and organise projects. When the time comes that the majority of us rely on the internet for work, it is inevitable that we will have to take it more seriously.

There will always be some apps where anything goes, but more and more, we will expect people in online spaces to behave like they would in the office or a park full of families.

Of course, the internet could also become an even more powerful means of escape for the millions of people who have lost work in an economic apocalypse that is almost as terrifying as covid-19 itself. With nothing to lose, shut in our homes, we may be vulnerable to extremist manipulation.

After the pandemic is over, the internet won't feel as much like an imaginary realm any more. It will be as real as a pay cheque – and that might actually make us demand more accountability from our favourite social apps.

Before the outbreak, abuse and fake information spread like wildfire on these platforms because very few people considered digital goings-on to be vitally important. But when so many of us have gone online to do our work or see our quarantined loved ones, internet falsehoods won't seem as harmless. ■

Coronavirus

Important subscriber update: app access



If you are reading this as a subscriber to *New Scientist*, we would like to reassure you that the production of your magazine remains uninterrupted. However we must plan for the possibility that in the coming weeks we may not be able to get a magazine printed and delivered to both newsstands and subscribers because of some unforeseen circumstances in our supply chain.

We are therefore pleased to tell you that during these uncertain times, we have given all of our subscribers **access to the *New Scientist* weekly app** to enable you to read the magazine in digital form. Available on iOS and Android smartphone or tablet devices, new issues of the magazine are available to download every Thursday. Once you have downloaded an issue, an internet connection is no longer required, so you can read on the move. Visit newscientist.com/appaccess for further help and a step-by-step guide.

For help, please contact us by email at subscriptions.us@newscientist.com and quote your 8-digit subscriber number, found on the address label of your subscription copy. Our call centres have been closed to protect the health and well-being of our staff, and we are currently experiencing a higher than usual volume of emails, so please bear with us if it takes us longer than usual to get back to you.

We will continue to keep you updated with further information by email as and when we know more. We will also publish regular updates here: newscientist.com/cvupdate

We thank you in advance for your patience at this time.

You can also write to me personally at editor@newscientist.com if you have any concerns or comments.

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All the best,

Emily Wilson Editor, *New Scientist*

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Editor's pick

Lessons can be learned from the covid-19 crisis

28 March, p 23

From Bryn Glover, Kirkby Malzeard, North Yorkshire, UK

David Adam argues that even the "best science" doesn't have the final word on covid-19. Still, we should applaud the willingness of some politicians to respect the best advice the scientific community is able to offer. I hope that this is extended to other areas of policy, particularly climate change. The political responses of most of the world's leaders to it have fallen somewhat short of what the overwhelming majority of scientific advice requires.

From David Holdsworth, Settle, Cumbria, UK

Perhaps the readiness to adopt big lifestyle changes in the face of covid-19 can prompt the realisation that the climate threat isn't going to go away unless we take similar drastic action. Countries that tried to go on with business as usual during the outbreak seem to be having worse outcomes than those that were decisive and took swift, large-scale action.

From Jon Atack, Radcliffe-on-Trent, Nottinghamshire, UK

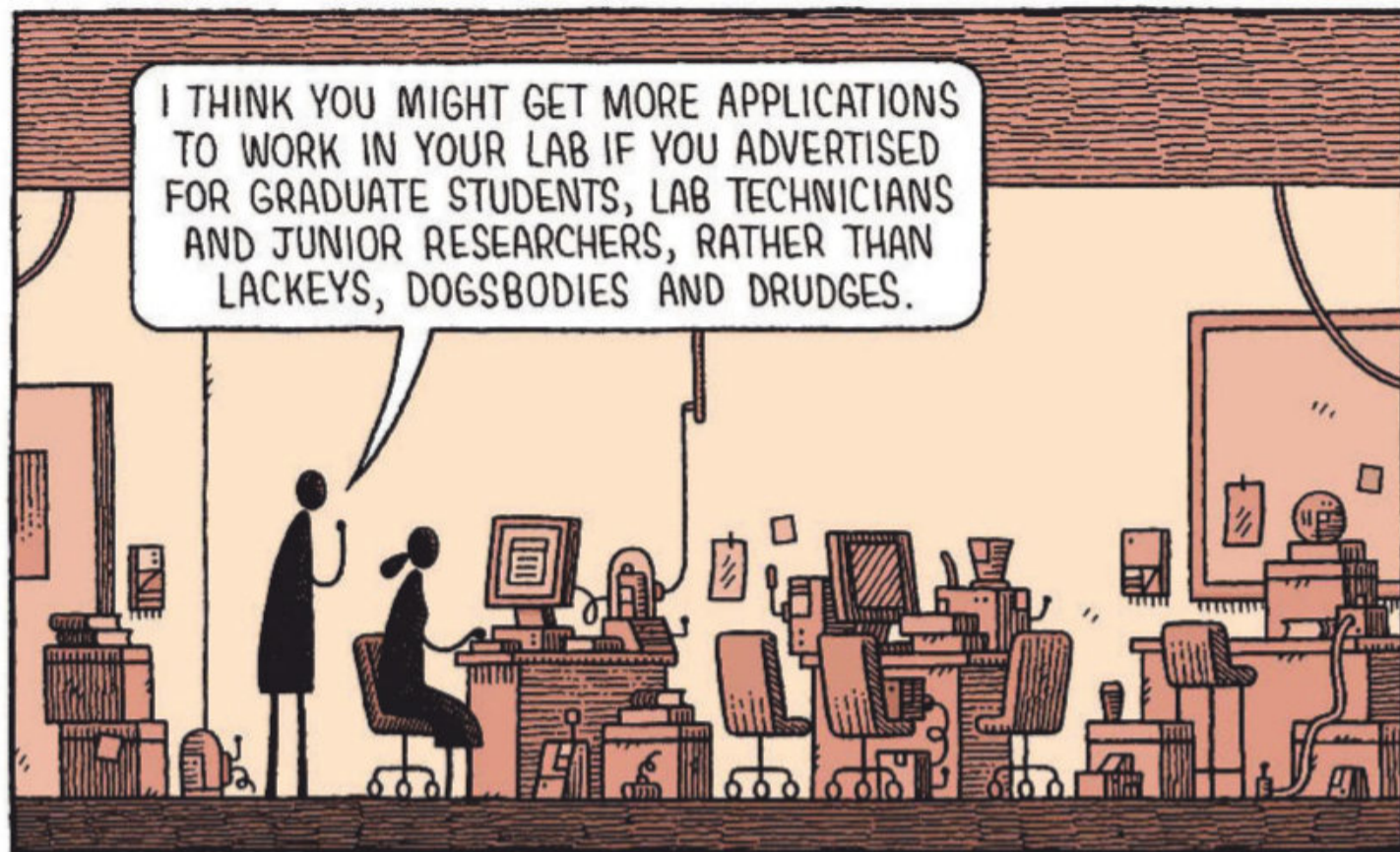
The crisis would be significantly lessened if governments adopted a universal basic income programme for the duration. The cost could be reclaimed through taxation when earnings resume. Research in Finland has found that such schemes confer health benefits (16 February 2019, p 10). Adopting one could also show how they compare with "universal credit" approach used in the UK.

Thank you for providing us with the facts

From Anna Butcher,

Brookton, Western Australia

Thank you to all the staff at *New Scientist* for giving us the facts about covid-19. You are amazing. We were travelling in Italy and the



TOM GAULD for NEW SCIENTIST

Netherlands in February and early March. Language was no barrier to making informed decisions, but the lack of facts was.

We were surrounded by misleading anecdotes, biased and unscientific information, misinformation and missing information. Facts help you make informed decisions when all you feel is confusion, fear and anger. Access to *New Scientist* articles and podcasts has been invaluable to us. Thank you for making a difference.

The relative merits of running and walking

14 March, p 34

From Brian Horton, West

Launceston, Tasmania, Australia

Your cover suggests that Steve Haake will tell us whether running or walking is best for your health. His answer seems to be that they are both good, though running can let you take more exercise in a given time.

But for a 20-minute jog, say, this doesn't account for the time needed to change into running gear then have a shower and get changed afterwards. That quick

jog would take up most of your lunch break, whereas I can zip out of the door and take a brisk, 20-minute walk without needing to get changed before or after.

So if you are time-poor, then a few brisk walks may be easier to fit in than jogging.

If you enjoy walking fast, then you can exercise just as hard as a runner would in the same time. It all depends on what you enjoy doing.

From Alexander Grant, Derby, UK

You ask about the relative merits of running and walking. I am 82 years old and consider myself to be reasonably fit. I haven't been to a gym since my schooldays and I don't go running. In my younger days, I cycled to work 12 kilometres each way five days a week and did a lot of hillwalking and mountain climbing. Until the coronavirus put a temporary stop to activities, I enjoyed Scottish country dancing and 8-kilometre walks in the Peak District twice a week.

I am fairly active in my garden, including occasionally lifting weights, such as bags of compost. How does this compare with the

benefits discussed in your article, including bone build-up?

From Peter Billard, Stuttgart, Germany

Besides running and walking, there is a comparatively new kid on the block, namely "Nordic walking". This is walking with poles, derived from Nordic skiing. Like walking and running, it can be practised at various levels. It can also allow people who are elderly or frail to remain active while protecting them from falls. The poles act as a climbing aid when going uphill, and dampen impact on joints and the spine when going downhill.

The upper body is more actively engaged in propulsion than it is in running or walking. To derive the greatest benefit, a course of instruction is advisable.

Organic farming's impact is even more complicated

21 March, p 25

From Richard Oliver, Attenborough, Nottinghamshire, UK

Christel Cederberg and Hayo van der Werf are no doubt right that broad comparisons of the

environmental impact of conventional and organic agriculture are prone to be overly simplistic. Both systems operate under rules and regulations designed, in part, to mitigate environmental effects.

Organic production adds an additional layer of prohibitions, particularly on the use of synthetic fertilisers and pesticides, but still permits the use of inorganic pesticides. It is true that global pesticide use has risen in the past 30 years, but this is mainly due to declining costs to farmers and the greater geographic spread of crops like bananas and grapevines. The main trend is for declining use of pesticides on a weight-per-hectare basis as new synthetic products replace less potent ones.

Because synthetic pesticides aren't permitted in organic agriculture, some crops remain reliant on the use of inorganic fungicides such as copper, first introduced in 1885.

While the average rate of fungicide use is falling in the UK, the use of inorganic fungicides now averages more than 2.5 kilograms per hectare. The European Food Safety Authority has recently reiterated the potential environmental toxicity of copper, whereas all new synthetic pesticides must pass stringent modern safety tests.

We have the free will to declare anything illusory

Letters, 21 March

From Hazel Russman, London, UK
Luce Gilmore states that the problem of free will vanishes once it is accepted to be illusory. Of course it does, and so does any other problem that is treated in the same way.

Why don't we declare covid-19 to be illusory? Then we can all go back to normal life.

Honeywell is no stranger to advanced computing

7 March, p 12

From N. C. Friswell, Horsham, West Sussex, UK
Your report on the Honeywell company working on quantum computing would come as little surprise to some readers with long memories. In the 1960s, Honeywell was one of the big names in commercial computing.

At the time, I worked for an electricity supply company. It had a massive Honeywell 800 computer to do its billing, housed in air-conditioned rooms with tape drives and punched card input. Software engineers were allowed an hour or so in the night to do our studies. Each alteration to our programs was put onto punched cards and batch-processed overnight. If you made a mistake or needed to tweak your programming, you started again.

My grandmother's experiments on gulls

7 March, p 18

From Susan Hill, Abingdon-on-Thames, Oxfordshire, UK
I was very interested to read Jason Arunn Murugesu's report of gulls preferring food that has been touched by humans. In the 1950s, my grandmother lived in Bridlington, on the Yorkshire coast of the UK. She was inclined to feed the gulls on the town's promenade with laxative chocolate for her amusement. The gulls would catch the pieces as they were thrown up to them. I don't believe she stayed around to see the effects. ■

For the record

■ *Cosmosoma myrodora* is in fact a moth; an example of a pollinating wasp is the European paper wasp (21 March, p 41).

30 years ago, *New Scientist* eagerly anticipated a landmark moment in astronomy



"Next week, NASA plans to launch the Hubble Space Telescope into orbit, turning it into the world's most powerful optical telescope. Once up there, it will look back through 14 billion years of the history of the Universe," we wrote in our 7 April 1990 issue.

Our reporters Susan Watts and Helen Gavaghan observed that "in even the clearest night, from the highest mountain and with the largest of telescopes, the Earth's atmosphere restricts our view of the Universe". Orbiting 600 kilometres above Earth, the Hubble Space Telescope would "see so far and so clearly that astronomers say only that they expect the unexpected from the data that Hubble will collect".

The pair reminded readers that Riccardo Giacconi at the Space Telescope Science Institute in Baltimore, Maryland, had told the annual meeting of the Astronomical League in 1986 that "ultimately the sociological impact of this new knowledge will be as great as the revolutions started by Copernicus, Galileo, Kepler and Newton". That was the year that Hubble would have launched, had the Challenger space shuttle not exploded.

Yet following its launch from the Discovery space shuttle on 24 April 1990, there were early indications of problems with Hubble. The telescope was sending back blurred images. We reported suspicions that vibrations were causing this in our 19 May 1990 edition.

The first shots were still encouraging: they were already clearer than images recorded by ground-based telescopes. By July, though, the sad truth had dawned. A faulty measuring device had made the primary mirror 2 micrometres too flat, less than the width of a human hair. This meant the multibillion-dollar telescope couldn't focus light as well as was expected.

Soon, there were plans for a repair. Five pairs of mirrors, each around the size of a postage stamp, were installed three years after Hubble launched to correct the primary mirror. "NASA finally seems to have got something right," we reported on 22 January 1994, as "the telescope has at last begun to produce sharp images of distant galaxies".

