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WEEKLY November 14–20, 2020

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How excited should we be?

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The population question

Those who advocate limiting population must be clear how they intend to do it

LETTERS to *New Scientist* in response to coverage of environmental issues often raise a glaring omission: why aren't we mentioning the elephant in the room, namely the number of humans on the planet?

A pandemic assisted by our incursions into nature has now given questions about human population size a renewed focus. Such questions have been hugely contentious since at least 1798, when Thomas Malthus issued the dire warnings that still set the tenor of the debate in *An Essay on the Principle of Population*.

On page 34, you will find our analysis of where that debate stands today. While longer-term reductions in human numbers can only be good for the planet, those who advocate limiting population as an environmental panacea must answer two outstanding questions.

The first is what they propose we do to reduce our impact as we grapple with the climate emergency in the crucial coming years, given that efforts to reduce population necessarily play out over decades. The second is what tools they propose we use to reduce our headcount.

"We know what works to limit population growth, and it is broadly what the world has been doing"

We know what works to limit population growth without resorting to brutal and disastrous coercion. It is broadly what the world has been doing for the past half century, albeit often in the face of significant opposition: assisting the economic development of those, mainly poorer, countries with high population growth, broadening access to education, especially for girls and women, and ensuring access to contraception and abortion.

There are worrying signs that the pandemic, by limiting access to family planning, has increased birth rates in some lower-income countries, reversing a decades-long downwards trend. Access to education has also been hit.

Consumed by the economic shock of covid-19 at home, richer countries may be tempted to turn their backs on these problems. For the long-term future of everyone on the planet, they should look to where all our interests lie: in redoubling their efforts to help the less well-off achieve economic growth more sustainably than they did themselves, while urgently reducing their own consumption, too. ■

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US Newsstand **Tel** +1 973 909 5819
Distributed by Time Inc. Retail, a division of Meredith Corporation, 6 Upper Pond Road, Parsippany, NJ 07054

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Post New Scientist, PO Box 3806, Chesterfield MO 63006-9953

© 2020 New Scientist Ltd, England. New Scientist ISSN 0262 4079 is published weekly except for the last week in December by New Scientist Ltd, England. New Scientist (Online) ISSN 2059 5387.

New Scientist Limited, 387 Park Avenue South, New York, NY 10016

Periodicals postage paid at New York, NY and other mailing offices
Postmaster: Send address changes to New Scientist, PO Box 3806, Chesterfield, MO 63006-9953, USA. Registered at the Post Office as a newspaper and printed in USA by Fry Communications Inc, Mechanicsburg, PA 17055

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US vice president-elect Kamala Harris and president-elect Joe Biden

US election

A new covid-19 approach

In contrast to his predecessor, US president-elect Joe Biden will use a science-based strategy to tackle the pandemic, says **Adam Vaughan**

US PRESIDENT-ELECT Joe Biden has said he will "listen to science", promising to take new stances on addressing covid-19, climate change and other key issues.

The transition team for Biden and Kamala Harris, the US's first black, Indian-American and female vice president-elect, has pledged to double the number of drive-through coronavirus testing sites, address shortages of personal protective equipment and work with the US Centers for Disease Control and Prevention to "dial up or down" social distancing.

The incoming administration will also establish a new covid-19 task force, allocate $25 billion for vaccine development and distribution, and cancel plans for the US to leave the World Health Organization.

This approach contrasts with that of Donald Trump's administration, which has sent mixed messages on mask-wearing and undermined key science agencies fighting to limit the spread of the virus. However, as Biden won't be inaugurated until 20 January next year, he is likely to inherit a far worse crisis than today's.

As the US election dominated attention, the country's covid-19 cases surged to their highest levels yet. More than 100,000 daily cases were reported for three consecutive days between 4 and 6 November – the first time this threshold has been exceeded – taking the US near the milestone of 10 million cases cumulatively. Daily deaths have yet to reach the heights that they hit in April, but have started to increase.

The new administration's efforts on covid-19 will overlap with one of its other top priorities, tackling racism, through the creation of a task force on ethnic disparities around the illness. So far, black people have accounted for 108 deaths per 100,000 people in the US, almost twice the rate for white people in the country.