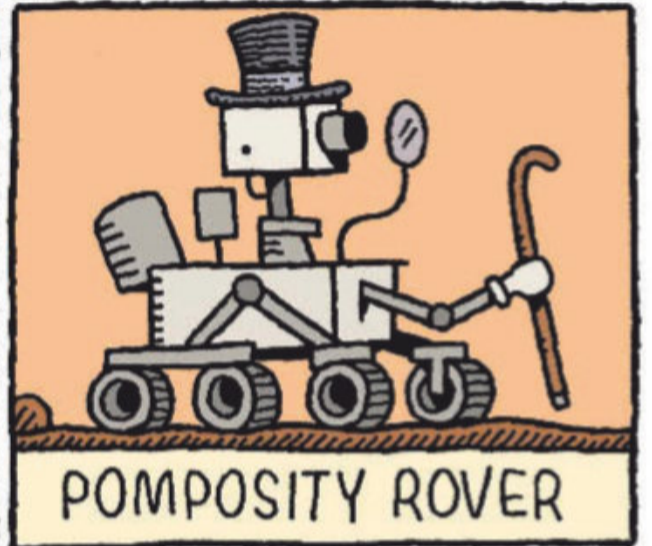
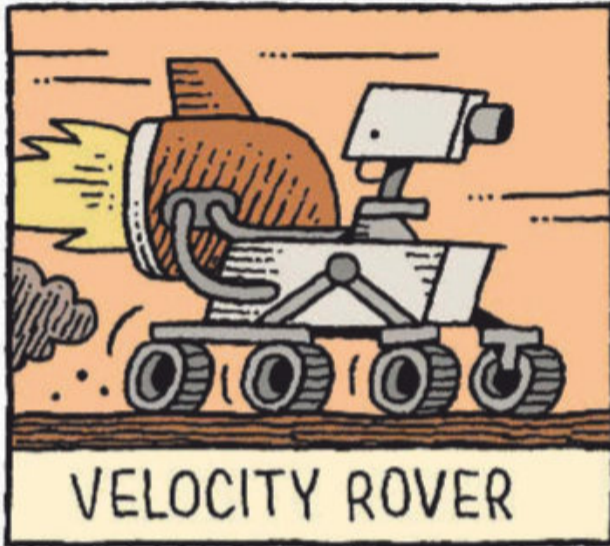
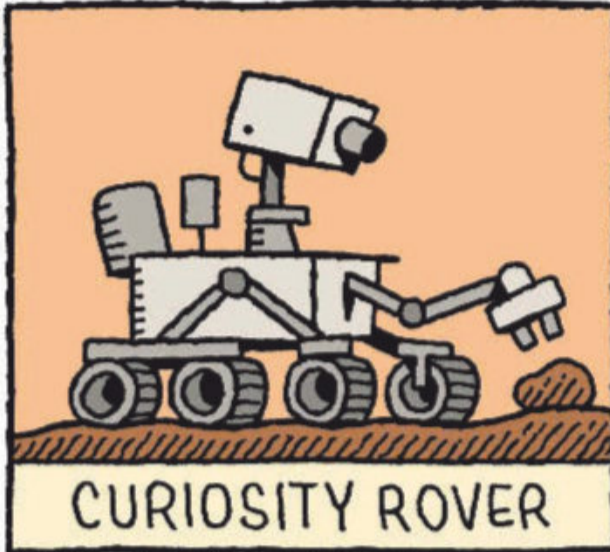
Hubble went on to produce a plethora of observations: there are more than 1500 mentions of it in *New Scientist's* archive, including its iconic images, such as the Pillars of Creation. Mike Holderness

To find more from the archives, visit newscientist.com/old-scientist



Want to get in touch?

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Keeping it funny



Artist **Tom Gauld**

Department of Mind-Blowing Theories: Science cartoons
by Tom Gauld (Canongate)

NO, DON'T worry, you haven't flipped to the wrong page, and we haven't printed the same one twice. This week, we have a jumbo dose of Tom Gauld, who has been producing weekly cartoons for *New Scientist* for the past few years.

"I like being the funny guy in the midst of a thoughtful magazine," he says. Seeing Gauld's cartoons before the rest of the world is a perk of working for *New Scientist*. They tackle a huge variety of scientific topics and always make everyone laugh and smile. His new book, *Department of Mind-Blowing Theories*, was published this month and draws together some of his best work.

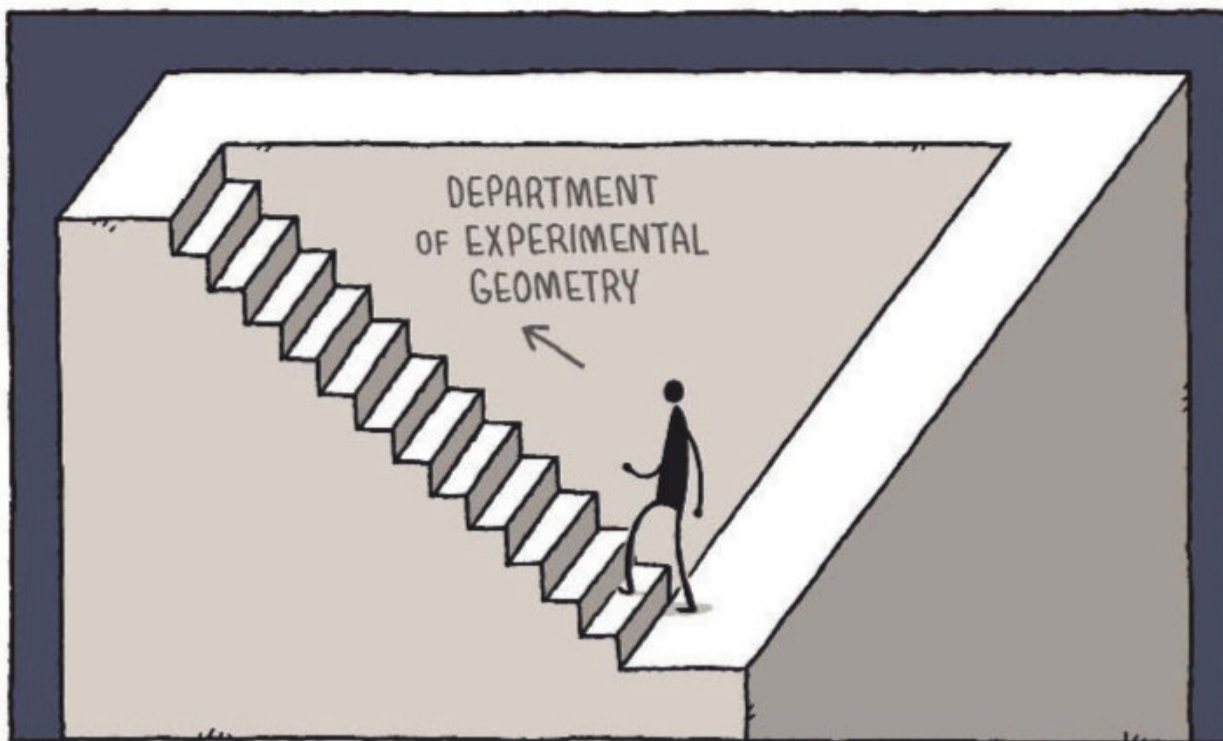
How does Gauld come up with his ideas? "I always carry a sketchbook – one in my pocket, and one in my bag," he says. He tries to catch ideas as they emerge, so that each week "I'm not starting from nowhere".

Take the Department of Experimental Geometry cartoon (top near-left). "That was a case of the joke fitting the image," says Gauld. "I've always liked weird mathematical drawing and knew it would be a good basis for a joke."

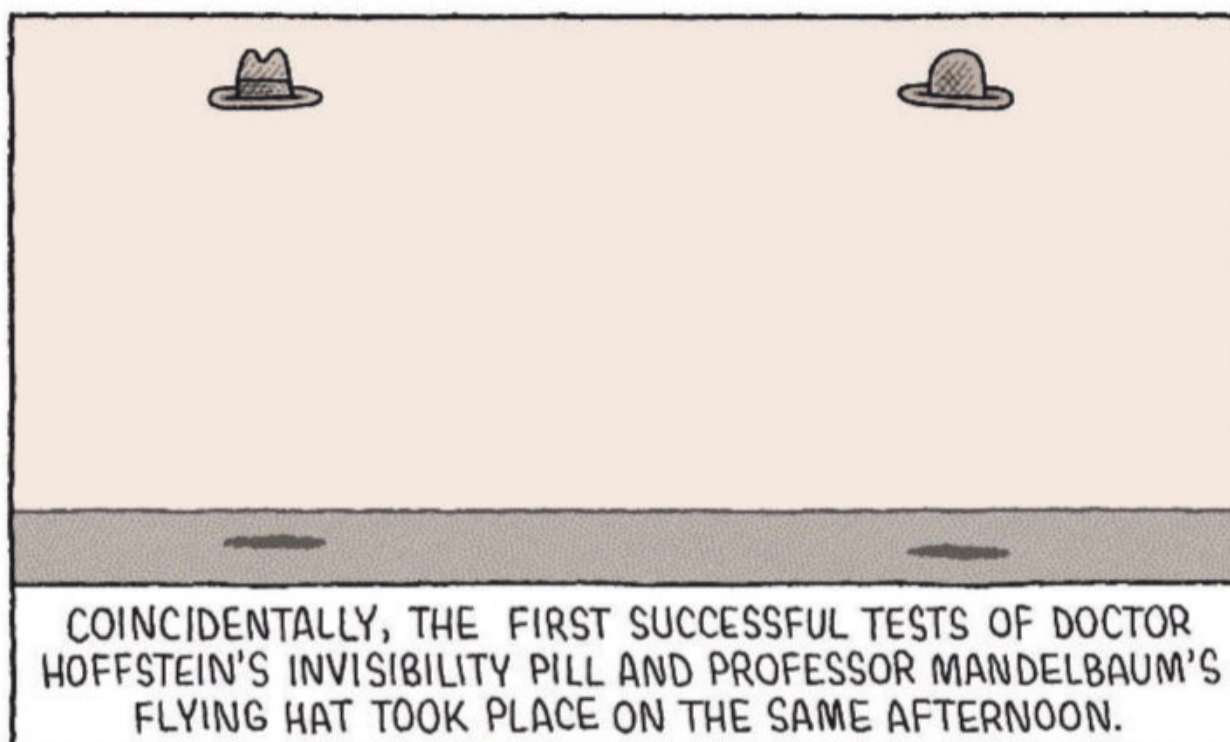
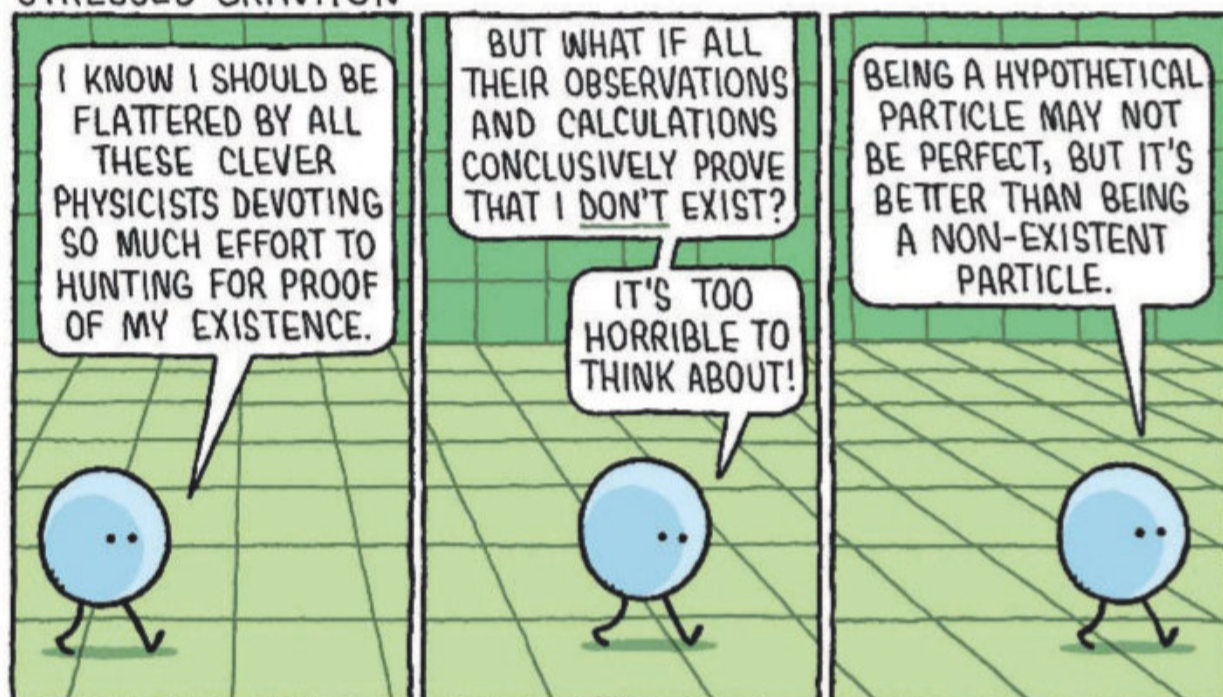
Science wasn't always a natural topic for Gauld, as he hadn't studied the subject since secondary school. "When I got the job, I started educating myself. I subscribed to lots of science podcasts and began reading the magazine thoroughly," he says.

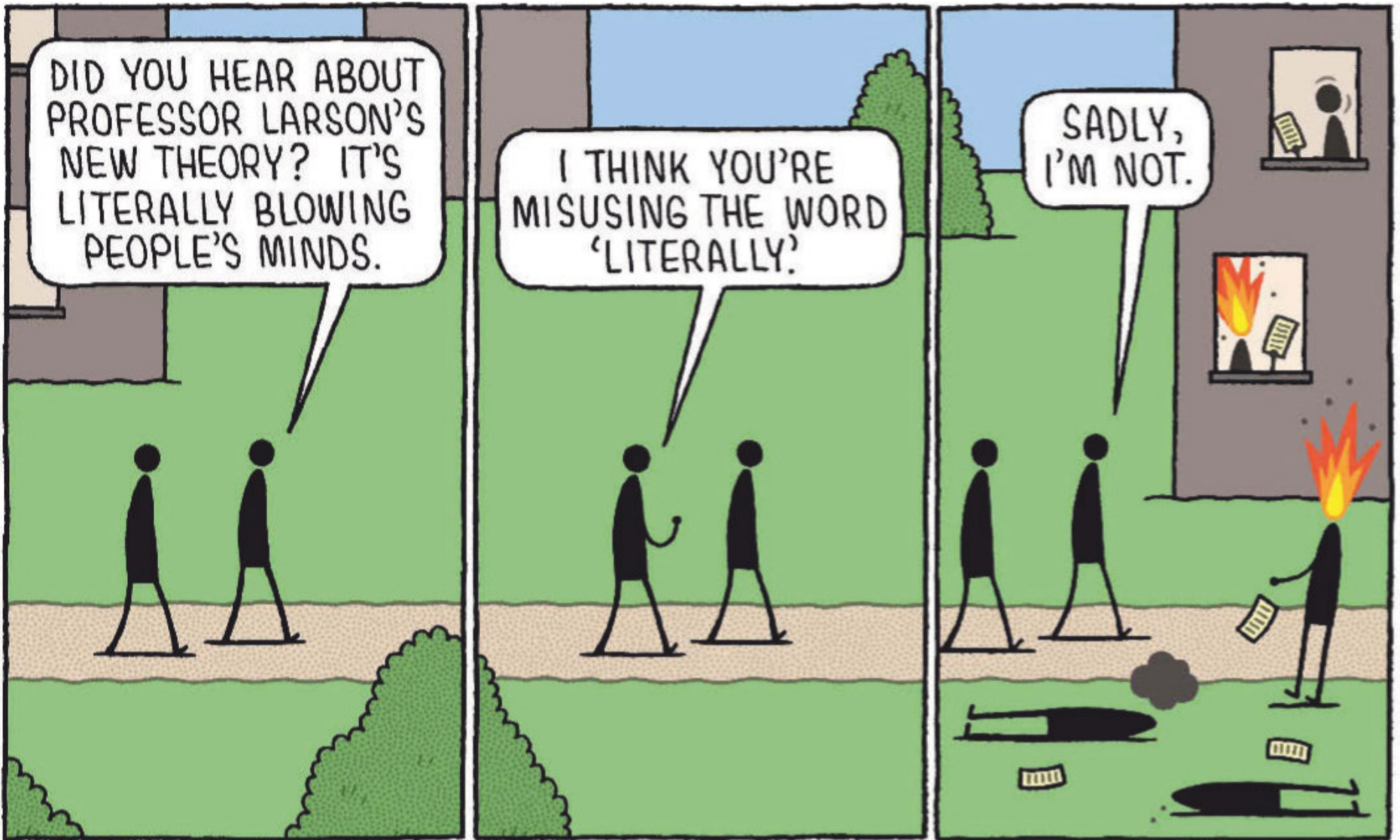
Gauld's cartoons are also a big hit on social media, where they are regularly shared and commented on.

Scientists are often the butt of the joke in his work, but they also seem to enjoy the cartoons. Gauld says several scientists



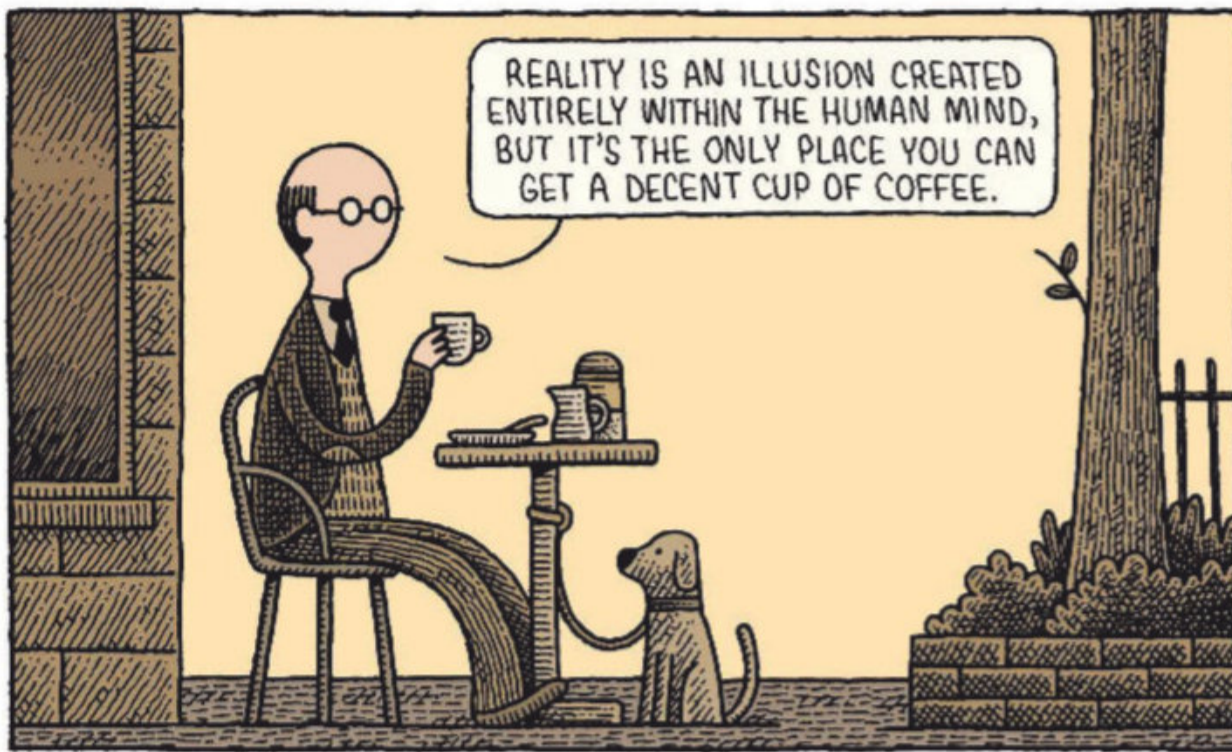
STRESSED GRAVITON



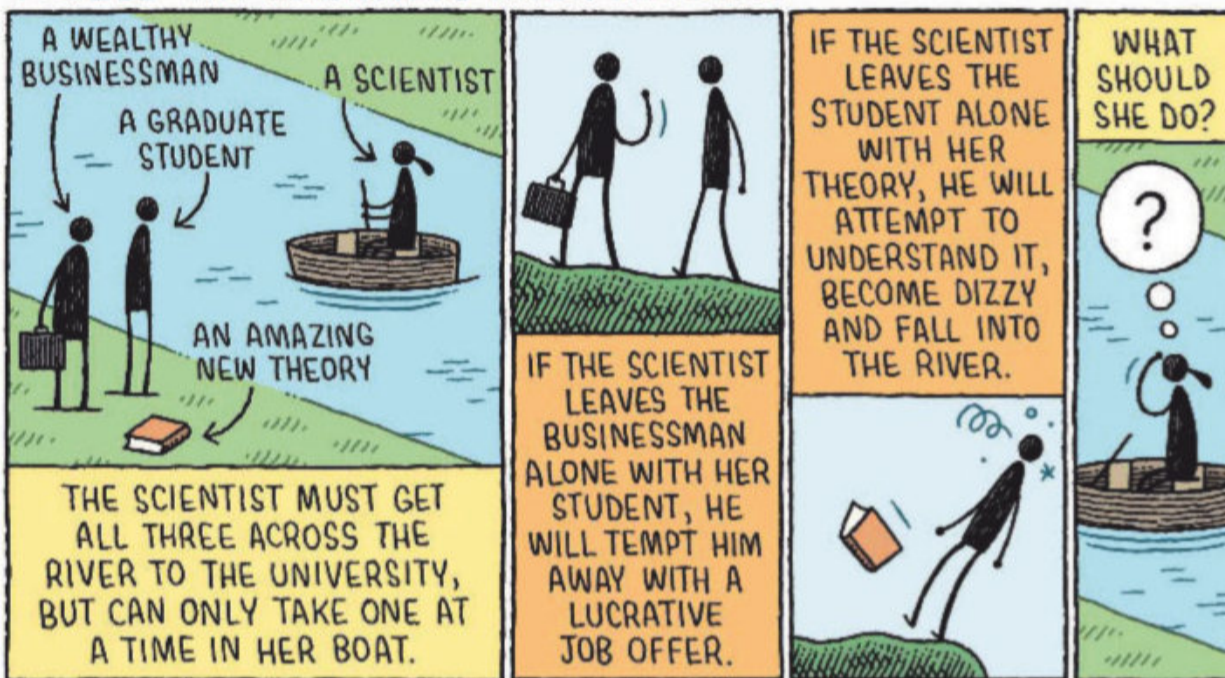


DOG PHILOSOPHER





PUZZLE: THE SCIENTIST'S RIVER PROBLEM



have asked for his permission to include one of his cartoons in a presentation or a paper.

So why do they like them? "I think it's because I have a respect for their work. I make fun of it in a careful way, like teasing a friend," he says.

That teasing serves a purpose. In an interview with *Science* magazine, cartoonist and scientist Jason McDermott said: "There are divides between scientific fields and between scientists and the general public. Comics can help bridge these divides by making a hard concept or complicated subject more approachable."

Gauld, with his uncanny ability to humanise scientists and their fields, achieves this every week. Take his cartoon about "literally blowing minds" (top far-left). Gauld tells me it was inspired by a tour guide at a stately home who warned him that the next room was "literally mind-blowing".

The joke is ultimately about language, but it also fits into the world of research, says Gauld. "You should try to be clear in science." Of course, it works so well because science is often filled with bewildering terminology.

So what is next for Gauld? He has quantum mechanics in his sights. "That's my dream – to draw a really good quantum mechanics joke." ■

Jason Arunn Murugesu

The truth is out there

Visions of flying saucers tap into a deep cultural obsession with aliens. Can a new book explain where it comes from? **Jeff Hecht** explores



Book

They Are Already Here: UFO culture and why we see saucers

Sarah Scoles
Pegasus Books

SOME people spend an awful lot of time hunting down UFOs. For Sarah Scoles, author of *They Are Already Here*, it comes down to human curiosity and a drive to seek answers beyond our reach.

That isn't what I expected. My introduction to unidentified flying objects was a pulp magazine called *Flying Saucers from Other Worlds*, which I read as a kid. Its editor Ray Palmer had recently changed the magazine's content from science fiction to "factual" news on UFOs, much of which was sane compared with the bizarre conspiracy theories it still included, such as how the saucers came from inside a hollow Earth. I found it funny.

Scoles's introduction to UFOs was very different. She read a 2017 *New York Times* article about an incident that had happened a few years earlier when the US Department of Defense (DoD) was shown images of a glowing object flying against the wind taken by two Navy fighter pilots. For her, this was "all but a declaration not just that UFOs are extant, but also that they are extraterrestrial", she writes in the book, and that the DoD knew. As a former Mormon turned science reporter, she wanted to know more.

This incident was reported to what is left of the DoD's Advanced Aerospace Threat Identification Program, set up in 2007, closed in 2012, but which the *NYT* article claims continues in other forms.

Millions of military dollars have been spent on UFO research, some



Cycling to Alienstock festival in Nevada; below, a photograph of a "UFO"

going to Bigelow Aerospace, better known for making space station modules.

Another recipient is the To the Stars Academy of Arts and Science. It was co-founded by Tom DeLonge, former singer of rock band Blink-182. He expresses his passion for UFO research on the company website, and an "Invest now" button solicits a minimum contribution of \$350. Harold E. Puthoff, an engineer who some 40 years ago investigated whether spoon-bender Uri Geller had paranormal powers for the CIA, is another co-founder.

The more of this book I read, the



weirder it got – like slipping into an *X-Files* world of unreality and conspiracies. Not a good feeling.

That faded as Scoles turned to the origins of the modern UFO era

“UFO believers fast became a community, like a church, a sci-fi club, even a scientific society”

in 1947, when businessman and pilot Kenneth Arnold reported “flying saucers”: nine lights flying in formation over Washington state. The Associated Press agency told the world; federal agencies set up secret UFO hunts; Palmer and Arnold wrote one of the first books on UFOs; the public got interested.

People were suspicious about the official version of the story. With reason. “The [US] government did lie” about events at its Roswell site in New Mexico during the cold war, says Scoles. But the goal was to fool the Soviets about US technological superiority, not to hide aliens.

UFO believers fast became a community, like a church, a sci-fi club, even a scientific society.

These days that search takes many forms. Some gather to share information, others retreat to the desert to seek cosmic resonances or gateways to other worlds.

Still others discover peace or beauty in remote places, and are drawn into a community of seekers. Judy Messoline, for example, bought 130 hectares in rural Colorado seeking a quiet life, but ended up building the UFO Watchtower, now a centre for tourism – and, almost, pilgrimage.

The search can also become part of what defines self and identity, says Scoles. Outside the DoD programme, the establishment frowns so strongly on UFOs that it takes real stubbornness to continue. Saucer seekers can end up labelled as contrarians.

Near the end, Scoles describes driving 8 hours to the Sunspot Observatory in New Mexico after the FBI shut it down without explanation. The saucer world thought something was afoot, but Scoles found none of the expected road blocks to stop her.

Eventually, the FBI said it had shut the place as part of a wholly unrelated investigation. She doubts that is the whole story, and she is probably right. In an imperfect world we won't get answers to all our questions.

In the end, Scoles shows that the quest for UFOs is about belief in things beyond our comprehension and in us as individuals and as a society. Relegating UFOs to a historical footnote isn't happening any time soon. ■

Jeff Hecht is a consultant for *New Scientist*. A short story of his, *The Saucer Man*, was published in *Interzone* magazine in 1997

TOP: BRIDGET BENNETT/JAFP VIA GETTY IMAGES; BOTTOM: U.S. DEPARTMENT OF DEFENSE

Beautiful, sedate mysteries

Something odd is happening in a town with an experimental physics research lab at its heart, finds **Anne Marie Conlon**



TV
Tales from The Loop
 Amazon Prime Video

CREATING a TV show from an assortment of artworks is no easy task. With *Tales from The Loop*, the result is an eight-part series that follows the strange goings-on in a town set atop an experimental physics research facility. It is visually stunning, though at times it leaves you wanting more.

The stories are inspired by a collection of paintings of the same name by Swedish artist Simon Stålenhag. The original pieces feature primarily rural scenes in a fictional Swedish town, but with a sci-fi twist, such as children playing in a field shadowed by a large robot. These interlopers from another world are caused by the reality-bending effects of The Loop, the town's mysterious physics lab.

As showrunner Nathaniel Halpern told *New Scientist*, the producers presented him with Stålenhag's art

The show's altered reality conjures floating tractors and disappearing houses

as a jumping-off point for the series. "It was obviously a unique situation in that I hadn't really heard of anyone adapting paintings before. It was that somewhat unique process of just looking at his images and thinking, 'what is this world, what are the stories that pop out of those images to me', and then I wrote them."

Each instalment stands alone, but they also weave into the larger story of a town and its residents. In the first episode, we meet a girl and her mother, who works as a research scientist at The Loop.

Lingering shots of snowy landscapes are set to beautiful music by Philip Glass and Paul Leonard-Morgan. The pace is slow, so you can drink in the calm scenery and ponder the mysteries below the surface.

When the scientist and her home later go missing, her daughter is helped by another child in the town, whose mother Loretta also works at The Loop. We are presented with an intriguing mystery: did they simply disappear? If so, how? And could this have something to do with black holes?

Unfortunately, this is where the episode starts to wane. A twist diffuses the suspense, which leaves

an unsatisfying series of questions as to what actually happened that don't really get answered.

The second episode I saw continues on this theme. It follows Loretta's father-in-law, who runs The Loop, as he confronts a life-threatening illness. He takes his grandson to see a hollow metal structure, which can somehow predict how long your life will be. Here, they discuss life and death and... not a lot else happens.

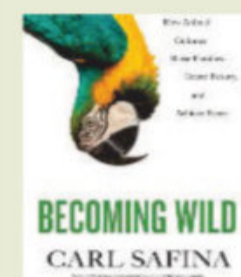
The difficulties of adapting an art collection for the small screen are evident in *Tales from The Loop*. We are confronted with interesting artefacts in the town's landscape, such as huge, retro-looking robots, that are either half-explained or just ignored. This works for a painting, as you aren't awaiting the full story, instead expecting to ponder it on your own time. Yet with a TV series, it feels like something is missing.

This is a show I really wanted to enjoy: the set-up is intriguing and the visuals are wonderful. Halpern's quest to create a sci-fi programme rooted in the ideas of *The Twilight Zone* and what he calls "empathy for the human condition" is a noble one. Unfortunately, this isn't quite achieved here. ■



Watch

See is a chilling fantasy on Apple TV+ set 200 years after a virus robbed most people of their sight. In this unnerving tale from *Peaky Blinders* writer Steven Knight, the ability to see is now considered heresy.



Read

Becoming Wild: How animal cultures raise families, create beauty, and achieve peace by Carl Safina (Henry Holt & Co.) shows that we aren't alone. The ecologist seeks out the cultural lives of species that also rely on learning and traditions to survive.



Visit

The International Space Station is open for virtual visitors, thanks to Google Arts & Culture, which also provides remote access to more than 2500 museums and galleries worldwide. What better time to start your virtual art collection?