Biden's presidency will also mark a break with Trump's approach to climate change. The president-elect has said that when he takes office, he will immediately reverse Trump's withdrawal from the Paris climate agreement that came into effect on 4 November and call on other countries to increase their ambition.

His transition team said the administration would put the US on "an irreversible path to achieve net-zero emissions, economy-wide, by no later than 2050". The move would decrease global warming by 0.1°C, according to estimates by analysts Climate Action Tracker. The group said that, combined with net-zero targets from China, Japan, South Korea and other countries, a "tipping point" is being approached that brings the Paris accord's 1.5°C target within reach.

Although the Democratic party's lack of control of the US senate may limit how bold the new administration can be on carbon emissions, there is plenty that it could deliver. In debates, Biden said that he would "transition from the oil industry" and promised to end new drill leases for public land and water, which would have a big impact offshore.

Unlike Elizabeth Warren, his rival in the race to be the 2020 Democratic presidential candidate, Biden doesn't support a break-up of technology titans. However, a case brought last month by the US government accusing Google of being a "monopoly gatekeeper" may still go ahead under Biden. Meanwhile, on 20 January, Trump will lose the privileges that world leaders enjoy on Twitter, meaning he could face bans for future inflammatory tweets. ■

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

Briefing: Pfizer vaccine trial

How exciting is the Pfizer vaccine?

The company says its vaccine is 90 per cent effective. What does this really mean and what do we still need to know? **Graham Lawton** reports

US DRUG-MAKER Pfizer and its German partner BioNTech released some positive-looking results on 9 November from a clinical trial of their experimental covid-19 vaccine BNT162b2.

The headline figure is "90 per cent effective". While the results are an important step towards a coronavirus vaccine, the news may not be quite as good as it first seems.

What did Pfizer and BioNTech find?

The results are from a phase III clinical trial, the final stage of testing whether a vaccine or drug is both safe and effective. The companies gave the vaccine or a placebo to 43,538 participants in a double-blinded study, meaning that about half the people were dosed with the real thing and half with the placebo, but nobody knows who got what. They then waited until there were 94 confirmed cases of covid-19. As of 8 November, 38,955 participants had received two doses.

An independent committee then "unblinded" the study and found that about 90 per cent of the cases were in the placebo group. The raw numbers haven't been released, but back-of-the-envelope calculations suggest that 85 cases were in the placebo group and nine were in the vaccine group.

Does this mean we are on the brink of a successful vaccine?

Not yet. It is an interim verdict, not a final one. And the "end point" of this trial – the criterion against which success or failure is judged – is almost the bare minimum. It merely looks at whether people are protected from being infected by the virus, not whether the vaccine prevents severe illness or death.

Of course, people who don't catch the virus cannot get very ill or die from it. But if 10 per cent of vaccinated people remain vulnerable, that may still add up to a lot of illness and death. The trial isn't big enough to pick that up.

"The studies do not have adequate numbers of patients in them to be able to reliably tell us if they prevent severe disease," says Susanne Hodgson at the University of Oxford's Jenner Institute, which researches vaccines, who spoke to *New Scientist* about covid-19 vaccine trials in general, not about Pfizer's specifically. "We will need to give these vaccines to much larger populations in order to collect that kind of data."

Hodgson has been working on the UK clinical trials of the SARS-CoV-2 candidate vaccine being developed by the University of Oxford and AstraZeneca but has no links to the Pfizer/BioNTech vaccine.

> "With cases soaring in many parts of the world, we could have final trial results by Christmas"

Another thing to bear in mind, says Hodgson, is that vaccine effectiveness in the real world can be lower than that seen in clinical trials. This may be because vaccines don't work very well in older people, and are usually tested in younger ones. Pfizer and BioNTech haven't released specific details of the age profile of their study.

So we still have to wait for the final result?

Yes. The trial will go on until there have been 164 confirmed infections, with another interim assessment after 120 infections. The chances of the result flipping are vanishingly small.