AMAZON ORIGINAL

NASA

The film column

A cuckoo in the nest A young couple in need of a starter home meet an estate agent who is very definitely not what he seems, and nor is the estate he shows them. *Vivarium* packs a powerful punch, says **Simon Ings**



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



VERTIGO FILMS

You can buy one of Vivarium's homes, but can you leave?

This is territory that director Lorcan Finnegan and writer Garret Shanley want to make their own. This is their second film together after *Without Name* (2016), where a land surveyor measuring an ancient forest soon loses his reason in an environment with plans of its own.

Their focused film-making is paying dividends. Just look at the leads in *Vivarium*. Poots and Eisenberg are more than just guns for hire here – they are also executive producers. That they had a ridiculous amount of fun making this movie is evident with every glance, gesture and squeeze of the shoulder.

But *Vivarium* is no romance. Cut to day 98. The baby has grown into – well, as a matter of fact, Senan Jennings, a terrific 9-year-old actor from County Kildare in Ireland. A little overdubbing and voila, Jennings is playing a cuckoo even more unsettling than Aris's.

"Are you overwhelmed, mother?" he asks at one point. Yes, she is. And yes, we are too.

With its cinema release delayed due to the coronavirus pandemic, *Vivarium* is instead available digitally through Amazon Prime Video, Sky Store, Virgin, Google Player, Apple TV and BFI Player.

I am glad for the filmmakers, who certainly deserve their day in the sun after being deprived of a cinema release.

I am also pleased on behalf of all those young couples who might have assumed that *Vivarium*, with its personable young cast and witty premise, would make a perfect date-night movie. You dodged a bullet there, guys. ■



Film

Vivarium

Lorcan Finnegan
XYZ Films

Simon also recommends...

Films

The Truman Show (1998)

Peter Weir

Jim Carrey and Ed Harris star in screenwriter Andrew Niccol's tale of a man who grows up in a perfect suburban setting, only to discover that it is a film set.

Under the Skin (2013)

Jonathan Glazer

Scarlett Johansson plays a predatory alien seeking existential purpose in Scotland. Michel Faber's original 2000 novel is a cracker, too.

THE unnerving strangeness of *Vivarium* is apparent from the off. In the first 5 minutes, a young child leaving pre-school finds two baby birds lying dead at the foot of a tree, wrestled out of their nest by a cuckoo hatchling.

Schoolteacher Jemma hunkers down by the girl to offer some comfort. "That's nature," she says. "That's just the way things are."

The girl isn't buying this. "I don't like the way things are," she says. "It's horrible."

How right she is.

Mind you, the film's title has primed us for a classy sci-fi horror. A vivarium is, after all, "an enclosure, container or structure adapted or prepared for keeping animals under semi-natural conditions for observation or study or as pets", according to the *Oxford English Dictionary*.

Jemma (Imogen Poots) and her gardener boyfriend Tom (Jesse Eisenberg) are in search of their first home. They visit a local estate agent and are greeted by Martin, played by Jonathan Aris, who turns his handful of lines into a show-stopping,

screen-chewing masterclass in the art of desperately trying to be what you aren't.

Martin cajoles the couple into visiting Yonder, an estate of identical, medical-green, new-build houses. Once there, he abandons them. By the time they realise they are trapped, the estate is folding back on itself

"By the time they realise they are trapped, the estate is folding back on itself like a 4D Möbius strip"

like a four-dimensional Möbius strip and a box has arrived outside the house the estate agent took them to. Inside, there is a baby. At least, it looks like a baby. On the lid of the box, there is a message: "Raise the child and be released."

The rest of *Vivarium* plays out with a horrible inevitability. Whether you think the film's determined logic makes it powerful and compelling, or thin and gratuitous, will depend on your mood that day.



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GRAHAM CARTER

Welcome to the antiverse

Mysterious particles uncovered in the Antarctic could be evidence of a mind-bending mirror universe, reveals **Jon Cartwright**

IN THE Antarctic, things happen at a glacial pace. Just ask Peter Gorham. For a month at a time, he and his colleagues would watch a giant balloon carrying a collection of antennas float high above the ice, scanning over a million square kilometres of the frozen landscape for evidence of high-energy particles arriving from space.

When the experiment returned to the ground after its first flight, it had nothing to show for itself, bar the odd flash of background noise. It was the same story after the second flight more than a year later.

While the balloon was in the sky for the third time, the researchers decided to go over the past data again, particularly those signals dismissed as noise. It was lucky they did. Examined more carefully, one signal seemed to be the signature of a high-energy particle. But it wasn't what they were looking for. Moreover, it seemed impossible. Rather than



bearing down from above, this particle was exploding out of the ground.

That strange finding was made in 2016. Since then, all sorts of suggestions rooted in known physics have been put forward to account for the perplexing signal, and all have been ruled out. What's left is shocking in its implications. Explaining this signal requires the existence of a topsy-turvy universe created in the same big bang as our own and existing in parallel with it. In this mirror world, positive is negative, left is right and time runs backwards. It is perhaps the most mind-melting idea ever to have emerged from the Antarctic ice – but it might just be true.

The ambitions of the balloon experiment, the Antarctic Impulsive Transient Antenna (ANITA), were never so grand. Earth is constantly bombarded by particles known as cosmic rays that come from the furthest reaches of space, some of which have a million times more

energy than we can generate with our best particle accelerators. Cosmologists are curious to know what these ultra-high-energy cosmic rays are made of and where they come from, but these questions are difficult to answer. For one thing, the trajectories of the rays are distorted by our galaxy's magnetic fields, making their

“No known physics can account for the perplexing signal”

point of origin almost impossible to trace.

Luckily, whatever does generate ultra-high-energy cosmic rays almost certainly generates a more useful beacon: neutrinos. Owing to their lack of charge, these tiny particles are unswayed by magnetic fields, and zip through space in straight lines. As a consequence, locating the origin of a neutrino – and that of any cosmic rays generated in tandem – is simply a matter of extrapolating its trajectory backwards from its point of impact. And that is where ANITA comes in.

When a high-energy neutrino plunges into the Antarctic ice, it creates a shower of charged particles that generate radio waves. If ANITA detects these radio waves emanating from the surface, its researchers can figure out where the neutrino struck, and work out the origin of the accompanying cosmic rays. “There's nothing unknown about the process,” says Gorham, an experimental particle physicist ➤



NASA BALLOON PROGRAM OFFICE

at the University of Hawaii and principal investigator at ANITA.

Yet it couldn't explain what the researchers identified in 2016. Instead of crashing into the ice from overhead, the high-energy particle they were dealing with seemed to have erupted from the ground, presumably having entered Earth on the other side. Normal, low-energy neutrinos can make such a journey, because they pass through matter with ease. But high-energy neutrinos hit an object as solid as a planet in something akin to a particle belly-flop: they simply can't pass through it unhindered. Neither can cosmic rays.

The next idea was to try some creative workarounds. Neutrinos come in three known types: electron, muon and tau. None of these can traverse matter at high speed, but the tau neutrino can very occasionally transform into another particle known as a tau lepton, before reverting to a tau neutrino. It was just possible that a high-energy tau neutrino survived the transit through Earth by performing this type of shape-shift on entry. But it was a contrived idea, and the ANITA scientists knew it. "Not everyone was comfortable with the hypothesis," says Gorham.

The whole puzzle only got worse in 2018, when ANITA spotted another apparent signal of a massive particle erupting from the ground. An independent analysis by Derek Fox and others at Pennsylvania State University showed how unlikely spotting two events of this type ought to

have been. According to their calculations, the chances of a tau neutrino getting a free pass through Earth during an ANITA flight twice was one in a million. "Now we're out of easy explanations," says Gorham.

The harder ones take us beyond physics as we know it. For more than 40 years, particle physics has been governed by the standard model, a set list of particles and forces that has proven remarkably accurate at explaining the natural world. But in times like these, researchers are often tempted to go off menu. Ivan Esteban at the University of Barcelona in Spain, for example, has suggested that the culprit could be the axion, a hypothetical particle predicted in the late 1970s to redress an imbalance in one of the four fundamental forces of nature. He believes the radio signals could be caused by axions turning into photons as they interact with Earth's magnetic field.

“CPT symmetry has never been broken. But it spells trouble for the universe”

Meanwhile, Fox and his colleagues have turned to supersymmetry, a hefty extension to the standard model in which every known elementary particle has a twin that is typically more massive. They believe a supersymmetric tau, or “stau”, stands much better odds of making the journey through Earth and generating the ANITA signal. The trouble is, other experiments designed to detect supersymmetric particles, such as the Large Hadron Collider at CERN near Geneva, Switzerland, have resolutely failed to do so. That has led many physicists to look askance at predictions that depend on supersymmetry.

For Neil Turok at the Perimeter Institute for Theoretical Physics in Waterloo, Canada, all such proposals are needlessly complicated. Rather than inventing hordes of new particles to explain mysterious phenomena, he believes we should work with what we know already. “Particle physics has gone from being the most economical predictive theory we know, to the least, and an amazing number of people have accepted that,” he says. “Well, I haven't.”

Turok's passion for keeping things simple might have led him to a remarkable solution to the problem of the ANITA signals. Initially, he was concerned with a field very remote from the Antarctic ice: the immediate aftermath of the big bang. One of the few guides to help study this period is the notion of symmetry, the idea that physical laws remain the same under certain transformations.



The balloon-mounted ANITA experiment surveys more than a million square kilometres of Antarctic ice for signals from cosmic rays

We refer to these symmetries by shorthand. C, for example, is short for charge conjugation symmetry, which holds that flipping the charge of a particle – replacing it with its antimatter equivalent, in other words – has no effect on its essential behaviour. P stands for parity transformation symmetry, under which the physics in one scenario is indistinguishable from that in its mirror image. T represents time reversal symmetry, which means that a process played backwards in time doesn't violate any physical laws.

One or two processes involving fundamental particles are known to violate the C, P and T symmetries individually. In all such cases, however, the other two symmetries are also violated to compensate, so that, taken as a whole, CPT symmetry is never broken. “No one has ever found a way to avoid it,” says Turok. “It’s a very deep statement about nature.”

In 2018, Turok and his Perimeter Institute collaborators, Latham Boyle and Kieran Finn, set out to discover what CPT symmetry would mean if it also held in our universe's earliest moments. They found that their resultant calculations placed strict limits on the types and numbers of particles spewed out in the big bang. One of these was a heavy “right-handed” neutrino. This is, contrary to Turok's guiding philosophy, a hypothetical particle, but one that is widely believed necessary to counterbalance the mass of the neutrinos we already know about, which are called left-handed because of the way they spin.

With its abundance fixed by CPT symmetry, Turok and his colleagues found that if they tuned its mass just right, it matched the photofit of one of the universe's most elusive substances – dark matter, the universe's missing mass that physicists have been seeking for decades. “We couldn't believe it,” says Turok. “The right-handed neutrino just dropped out as a dark matter candidate.”

Dark matter candidates aren't hard to come by. This one, however, had a mass of 500 million billion electronvolts, or about one million-billionth of a gram. What Turok didn't know at the time was that this was dead in line with the mass of the particle ANITA had seen.

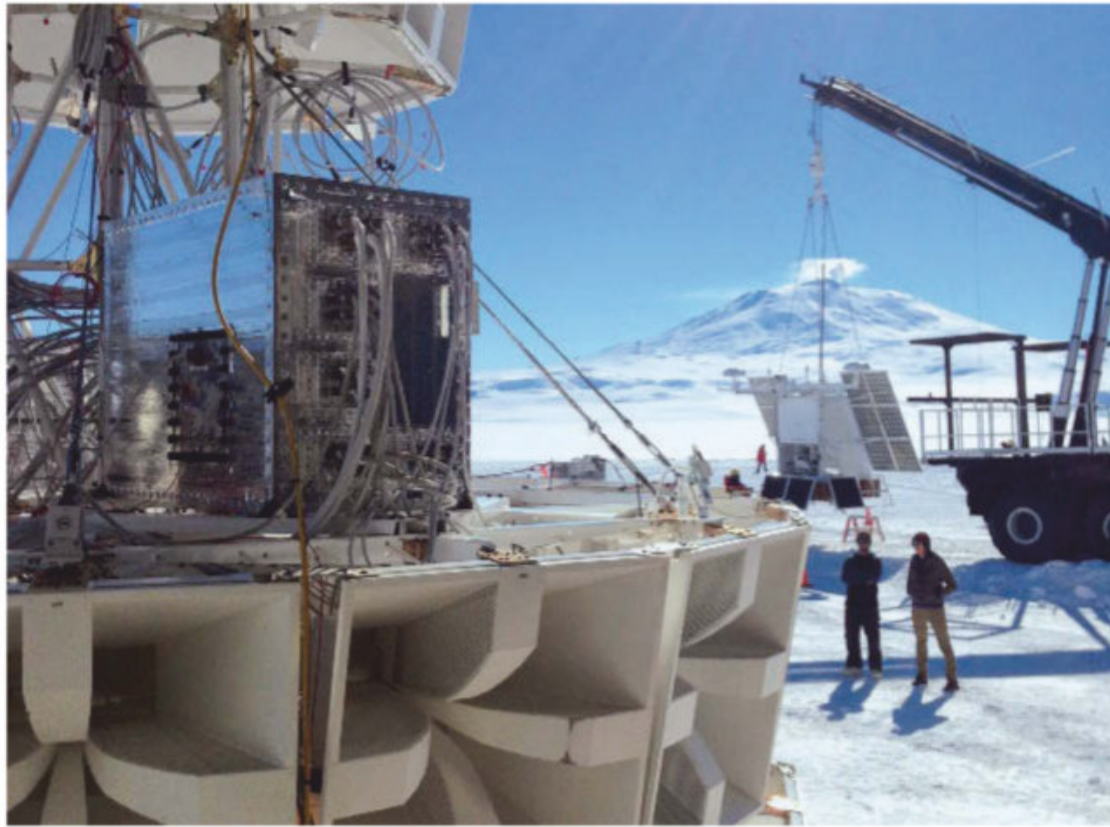
Fearful symmetry

Theorist Luis Anchordoqui at the City University of New York in the US and his colleagues were the first to point out the coincidence. They suggested that, over millions of years, right-handed neutrinos pervading the cosmos have been scooped up by Earth's gravity, nestling in the planet's interior ever since. And they also predicted that these dark matter particles occasionally decay into Higgs boson and tau neutrino pairs, thereby creating the ANITA signals. “The ANITA energy is exactly the one these guys are predicting,” says Anchordoqui. “That's the amazing thing.” It is a specific, quantitative prediction, and it is backed up by experiment, a rare thing in particle physics right now.

But if the premise underlying the idea is true, that spells trouble for the universe as we know it. One consequence of CPT symmetry holding in the very first moments after the big bang is that our cosmos would have contained equal quantities of matter and antimatter. Infamously, these two don't get along, and would have promptly annihilated one another, leaving only energy behind. The fact that matter vastly outnumbers antimatter today leads many cosmologists to think that CPT symmetry wasn't always as rigidly adhered to as it is today. By doubling down on its infallibility, Turok and his colleagues were left with a major question: how does our universe even exist?

As it turns out, the answer lies in CPT symmetry itself – and it is mind-blowing. To understand it, consider one of the most basic particle processes we know of: the creation of an electron and its antimatter counterpart, a positron, in the presence of a strong electric field. In strict adherence to CPT symmetry, however, there is another way of viewing this: the positron is an electron that travelled backwards in time until the moment of electric-field generation, and then turned around to go forwards in time. Weird as it sounds, the two descriptions are entirely equivalent, and there is no way to find out which is “real”.

Turok's extraordinary prediction is that something similar happened to our universe. The conventional view of the big bang is that it was the moment of creation for a single ➤



A mystery particle spotted by ANITA in 2016 could be evidence of a parallel universe

cosmos that is almost completely devoid of antimatter. But for CPT symmetry to be conserved, then the big bang would have had to create two parallel universes, with most of the matter funnelled into one – ours – and most of the antimatter ending up in the other. In the other universe, everything would be upside-down and back to front, and any stars or planets it might contain would be made of antimatter rather than matter. Even more astonishingly, this anti-universe would be contracting backwards in time towards the big bang, rather than expanding away from it.

Turned on its head

At least, that is what it would look like from our point of view. Just as CPT symmetry dictates that a positron travelling forwards in time is equivalent to an electron travelling backwards in time, so too is our impression of the anti-universe relative. To inhabitants of the anti-universe, it is our universe that is upside down, shrinking towards the big bang and filled with the “wrong” sort of matter. We can’t know which universe we are in, only that the other universe is, relatively speaking, backwards. In cosmic terms, this means that time isn’t an arrow imposed by some external observer. It is more like a personal weathervane, pointing in whichever direction it is that our universe expands.

This is a radical departure from the existing view of cosmology, and Turok is the first to

admit that there are one or two loose ends. But he believes he and others will be able to resolve the remaining difficulties without the need for any new particles. “If we can, there will be no contest anymore: our theory will be infinitely better than anything else,” he says.

Yet there is potentially a spanner in the works. If ANITA has indeed caught the right-handed neutrino that the anti-universe idea predicts, common sense dictates that other neutrino observatories ought to have caught it, too. Towards the end of last year, the neighbouring IceCube experiment – which continuously watches for flashes of light generated as the decay-products of neutrinos blast through a cubic kilometre of Antarctic ice – announced that it had found no high-energy neutrinos coming from the direction claimed by ANITA.

“This anti-universe would be contracting backwards in time”

This isn’t a killer blow for the anti-universe. Anchordoqui points out that the track of a high-energy tau neutrino can be mistaken for that of a lower-energy muon neutrino, of which IceCube has spotted at least one. It is a controversial view, but it suggests that both ANITA and IceCube may have discovered tantalising evidence for a parallel universe.

There are many other avenues for support, too. The anti-universe idea predicts that the big bang ought to have generated no primordial gravitational waves – ripples in space-time that many cosmologists are hunting but have failed to detect. And it predicts that the lightest of the three neutrinos is actually massless, a finding Turok believes could be confirmed in the next five to 10 years. It is by hard predictions such as these that the anti-universe idea will live or die. “We’ve tied our hands,” he says.

Meanwhile, the focus is returning to the Antarctic, and the possibility of capturing more massive particles as they explode from the ground. It has been three years since ANITA’s fourth flight descended softly to the ice, and an analysis of the latest data is still in the making.

Gorham is reluctant to preview the contents. “We don’t know how to represent it yet,” he says. “But we’ve got something.” ■



Jon Cartwright is a *New Scientist* consultant based in Bristol, UK



The fever paradox

Fever can be deadly, but in moderation it could have some surprising upsides, as **Linda Geddes** discovers

AS NEWS about coronavirus spread around the world, paracetamol soon began to disappear from shop shelves as people stocked up at home. In some places, the price of the drug shot up. That probably comes as little surprise given that one of the key symptoms of the infection is a fever.

We tend to routinely use drugs such as paracetamol or ibuprofen to try to bring down a high temperature, believing fever to be, at best, a passive and unwelcome bystander to infection and, at worst, a direct contributor to our illness. Yet mounting evidence suggests that fever may, in fact, be a strategy the body uses to ramp up its defences. This new understanding of what is going on when we are burning up could help us come up with better approaches to fighting infection altogether.

Normal body temperature is generally thought of as 37°C, although anything between 36.5°C and 37.5°C is considered normal (see “Highs and lows”, overleaf). However, once your temperature hits 38°C, you have officially got a fever.

The most common cause of this is infection.

“When immune cells recognise the telltale signs of a germ in the body – and often this can be quite early on in an infection – they release secretions which act on a brain area called the hypothalamus,” says Daniel Davis, an immunologist at the University of Manchester, UK, and author of *The Beautiful*

INNA NOVIGEL/SHUTTERSTOCK

Cure: Harnessing your body's natural defences. The hypothalamus is responsible, among other things, for controlling body temperature, and it responds to these signals by releasing hormones that cause various heat-boosting responses. Blood vessels in our skin constrict so less heat is lost at the body's surface. Fat cells start burning energy and our muscles rapidly contract, causing shivering – both of which warm us up. As a result, the body's temperature starts to rise.

If it rises too far, that can be fatal. Our cells begin to die, releasing proteins into the blood that can damage the kidneys and other organs, resulting in their failure. The exact temperature this happens at probably depends on the source of a person's fever, as well as other factors such as how hydrated they are. “The number 40 [degrees] scares a lot of doctors,” says Mark Peters at the UCL Great Ormond Street Institute of Child Health in London.

Even so, many hospital doctors will routinely give fever-reducing drugs as soon as a patient's temperature hits 38°C. Even a mild fever comes at a great cost: raising your body temperature by just 1°C requires a 10 per cent increase in energy expenditure. Fever is associated with a higher pulse and breathing rate, placing additional strain on the heart and lungs that could be risky in seriously ill people.

So if fever can kill us, why does it happen? ➤

HIGHS AND LOWS

Although 37°C is often cited as normal body temperature, it varies throughout the day, with thermometer readings some 0.8°C to 1°C lower first thing in the morning compared with the evening.

Body temperature also tends to be higher in women than in men – and even within women, it is approximately 0.4°C higher during the second half of the menstrual cycle compared with the first. Younger people also tend to have higher body temperatures than older people.

There is even evidence that our body temperatures may be falling over time – possibly because we are exposed to fewer pathogens in the modern world, meaning our immune systems are less active and our bodies less inflamed. One recent study found that, on average, body temperature in the US has fallen by around 0.03°C per decade since the early 19th century. Men born then were 0.59°C hotter than men today, while women's body temperature appears to have dropped about 0.32°C since the 1890s. The average body temperature for 21st-century humans is about 36.6°C – not 37°C as widely thought.

Fever-like responses are observed in many organisms, suggesting fever's evolutionary origins may stretch back hundreds of millions of years. Even some plants have been shown to increase their leaf temperature in response to fungal infections, while cold-blooded creatures will deliberately raise their body temperature if they have an infection, by sitting on a hot rock, for instance. In the case of the desert iguana, not being allowed to do so was seen to cause a 75 per cent reduction in survival rates.

That suggests fever might not be all bad. "Things that have a very high metabolic cost would not be preserved throughout evolutionary history unless they came with a clear survival advantage," says Peters.

The idea that fever might actually have medical benefits goes way back. The ancient Greek physician Hippocrates claimed that "those who cannot be cured by [medicine or] surgery can be cured by heat; and those who cannot be cured by heat are to be considered incurable". In 1927, the Nobel prize for medicine was awarded to the Austrian physician Julius Wagner-Jauregg for his discovery that triggering a high and persistent fever by inoculating people with malaria could treat their syphilis; the malaria was later treated with quinine.

Fever reliever

Modern medicine has moved on considerably, and so has the way we think about fever. It is easy to see it as the thing that is making us ill, not a symptom along with other things like a runny nose or sore throat. "People often equate fever with the cause of the fever – even many doctors struggle to get their heads around that separation of fever being the response to a problem, and not necessarily the problem itself," says Peters.

Fever can also feel unpleasant, and many of us feel glad when our temperature drops after taking some medication. From all these perspectives, it makes sense to want to bring temperatures down as quickly as possible. That's certainly how the medical profession views things, says Peters. "Correcting fever has become a routine part of intensive-care practice, almost to the point where it's not discussed."

But there are hints we might be missing something. Take the common viral infection chickenpox. In a study of 72 children, those who weren't given drugs known to reduce fever recovered faster. Likewise, a study of

Iguanas sit on hot rocks to raise body temperature when they have an infection

“By increasing your body temperature, you may be slowing the ability of a virus to multiply”

56 people infected with one of the viruses that causes the common cold found that those who took certain fever-reducing drugs remained infectious for longer.

Similarly, people who are admitted to intensive care units with infections and a slightly raised temperature tend to fare better than those who have a normal temperature, or one higher than 40°C. One reason for this may be that bacteria and viruses find it easier to replicate and infect cells at temperatures below 37°C. "By increasing your body temperature, you may be slowing down the ability of a virus to multiply," says Davis.

It also seems that the immune system works more efficiently when the body gets hotter. Immune cells that act as first responders to infection, such as dendritic cells, macrophages and neutrophils, have been shown to arrive at the scene faster, and have an improved capacity to engulf



CLAUDIO CONTRERAS/NATUREPL

CREDIT

and destroy infectious agents at 38°C to 40°C. Fever also seems to make these cells better at recruiting and activating T-cells, which coordinate longer-term “adaptive” immune responses, such as antibody production. And T-cells and antibody-producing B-cells also better respond to instructions from the immune system at these temperatures.

Recent studies are providing new insights into how this happens. One published last year suggested that running a temperature of 40°C may help T-cells crawl out of the blood towards sites of infection, by producing proteins that allow them to anchor to the blood vessel wall.

Raising body temperature by just a few degrees also speeds up a cellular “clock” that controls the switching on of a set of inflammation-promoting genes, according to recent work by Mike White at the University of Manchester and his colleagues. “You see a dramatic change in the timing of this system, where pretty much every degree makes a difference,” he says.

This is unusual in biological systems: even the circadian clock, which generates roughly 24-hour rhythms in our physiology, is insensitive to temperature. That implies fever may be a deliberate strategy to bolster our immune defences in the face of infection. “It suggests that the immediate immune response is that bit faster at higher temperatures,” says White, which may explain the speedier resolution of some illnesses.

All of this raises the question of when – and how – fever should be treated. Peters recently



SCIENCE PHOTO LIBRARY/LAMY

For a mild fever, rest and plenty of fluids can help

conducted a trial in 100 children who were critically ill with suspected infections. He wanted to explore whether it was feasible to let their temperatures rise as high as 39.5°C before administering fever-reducing drugs, instead of 38°C, which is the current practice in most UK hospitals. The children continued to receive other treatment. The trial showed that there were no adverse outcomes from treating at higher temperatures, but it wasn't designed to test if this resulted in faster recovery.

Meanwhile, a recent meta-analysis combined the results of various trials assessing the impact of treating mild fever in hospitalised adults. It concluded that there was no difference in survival between those who received more active management of their fever and those who received less. So far then, the results suggest there isn't a lot in it, although it is still early days.

It might be that we are focusing on the wrong problem, however. The question isn't whether we should treat fever, but in which patients we should do it, says Edward Walter, an intensive care doctor at Royal Surrey County Hospital in Guildford, UK, who recently reviewed the medical literature on fever. Rather than seeing it as a single thing, he says that running a high temperature can be a response to various problems. In addition to infection, these include brain injury, heatstroke and taking certain drugs such as ecstasy, so our response to it might need to be more nuanced, he says.

Another good question to ask is whether we have the means to treat the underlying cause of the fever. “If you're going to get an advantage from fever, it will probably be in populations where you cannot easily achieve control of the infection by existing means,” says Peters. With pneumonia triggered by a bacterial infection, for instance, antibiotics will often

treat the pneumonia, in which case there may be limited benefit to letting a fever run.

However, we currently have no effective drugs for pneumonia triggered by the new coronavirus, and so Peters speculates that mild fever could be helpful in such a situation.

Not everyone agrees. “You cannot really say fever is good, period, or fever is bad, period,” says Andrej Romanovsky at the University of Arizona, who edits the journal *Temperature*. “The only practical way to answer how we should treat fever is to run clinical trials in specific populations suffering from a specific disease and using specific [fever-reducing] drugs.”

In the case of covid-19, such trials may be years away. In the meantime, the UK's National Institute for Health and Care Excellence (NICE) is reviewing evidence on ibuprofen to try to clarify whether it is safe for treating the symptoms of covid-19 infections, after French health officials controversially urged people with symptoms to avoid the drug. The current advice from the World Health Organization is that either paracetamol or ibuprofen can be used to treat symptoms of the illness. In the UK, the advice from the National Health Service is to take paracetamol – although it doesn't say whether that is for fever or for other symptoms such as a sore throat.

“Fever is probably helpful in a very limited way, in those situations where we have light infections, but we should also consider how a person is sleeping and how they feel,” says Romanovsky. “For mild cases, it probably doesn't matter whether you take a drug to take the fever down.”

And most health services advise that a mild fever of up to 38.9°C, in the absence of more worrying symptoms, will probably get better with rest and fluids. So if your fever is mild, and you aren't in great discomfort, you might want to remember what is going on inside. “Permitting a fever in the viral condition is likely to allow your immune system to do its job – as it has been designed by millions of years of evolution – better,” says Peters. ■

This article is not medical advice. Very high temperatures can be dangerous. If you are feeling unwell, seek the advice of your doctor, especially if your fever is accompanied by other symptoms.



Linda Geddes is a science journalist based in Bristol, UK, and a consultant for *New Scientist*



Features



Little green alien invaders

Forget Martians, one of the most successful conquerers of Earth is a species of parrot.

Graham Lawton investigates

IT'S MINUS 13°C in Fargo, North Dakota, and I'm talking to a woman about tropical parakeets. Page Klug, a biologist at the National Wildlife Research Center's (NWRC) field station there, has recently taken a keen interest in the squawky invaders. Not, she stresses, because they have got as far as North Dakota – not yet, anyway. But because she is a leading researcher on agricultural pests of the avian variety and her expertise is in demand.

To Londoners like me, this will come as no surprise. When I moved to that city three decades ago, ring-necked parakeets were a rarity, an occasional raucous flash of green in a park. These days it is a rare walk through the urban jungle that doesn't feature an encounter, and the city is now as famous for its parakeets as for its pigeons. "The population has really taken off," says Tim Blackburn, a biologist at University College London. "Pretty much anywhere you go in London you can't miss them, and they're obviously spreading very rapidly."

Ring-necked parakeets push native birds off bird feeders

What is happening in my backyard turns out to be happening all over the world. A decade ago, it was mostly a European problem. Now, more than 35 countries, from the US to Israel and most recently Azerbaijan, are experiencing an explosion in their populations of alien parakeets. This makes these birds among the world's most successful invasive species and, like other invaders, they are increasingly making a nuisance of themselves. How did these showy creatures from the tropics spread so far and wide? What does their success tell us about the world we are creating? And can anything be done about them?

Even before it started its world tour, the range of the ring-necked parakeet (*Psittacus krameri*, also known as the rose-ringed parakeet) was extensive. When first recorded in 1769, the species inhabited a band right across sub-Saharan Africa, from Gambia to the Horn of Africa. In the early 20th century, a separate subspecies, *Psittacus krameri borealis*, was described living on the Indian subcontinent. It is this population from which the European parakeets are descended, according to genetic evidence.

They probably arrived as pets. In the UK, the

first recorded sightings in the wild were in Norfolk in 1855, but the birds don't seem to have survived for long. A breeding pair with five offspring was reported living in a tree in Lincoln's Inn Fields in central London in 1886, but again didn't persist. The first long-term wild populations were established in Kent in the late 1960s, and by the 1970s there were small colonies in counties around London. The first northern populations were established in Greater Manchester around this time too. Now, parakeets can be found in Scotland and there have been a few sightings in Wales, but they have yet to make it to Ireland.

There is no shortage of colourful stories about how they got here. Some involve Hollywood goddesses, rock gods or even acts of god, but all are almost certainly apocryphal (see "Just so stories", page 44). The prosaic truth is that there was no single founding population. The birds probably escaped – or were released – from captivity in driblets and drabs over many years. Parakeets are expert escapologists and break out of cages and aviaries all the time, says Richard Bufton at the University of Birmingham, UK, who researches their spread.

The population remained in the low hundreds until about 1986, then exploded. The most recent census, from 2012, put the number of breeding pairs in the UK at 8600. "It's likely to be a lot more now," says Bufton. He maintains a register of sightings and reckons there are about 30,000 individuals across the country, which officially makes the ring-necked parakeet a common British bird. What's more, numbers now appear to be rising by about 30 per cent a year.

Exactly what caused the upswing isn't clear. "I suspect it's partly a natural stage of population growth," says Blackburn. "Populations often bounce along at relatively low levels, then reach a point at which they grow much more quickly." It may be that a recent escapee introduced new genes into the population, which increased individuals' chances of survival in their new environment.

Perhaps this was an adaptation to the cold. Blackburn points out that ring-necked parakeets live quite happily in the foothills of the Himalayas, so must already be adapted to cold to some extent. But not fully. "You often see them with missing toes as a result of frostbite," says Bufton. He thinks that parakeets exploit the urban heat island effect to cling on through the winter months, which in the UK means living in or near cities. The most northerly outpost they have conquered in the world so far is Glasgow. The recent

Just so stories

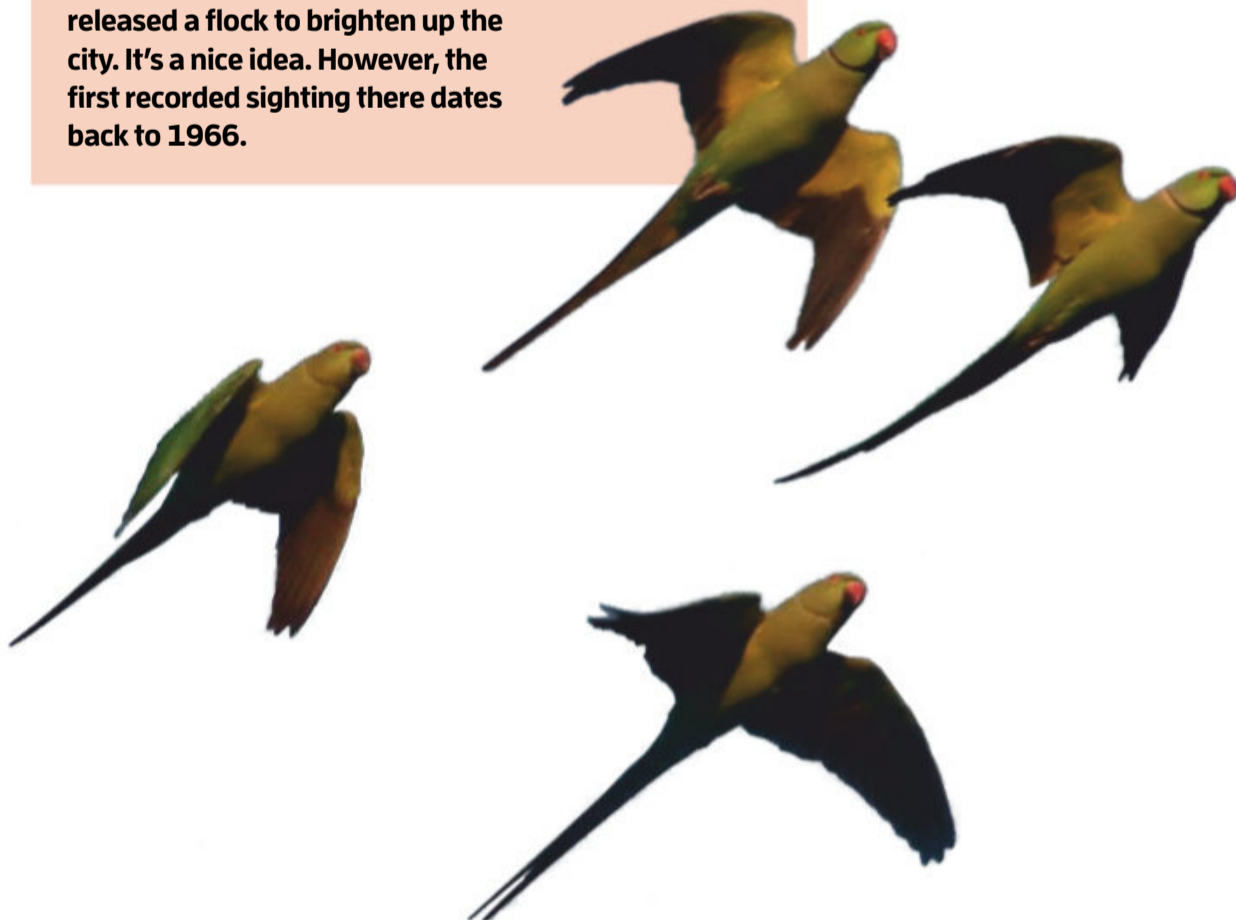
Tales of how ring-necked parakeets arrived in the UK are often as colourful and raucous as the birds themselves. One widely parroted yarn is that they escaped from the set of the Katharine Hepburn movie *The African Queen*, parts of which were filmed at Worton Hall Studios in west London in 1951. Another is that Jimi Hendrix released a pair on Carnaby Street in London in 1968 or thereabouts. A third is a mass escape, perhaps from an animal pound at Heathrow Airport or an aviary that had its roof blown off during the Great Storm of 1987.

These things may have happened, but claims that any were the original source of parakeets in the UK have been dismissed as urban myths. “They’re not the answer,” says Sally Faulkner at Queen Mary University of London. She and her colleagues recently used a technique from criminology called geographical profiling to analyse the spatial distribution of the birds from the 1960s onwards. It revealed that Britain’s parakeets originate from far and wide, over a long period of time.

Other origin stories are equally dubious. The population in Brussels, Belgium, for example, was supposedly started in 1974 when a zookeeper released a flock to brighten up the city. It’s a nice idea. However, the first recorded sighting there dates back to 1966.



“With 30,000 parakeets in the UK, they are officially a common bird there now”



arrivals in Baku, Azerbaijan – where midwinter temperatures hover around freezing – appear to survive by roosting near oil refineries that burn waste gas.

For now, invasive parakeets are considered synanthropic, meaning that they live in close proximity to humans so as to exploit artificial habitats such as heat islands and bird feeders. But climate change could alter that. “My suspicion is that as the climate generally warms, and particularly as winters get milder, there are probably more birds making it through the winter and that’s helping the population to grow,” says Blackburn. “Increasingly, I think we’ll see them outside the cities.” They will probably spread even further north. So, there may yet be life in Monty Python’s “Norwegian Blue” parrot – there is a blue variety of ring-necked parakeet.

Their further spread is an intriguing prospect, but no joke. “Alien species are one of the primary ways that humans are changing the natural world,” says Blackburn. “Understanding that invasion process is very important for understanding environmental risks humans are posing.”

In the US, parakeets have already expanded beyond cities: southern states, including Alabama, California, Florida, Louisiana, Texas and Virginia, have rural populations. And they are increasingly troublesome. “They have the capability of becoming serious agricultural pests,” says Klug. The birds naturally eat fruit, so flock to fruit trees, but they also devour nut and seed crops. They are destructive, wasteful eaters. “They’ll pick something up, give it a peck, ruin it for sale, but then drop it and move on to something else,” says Jim Groombridge at the University of Kent, UK.

In Europe, agricultural damage is less of a worry, but there is growing concern that expanding parakeet populations are putting a squeeze on native wildlife. Invasive species are one of the leading causes of biodiversity loss, and parakeets compete with other species in several ways. For a start, they nest in tree hollows. “They occupy nest sites much earlier than British birds do,” says Bufton. That can leave birds that nest in tree holes, like nuthatches and woodpeckers, with nowhere to go. “This is one of the reasons why they are so successful,” he says. “There’s also some evidence that they push certain native species off bird feeders and therefore potentially have impact through competition for food,” says Blackburn. In southern Spain, meanwhile, the parakeets are elbowing out the greater noctule, Europe’s largest bat, which is classified as vulnerable to extinction. The birds usurp its

DAN KITWOOD/GETTY IMAGES

nesting holes in trees and sometimes peck the bats to death.

There is also a growing realisation that parakeets can be a reservoir of pathogens. They carry some diseases found in livestock, although there is no evidence that they pass these on to them, says Blackburn. However, pet parakeets do sometimes transmit a flu-like infection called psittacosis to people; an outbreak of this “parrot fever” in France in 1930 apparently caused some owners to release their birds into the wild, which has been proposed as the origin of the European population.

Noise pollution

Another growing problem is the squawking. Parakeets are noisy birds and when they mass together in roosts they can be cacophonous. There are anecdotal reports of people being kept awake at night or being unable to sell their houses because of parakeet noise pollution, says Groombridge.

If you want to see the damage parakeets can do, look to Hawaii. Ring-necks arrived on Oahu island in the 1930s and found the conditions to their liking. For years they were little more than a curiosity, but now they are becoming a serious pest. “Parakeet populations can have these really long lag times where they’re not a problem. Then numbers start to increase exponentially,” says Klug. This is what has happened in Hawaii in the past two decades. By 2018, there were approximately 4650 birds on Oahu and a further 6800 on Kauai. “They are really starting to show an impact on agriculture and tourist resorts, with their faecal and noise pollution,” she says. Many people have had enough. “I think that the level of damage has reached a point that there is support for controlling that population,” says Klug.

Eradicating Hawaii’s parakeets wouldn’t be easy, though. There are essentially two options: the gun or the pill. Shooting is quick and deadly but hard to do safely when there are people and other animals around. Contraceptive-laced bait has proven effective in the lab, but is difficult to roll out in the wild, as you have to design feeders that are accessible only to your target species. Even then, parakeets are long-lived, so a contraceptive-led eradication programme may take 20 to 30 years. And there is a fear that a control programme could make things worse by driving parakeets out of the agricultural lowlands and into the highlands, where they could pose a threat to Hawaii’s endangered native birds. “They can be aggressive, so



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there’s a conservation component that we’re concerned about,” says Klug.

“At this point, with the numbers that there are, the effort is going to have to be long and sustained to be able to even bring their populations down,” says Klug. However, there is a precedent. Last year, Seychelles announced the extirpation of the ring-necked parakeet from its main island, Mahe, after an eight-year eradication campaign. The last of around 500 birds was shot in 2017 and none have been seen since then. “It’s the one successful campaign,” says Klug.

As yet, there is little appetite for parakeet eradication outside Hawaii and Seychelles. Nevertheless, biologists are beginning to advocate control programmes in some areas where the bird isn’t yet a pest. California, for example, with its almond, pistachio and fruit farms, is considered especially vulnerable to invasive parakeets. In a recent conference on vertebrate pests, Klug’s colleague Aaron Shiels at the NWRC field station at Fort Collins, Colorado, argued that California should consider controlling parakeets while it still can.

In Europe – and especially in Britain – that probably isn’t an option. The genie is already out of the bottle; parakeets are just too abundant and spreading too fast to control. “I suspect as time goes on, we will wish we’d done something about them 40 years ago,” says Bufton. “I think the time for eradicating them is long gone.” Besides, killing parakeets would be controversial. “A lot of people love them. I love them. I think they are awesome birds,” he says.

Parakeets like fruit but they damage far more than they can eat

But sentiment can turn. “Many people love seeing them in their gardens,” says Groombridge. “But once they hit a certain threshold, where suddenly all you’re seeing is parrots in your garden... It’s interesting how people’s perceptions change.” If familiarity breeds contempt then, like London’s maligned pigeons, parakeets may one day be regarded as flying rats.

Even if ring-necked parakeets were to go the way of the dodo, that wouldn’t necessarily end Europe’s parrot problem. There are many similar species that could take their place. The monk parakeet – a cold-adapted native of South America – is already out of control in some cities, including Barcelona in Spain. The Alexandrine parakeet from India – which looks just like the ring-necked but with a purple patch on its shoulder – is already in the UK, Belgium, Germany and Italy.

“There are about a dozen, if not more, parrot species that have breeding populations in Europe and which are classed as potentially invasive,” says Groombridge. “They’re waiting in the wings.” ■



Graham Lawton is a features writer and columnist at *New Scientist*

Our most beloved animals are dying out due to human greed.

Credit: Juan Pablo Moreiras/FFI



Millions of endangered animals are being illegally and cruelly slaughtered to satisfy the demand for markets that exploit human weakness. It's time to stand together to end illegal wildlife trade.

- **Fauna & Flora International is working to stop illegal wildlife trade at its source and dismantle the trade networks.**
- **Illegal wildlife trade threatens some of our most iconic and beloved animals, like pangolins, elephants and tigers.**
- **A terrible human price is being paid too as people are exploited through this trade – but the traffickers will stop at nothing.**

Over the last 50 years, illicit trade in wildlife has become one of the greatest threats to our natural world. Syndicates of traffickers are exploiting communities in developing areas, driving them to illegally hunt down animals for their body parts. These criminal networks only pay a tiny portion of the final price they get for the animals they receive. Beautiful animals are reduced to gory lumps of gristle, bone and keratin, then shipped off to far-flung markets.

Angry? We've barely started yet.

The animal parts are being shipped along with weapons, drugs, even people – these heartless profiteers don't care about the devastation they cause. Live animals are concealed during transport with no thought for their survival. Many of them don't make it. Perhaps it's a mercy when they choose to kill and freeze the animals, before hiding them in cargo containers the size of a small bus. Because that's

the industrial scale they're working on. It's not one or two animals here and there – it's entire species that we are seeing driven towards extinction, lost forever from our global heritage. And for one reason alone. To put more money in the pockets of these criminals – whatever the cost.

“If you value the natural world – if you think it should be protected for its own sake as well as humanity's – then please support Fauna & Flora International.”

Sir David Attenborough, Fauna & Flora International vice-president

Ruthless doesn't come close to describing them.

Organised criminal networks are taking advantage of people desperate for miracle cures. Trading on fears and desires, they ply their products at a hefty price – exploiting insecurities to fatten their wallets. You see, *these people will stop at nothing to turn a profit.*

Now, we all pay the price. COVID-19 has affected us all. It's unravelling our economies. It has sealed us up in our homes and is attacking the most vulnerable among us. In a short period, almost every person on the planet has been affected – and we still don't know the final toll.



Credit: Gary Morrisroe/FFI

we would never have imagined that these markets for body parts of wild animals would affect us in this way. It's time to say “enough”. Dr Rebecca Drury, Head of Wildlife Trade at Fauna & Flora International (FFI) says, “We would like to see stronger action to halt illegal hunting, trafficking and consumption of illegally-sourced wildlife. It is no longer an option to ignore the dangers of illegal and unregulated wildlife trade and consumption, to human health and to healthy, functioning ecosystems needed for life on earth to thrive. We must ensure that the lessons from COVID-19 pandemic are applied to prevent repeats of this global crisis.”

The source could well be these criminal profiteers.

We don't know for certain how the pandemic started. Some scientists suggest that the disease might have been transferred to a person from a pangolin being traded illegally in one of these markets – these are the most trafficked wild mammals in the world, with over a million consumed by the trade since 2000. Yet

Illegal wildlife trade must be stopped.

The governments of the world are doing what they can. But while bans are put in place, the despicable individuals driving the trafficking will try to use their illicit networks to keep selling, lining their pockets until they are stopped. It's precisely because this is a trade that happens in the shadows, that

Your response by 25 April could help stop the traffickers.

we must stop it at source. That's why FFI is raising funds – to help put a stop to this vile trade. To do so, they are asking readers of *New Scientist* to make an urgent contribution today.

Act now to stop the traffickers.

FFI are working to stop illegal exploitation of wild species - supporting governments to collect vital evidence that can help convict traffickers, disrupt their networks and bring them justice instead of profits. FFI are also keeping dedicated rangers going, making sure they have essential equipment

and training to respond like lightning to every poaching threat – stopping the trade at its very source. There's not a moment to waste. We must act now to save countless animals from this grim, ravenous, all-consuming market. Please cut the coupon and return it now, and you could help save beloved creatures like elephants, tigers and pangolins. If the coupon is missing, please send your cheque (payable to FFI) to: Freepost RTTH-TXTL-AJRK, Fauna & Flora International, The David Attenborough Building, Pembroke Street, Cambridge, CB2 3QZ by 25 April.

How you could help stop the trafficking

Your gift could help stop illegal wildlife exploitation at its source and dismantle trafficking networks. Illegal wildlife trade is one of the most serious and persistent threats to endangered species like elephants, tigers and pangolins. Here's how your support could help:

£5,000 could help build a case against a wildlife trafficker, collecting vital evidence needed to secure convictions.

£1,000 could help train rangers to tackle poaching threats in the field. The first line of defence, these brave people respond immediately to poaching incidents.

£500 could help pay for DNA analysis of important evidence, helping us to understand the trading networks so we can focus our efforts where they matter most.

£100 could help pay for an important item of equipment for a ranger, like a first-aid kit.

£50 could help pay for monitoring equipment like camera traps and GPS units, helping us run patrols in the highest-risk areas.

Any donations, large or small, will be received with thanks – every gift makes a difference. You could help strike a vital blow at the markets that make this trade so profitable. Please respond by 25 April at the very latest. Thank you.

Just some of the animals suffering from the illegal wildlife trade:



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Pangolins
killed for meat and scales

Tigers
reduced to a pile of skin and bones

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A doctoral degree in chemistry or biology or a related field is required.

Application Instructions

Candidates are required to submit a cover letter, CV, and a research statement. Also, four reference letters are required. Apply to: apply.interfolio.com/75371

A review of applications will begin May 11, 2020, and continue until the position is filled.

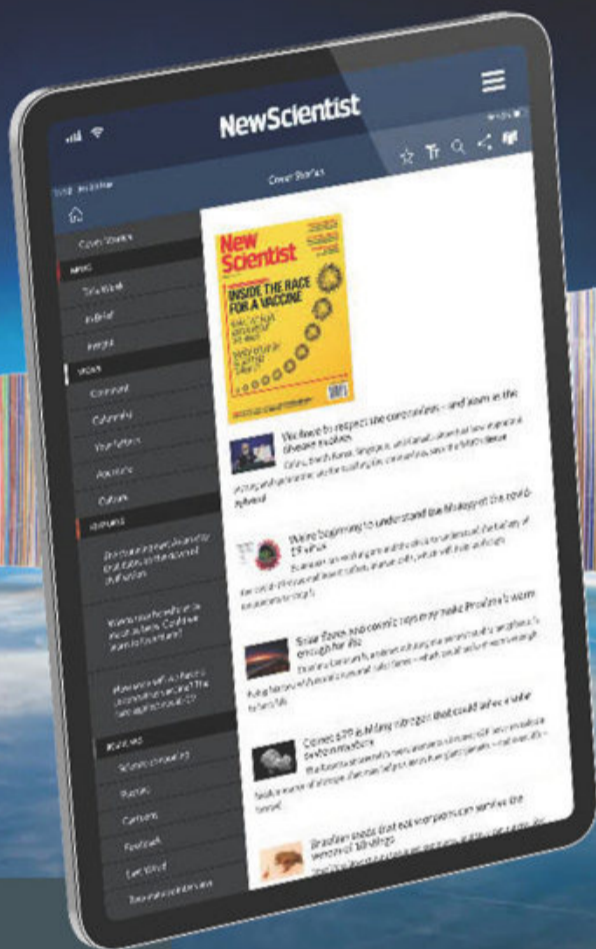
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Science of cooking **Week 15**

'Meat' from wheat

Seitan is a tasty meat alternative you can make from just flour. It takes a bit of time, but the results are worth it, says **Sam Wong**



Sam Wong is social media editor at *New Scientist*. Follow him @samwong1

What you need

Flour
Water

For vegan chicken nuggets:

Vegetable stock
Vegan coconut yogurt
Flavouring, eg paprika or oregano
Breadcrumbs
Vegetable oil

AS MORE and more people cut meat from their diets, seitan, or wheat gluten, has surged in popularity. Making it at home takes a bit of effort, but I would recommend it, if only to marvel at how flour can be transformed into something resembling meat.

As mentioned in earlier columns about noodles, pastry and pancakes, gluten is made from wheat proteins that link together in the presence of water, forming a strong but flexible network.

Gluten has acquired a bad name in some quarters, with many people blaming it for digestive trouble. People with coeliac disease have an immune reaction to gluten, but for those without this condition, there is little evidence that gluten is unhealthy. Some studies suggest that digestive problems are more likely to be caused by certain types of carbohydrates in wheat.

Plain flour is around 10 per cent protein, but stronger types of flour can be 15 per cent or higher. You can use any flour to make seitan, but the higher the protein content, the more seitan you will get.

Start with a kilogram of flour and 2 teaspoons of salt in a large mixing bowl. Add just enough water to bind the flour into a stiff dough – about 500 millilitres, but this will depend on the flour. Knead it until smooth, then rest it for an hour to let the flour hydrate.

The biggest component of flour is carbohydrate – mainly starch – which we don't want in the seitan. To remove it, wash the dough with water to dissolve the starch. Put



OLGA MILTSOVA/ALAMY



Science of cooking online

All projects are posted at [newscientist.com/cooking](https://www.newscientist.com/cooking) Email: cooking@newscientist.com

the dough in a bowl in the sink, add a bit of water and knead the dough until the water becomes milky. Pour off the water and repeat multiple times until the water stops turning white. This takes about half an hour. If you are feeling frugal (and aren't vegan), save the starchy water from the first few washes and mix it with egg to make a pancake batter.

After this, the dough will still be malleable, but with a texture more like a chicken breast. In China, seitan is called mianjin, meaning "wheat muscle".

Seitan can be deep-fried at this point, which gives it a spongy texture. But if you are using it as a meat substitute, boiling it first will make it denser and firmer.

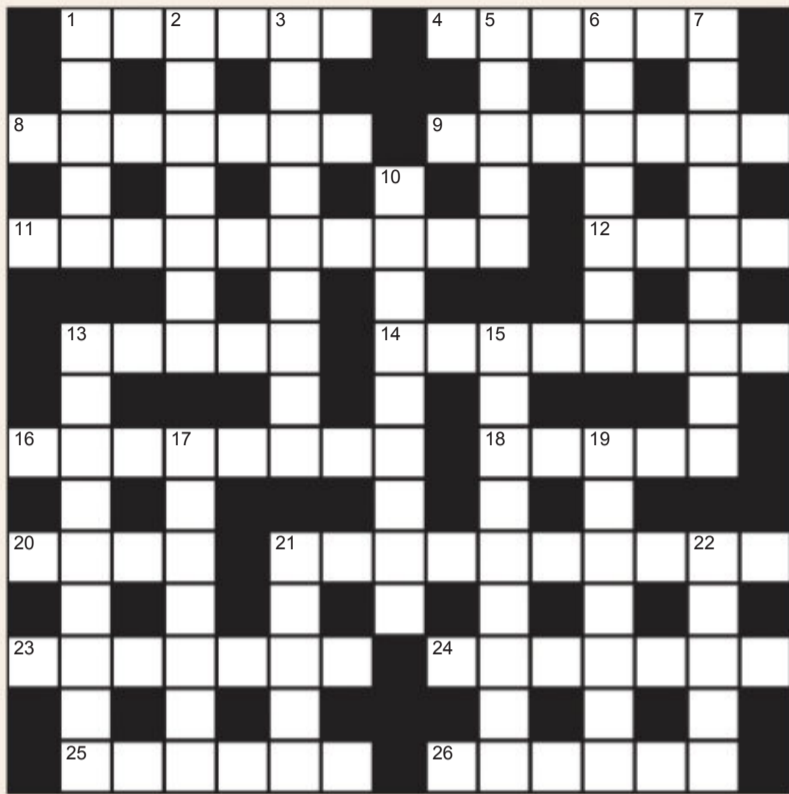
To make a vegan version of chicken nuggets, first cut the seitan into nugget shapes. It will expand during boiling, so keep them small – you should get 16 to 20 nuggets out of 1 kg of flour. Boil them for 15 minutes in salted water or stock – a good option to improve the flavour of the seitan, which is otherwise fairly bland.

Marinate the nuggets in dairy-free coconut yogurt mixed with paprika, oregano or other flavourings. Then coat them in breadcrumbs and deep-fry in vegetable oil for a few minutes, until they are nicely browned. Panko breadcrumbs are best as they contain large flakes that add a lot more crunch than ordinary breadcrumbs. ■

Next week

Baking without eggs: The best substitutes for making meringues and cakes

Quick crossword #55 Set by Richard Smyth



ACROSS

- 1** Term for the left atrioventricular valve (6)
- 4** Graphical representation of a computer user (6)
- 8** Baby born before 37 weeks of gestation (7)
- 9** Inability to process sense data (7)
- 11** Eczema (10)
- 12** Basic input/output system (4)
- 13** Skilled operator of an aircraft or ship (5)
- 14** Low-pH precipitation (4,4)
- 16** Woofers and tweeters (8)
- 18** Stalk (5)
- 20** Missile; multiple independently targetable re-entry vehicle (4)
- 21** Random signal (5,5)
- 23** α -iron (7)
- 24** Blood clot or other unattached mass (7)
- 25** Gecko, chameleon or gila monster, say (6)
- 26** Biocatalyst (6)

DOWN

- 1** --- -- .- (5)
- 2** Concerning heat (7)
- 3** Polymath of ancient Greece (9)
- 5** ___ nerve, major part of the autonomic nervous system (5)
- 6** Desktop control centre (7)
- 7** Soil bacteria genus (9)
- 10** Great Eastern or Great Britain, for example (9)
- 13** Behind the knee (9)
- 15** Genus of parasitic wasps (9)
- 17** Luis ____, Nobel prize-winning physicist (7)
- 19** Study of unidentified flying objects (7)
- 21** H₂O (5)
- 22** Sea-foam (5)

Answers and the next cryptic crossword next week.

Quick quiz #46

- 1** Laurasia + Gondwana = ?
- 2** Barbara McClintock won the 1983 Nobel prize in physiology or medicine for discoveries in genetics made by studying which plant?
- 3** What 1962 book by Rachel Carson about pesticide harms is credited with starting the modern environmental movement?
- 4** To make a Josephson junction, what special sort of material do you need?
- 5** Where is the sea known as Kraken Mare?

Answers below

Cryptic Crossword #28

Answers

- ACROSS** **1/6** Self-isolate, **3** See **27**, **9** Abscess, **10** Ebola, **11** Leach, **12** Ordeal, **14** Orally, **16** Urge on, **19** Stigma, **21** Phage, **24** Angst, **25** Inexact, **26** Sanitise, **27/13** Herd immunity
- DOWN** **1** Smallpox, **2** Lassa, **4** Musk Ox, **5** Upend, **6** See **1** Across, **7** Yuan, **8** Lethal, **13** Infected, **15** Antigen, **17** Ropier, **18** Rabies, **20** Get It, **22** Abate, **23** SARS

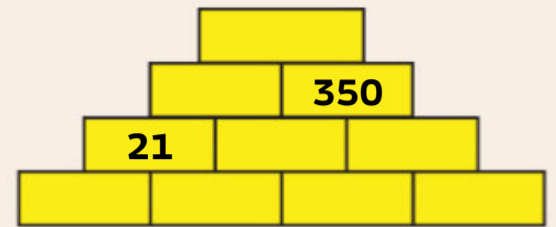
Quick quiz #46

Answers

- 1** Pangaea, the supercontinent that existed on Earth between around 350 and 175 million years ago
- 2** Maize
- 3** Silent Spring
- 4** Superconductors. Fix it up right, and current will flow indefinitely across the junction with no voltage applied
- 5** On Saturn's moon Titan. Consisting mainly of methane and with an area of some 400,000 square kilometres, it is the largest surface sea in the solar system beyond Earth

Puzzle set by David Bodycombe

#54 Pyramid of possibilities



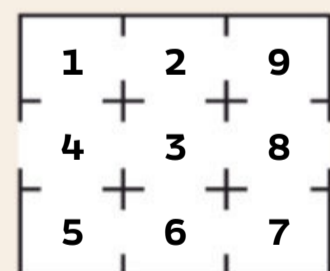
In the ancient land of Aztekia, people are proud of their historic ziggurat. In it, each block bears a different number that is equal to the product of the two whole numbers on which it rests. Given the two numbers shown, can you complete the monument? Bear in mind that no two numbers are the same on these ziggurats.

Answer next week

#53 Paintings by numbers

Solution

The neighbouring rooms of room 5, for example, must include rooms 4 and 6, and in general the neighbours of any odd numbered room must be even numbers, while even numbers must have odd neighbours. We can think of the gallery as a mini chessboard, with odds on white squares and evens on black squares. Since there are five odds and four evens, the corners and the centre square must be the five odd numbers. Where can room 1 be? It can't be bottom left, as the two rows above it must add to more than 200. By trying to trace paths 1-2-3... and so on, you can also quickly rule 1 out from bottom right, top right and centre. The only path that works is:



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Bottomless brunch

Working from home doesn't always bring out the best in us. The rot sets in early, with late starts and cheekily long lunch breaks.

By about day three or four, many people start to crave their normal office routine and attempt to replace it by going on tea rounds for the houseplants or asking the children to circle back once they have ideated third-quarter objectives for the cat. The next and final stage, or so we are told, involves dialling into video calls while not wearing any trousers.

We always thought this was something of an urban legend, a tall tale that freelancers whispered to office workers in a bid to make the grass seem greener on the other side. But now, at least according to *Yahoo Finance* reporter Daniel Roberts, we have harder evidence.

Dan Bartlett, an executive vice president of retail giant Walmart, told Roberts that the boom in video conferencing means "we're seeing increased sales in tops, but not bottoms".

Our doggedly sceptical colleagues in *New Scientist's* news team say it is a great story, but they don't buy it. As far as Feedback is concerned, that's fine. You only need to buy half.

It's the feds

One thing about a national lockdown that Feedback was looking forward to was the excellent excuse it afforded us not to exercise. But even this small silver lining has been irreparably corroded, as all sorts of fitness-minded individuals and organisations have arranged free, diverse and easy-to-follow training routines that you can conduct in the discomfort of your own home. How inconvenient.

One that has garnered a lot of attention these past few weeks is the FBI's fitness app. That's right, the same FBI that brought you sunglasses, cool jackets and the incarceration of Al Capone. It turns out that FBI agents need to pass an intensive test of physical

fitness, which the Federal Bureau of Investigation has now gamified and turned into an exercise app.

The organisation has been promoting it intensively at this time of home fitness, which is laudable. Or – to don sunglasses dramatically and stare into the camera – is it?

As various people on Twitter have pointed out, downloading the app might well turn out to be better for the feds than it is for you, in part because doing so gives the app access to your location, personal data and almost the entire contents of your phone. So enjoy working on your physique in an enclosed space, readers – you may well need the practice.

Criminal negligence

One of the few positive aspects of this time of global crisis has been the sense of solidarity. That unifying feeling, whether on social media, over the phone or out your window, that we are all in this together, no matter who you are.

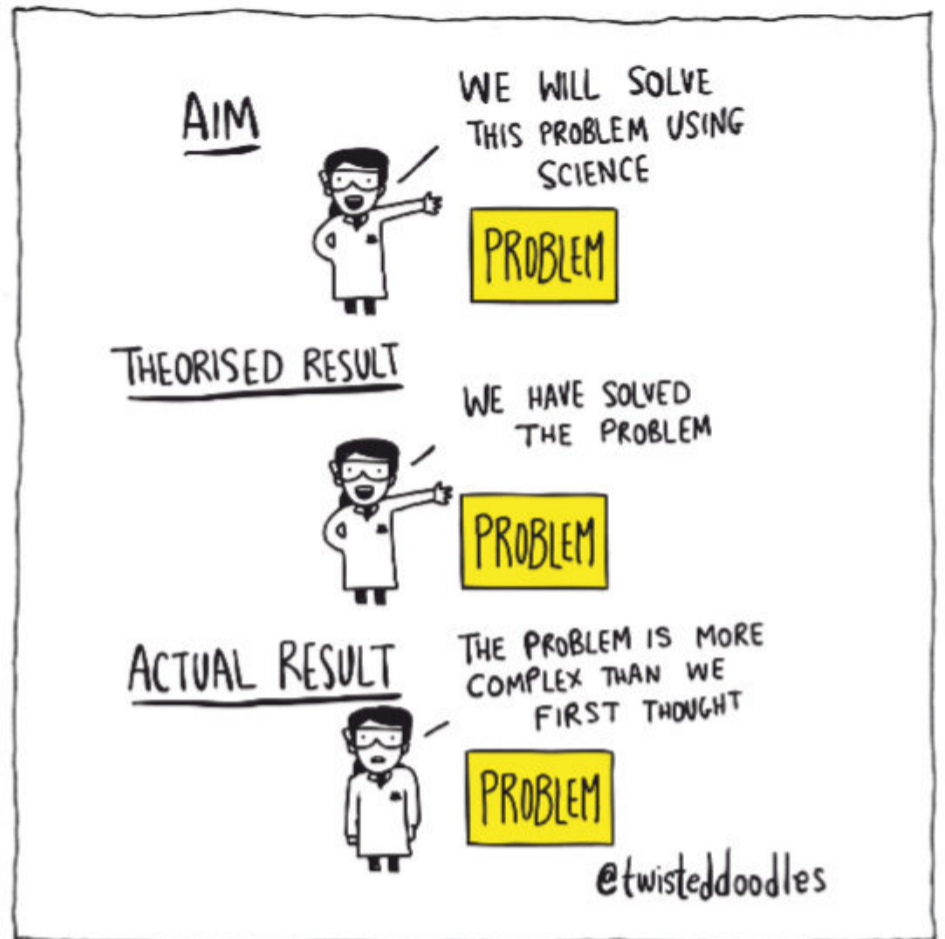
Even so, Feedback was surprised when we came across two unlikely groups seemingly attempting to flatten the curve: terrorists and gangs. According to some reports, ISIS has recommended that its followers stay away from heavily infected regions, and gangs in the favelas of Rio de Janeiro have been encouraging their co-residents to stay indoors.

Bad times roll

Time for the most baffling coronavirus-related press release of the week, a feature that could become a staple over the coming months as companies become increasingly shameless in their attempts to cash in on the crisis.

This week's winner cannot be improved with commentary. It is perfect in its simplicity and haunting in the appropriateness of its central punctuation mark. Ready? Here it is. "Toilet roll shortage: 70% willing to poo in the shower will you?" For the record, it's a no from us.

Twisteddoodles for *New Scientist*



Blunt appreciation

It is a lesson that every performer must learn early in their career: you have to know your audience. Or, in the case of noughties icon James Blunt, singer of the 2005 cringe-hit *You're Beautiful*, you have to know who isn't your audience.

As he recently tweeted: "During lockdown, while many other artists are doing mini-concerts from their homes, I thought I'd do you all a favour and not." Thanks, James, there is only so much we can put up with at the moment.

There are many people we would implore to take a similar vow of silence, not least those companies we ordered something from years ago that unfortunately still seem to have our email address. Look, we may have enjoyed that board game box set we got as a present in 2005, but come on,

"Mr Monopoly's COVID-19 response" isn't something we really want in our inbox.

Blame game

Feedback's eye was caught this week by an Israeli man who returned a Roman catapult bolt to the historical site he pinched it from as a teenager.

According to a report in *The Times* on the incident, he fears the end of the world is approaching and the relic had been weighing on his conscience.

It is an admirable sentiment, and one that Feedback can only applaud. So if anybody wants to learn from this and return the Haruki Murakami novel they borrowed from us in 2012 and never gave back, then we would be only too willing to absolve their guilty souls. ■



Got a story for Feedback?

Send it to *New Scientist*, 25 Bedford Street, London WC2E 9ES or you can email us at feedback@newscientist.com

Let it go

Why, when we hear some tunes, do they stick in our heads for days on end? How do earworms get in, and what is the best way to get rid of them?

Katherine Conroy
*ENT speciality trainee
Manchester, UK*

A significant proportion of our everyday thoughts is made up of spontaneous cognition, or mind-wandering. This includes “earworms”, or involuntary musical imagery.

Whether a piece of music becomes an earworm for you depends on many factors. Higher tempos and conventional melodies tend to be more infectious. Recent or repeated exposure and emotional triggers also make you more prone to an earworm. Unwanted ones can be banished with auditory distractions, particularly listening to a song you don't find catchy.

Jane Lille

Newdigate, Surrey, UK
Earworms seem to be based in a part of the brain that is specific to the memory of music, and can be stopped only by activating the same part. Reading, accessing verbal or visual memories, physical activity and intellectual discussion have no apparent effect.

I also find that they are usually tunes that I don't want to hear, and it may not be coincidence that advertising jingles and the theme tunes of children's programmes tend to become earworms.

I once arrived at my scuba diving club with a harvest hymn running round my head. I was unaware of it during the diving session, but later, while showering, I found the same hymn was still cycling steadily through its verses.

An earworm can be displaced by another tune. For me, the important thing for the replacement seems to be a good strong melody that I know well and enjoy. If I am walking, its beat

should be in time with my steps. Concentrating on playing it in my head for a minute or two invariably displaces the earworm, but for a while afterwards I have to avoid thinking about the problem tune, otherwise it returns and I have to repeat the exercise.

The interesting thing is that my chosen tune doesn't itself become an earworm. It quickly fades away, and it may be quite a long time before the next earworm takes up residence.

Brian Reffin Smith
Berlin, Germany

I find earworms can be removed by doing anagrams in your head. Think of a capital city, for example, not too easy, not too hard, and find an anagram of it. Amsterdam has loads. The effort seems to shove out the earworm.

Hillary Judd

Exeter, UK
Mentally singing two verses of *God Save the Queen* seems to eradicate any earworm. It works,



RF PICTURES/GETTY IMAGES

This week's new questions

Feline feelings Cats don't seem to have as many facial expressions as dogs. Is there a reason for this?
Monika Kozlovskis, Coff's Harbour, Australia

Extreme preservation If I wanted to be buried so that I was eventually fossilised, for possible discovery in the far future, where would be the best location on Earth to do this?
David Atkin, Fartown, West Yorkshire, UK

without becoming stuck as a replacement tune. Other people who have tried this remedy agree, but I have no idea why it works.

Malcolm Monie

Whitchurch, Shropshire, UK
I lead a bell-ringing group and some of our tunes are definite earworms. To kill one, all you have to do is to count the wrong number of beats to the bar. If you aren't sure, five is usually a good choice, as very few tunes have a quintuple metre.

Anne Hardwick

London, UK
Earworms are often simple, old-fashioned tunes, designed to be quickly picked up without effort, such as music hall choruses. A way to get rid of them is to concentrate on something more

Inscrutable: it can be hard to discern what a cat is thinking

complicated. *The Fairy Song* from Rutland Boughton's opera *The Immortal Hour* does it for me.

Broadly speaking

How do we know the universe is expanding? Why can't there be an alternative explanation, say that all atoms are shrinking?

Richard Swifte

Darmstadt, Germany
We can't be sure that the universe is expanding, but it is the most likely explanation, given the available evidence. The hypothesis is based on the observed “red shift” of light from distant galaxies towards longer wavelengths.

A star's intense radiation causes the electrons of atoms near its surface to change their orbital positions and absorb radiation at discrete frequencies. Each element produces a unique set of spectral absorption lines, like a barcode, which can be compared with standard measurements to calculate the amount of red shift. This is analogous to the Doppler effect of, say, a vehicle's sound changing frequency as it moves towards or away from you. The increase in red light suggests that the stars are moving away from us.

An alternative idea was proposed by cosmologist Christof Wetterich in 2013. He suggested that the mass of atomic particles could be continuously increasing, as their size correspondingly shrinks, and that this is also compatible with the observed red shifts. However, Wetterich's theory isn't taken too seriously, probably because most scientists prefer to adopt the simplest valid explanation that fits observations – a guiding principle known as Occam's razor. ■



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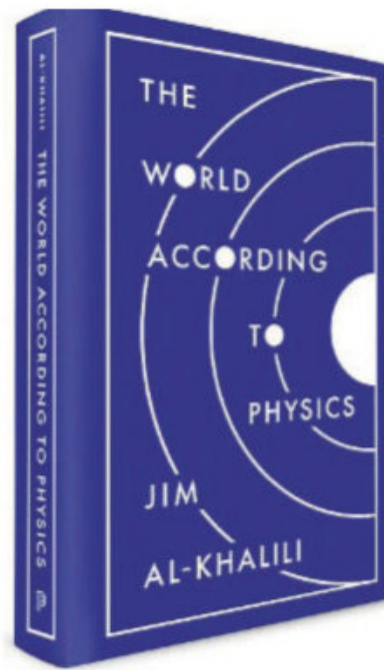
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Conserving marine wildlife isn't easy when you are working in one of the most overfished areas of the world, says **Justine Dossa**, but that makes it even more important

So, what do you do?

I coordinate the West African marine programme at BirdLife International. I'm based in Dakar, Senegal, but my work covers the length of the coast from Mauritania to Sierra Leone, and out to Cabo Verde.

How did you end up working in this field?

I have been passionate about wildlife protection since I was a teenager. I studied in my home country Benin and for an MSc in Belgium, then worked in marine turtle conservation in Benin and then Gabon before landing in West Africa. After a few years, I became known as a marine wildlife conservationist and specialist in turtles, sharks, rays and seabirds. That led me to BirdLife.

Can you tell us about the marine environment where you work?

The Canary Current Large Marine Ecosystem (CCLME) stretches more than 3000 kilometres from the Strait of Gibraltar to Guinea-Bissau. It is one of the four major upwelling systems in the world and one of the richest for biodiversity. Its coastal and oceanic waters host about 12,500 species.

Does that make it a good fishing area?

Yes, it ranks third in the world in terms of primary productivity. The fisheries in the CCLME region are of major economic and social importance for the coastal populations and states of the region.

What are the biggest challenges facing marine conservation in the area?

The huge data gaps and overfishing. For many years, the region has suffered from unsustainable fishing by both foreign and domestic fleets, and experiences the highest levels of illegal, unreported and unregulated fishing in the world.

Can you tell us about your main projects?

Our teams have made tremendous efforts to tackle illegal harvesting from seabird breeding colonies in Marine Protected Areas. We are also working on reducing by-catch of seabirds and sea turtles and threats from offshore oil and gas activities. Seabirds are a key component of marine ecosystems and important indicators of wider biodiversity and ecosystem health. Using data from tracking devices attached to birds, we have worked to identify hotspots where many species or many individuals occur consistently.

Is it difficult to convince others of the need for conservation?

Convincing people about the importance of reducing seabird by-catch by using simple, non-scientific vocabulary is something to experiment with. I remember this question: "How does a flying animal – a bird – become entangled in underwater fishing gear?" After a lot of effort, people are aware of this as a problem, which has helped start the first steps towards the reduction of seabird by-catch.

Do you have an unexpected hobby?

I have come to love birdwatching since joining BirdLife. One of my favourite birds is the northern gannet (*Morus bassanus*). Its eyes have a light blue to light grey iris. I spent hours watching them at their breeding sites in the UK and see the same birds wintering off our West African coast. I also love terns, after many months working in Senegal's biggest colonies of royal tern and Caspian tern.



If you could have a conversation with any scientist, living or dead, who would it be?

Luc Hoffmann, who was co-founder of the World Wildlife Fund and known as "the man who insists on preserving the Earth". He brought a revolution in conservation. Even after his death in 2016 his legacy continues.

What scientific development do you hope to see in your lifetime?

Tiny GPS devices for animal tracking and some equipment to reveal the interaction between fishing activities and marine biodiversity.

What's the best thing you've read or seen in the past 12 months?

It isn't really the best thing, but I want to share this: roaming cows digging through garbage cans in the middle of Dakar. It makes me think about how their diets have adapted to their situation of wandering in a vegetation-free environment. ■

Justine Dossa coordinates the West Africa marine programme for BirdLife International Africa

ROGER TIDMAN/GETTY IMAGES

"The marine ecosystem we are working to conserve is one of the richest in the world for biodiversity"

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