A bit like vote counting in the US presidential election, the case numbers in the placebo group have already reached a level that cannot be surpassed by the vaccine group, and are approaching the threshold needed to "win", at least according to criteria laid out by the World Health Organization (WHO) in its official assessment of what would constitute a safe and effective covid-19 vaccine.

A health worker in Turkey involved in the Pfizer/BioNTech vaccine trial

That threshold is 50 per cent reduction of relative risk, which in this trial would mean no more than 54 cases in the vaccine group from a total of 164 cases across both groups.

When might we reach that end point?

Extrapolating from the study so far, quite soon. The trial began on 27 July and racked up 94 cases in around three months. It needs just 70 more to get to the magic number of 164. With cases

DOGUKAN KESKINKILIC/ANADOLU AGENCY VIA GETTY IMAGES

soaring in many parts of the world – the trial is global with many volunteers in the US – that could happen before Christmas.

What happens then?
If the numbers are still good, the companies could decide to apply to a regulator such as the US Food and Drug Administration (FDA) for approval, or what is technically called "licensure". The FDA has said it won't cut any corners. It hasn't put an estimated timescale on the approval process, but says that it will adhere to standard procedure: review the data itself, seek advice from the Vaccines and Related Biological Products Advisory Committee, and initiate a period of public comment. It may ask for further data from the companies.

According to the World Economic Forum, vaccine approval usually takes one or two years. But the FDA has also said it will expedite the process without shortcutting it. "The FDA will not authorize or approve any COVID-19 vaccine before it has met the agency's rigorous expectations for safety and effectiveness," said FDA commissioner Stephen Hahn in a statement on 29 September.

And then we are home and dry?
No. Even if a regulator says yes, there are hurdles to overcome, not least a limited supply. "We expect to produce globally up to 50 million vaccine doses in 2020 and up to 1.3 billion doses in 2021," the companies said in a press release announcing the result. About 14 billion doses are required to vaccinate everyone, allowing for inevitable wastage and the fact that each person would need two doses.

Vaccines also require careful post-licensure evaluation, often called phase IV trials, because adverse reactions may be too rare to be picked up in clinical trials but serious enough to make the vaccine unsuitable for widespread use, says Hodgson. Some adverse reactions may take months or even years to be detected, she says.

No serious safety concerns have been seen in the present trial, the companies said. But the vaccine is of a type that has never been approved before – it is an RNA vaccine that uses messenger RNA from the virus to elicit an immune response, rather than the usual attenuated virus or viral proteins – so there may yet be surprises. The companies said that trial participants will be monitored for two years after receiving their second dose.

What about approval for emergency use?
That is a distinct possibility. The FDA has a procedure called emergency use authorisation (EUA), which can grant temporary approval to unproven medicines in an emergency situation. Pfizer and BioNTech said they intend to apply for one for their vaccine but don't yet have enough safety data. They are gathering that information and could have enough in the third week of November. The FDA has already issued a number of EUAs, but one has since been revoked. The WHO also has emergency use listing criteria, but Pfizer and BioNTech haven't announced plans to go through the WHO's process.

> **"Even a partially efficacious vaccine could have a significant impact on the course of the pandemic"**

Are there any other negatives?
Yes. This vaccine requires two doses, which the WHO regards as less than ideal. Single-shot vaccines are better because you need to make fewer doses and there is no requirement for a booster shot that people might end up missing.

Another downside is that the results exclude people who have been infected with the virus before. A successful vaccine will inevitably be given to people who have had the disease, so we need to know its effect on them too. Again, the companies say they have data on this and will continue to investigate it as the trial runs on.

Then there is the fact that the results were released by press release, not in a scientific paper, so the fine details are hard for scientists to evaluate. Pfizer and BioNTech said they will submit the data to a peer-reviewed journal.

We also don't know at this stage how long any protection from the vaccine would last.

If the vaccine succeeds, is it likely to produce herd immunity?
Again, we don't know for sure, but it looks reasonably promising if enough people get vaccinated. If the vaccine stops 90 per cent of people who receive it from getting infected, as appears to be the case in the trial, then those people are a dead end for the virus. In theory, they cannot catch or transmit it, although the data released by the companies doesn't confirm this beyond doubt.

Given that the herd immunity threshold for SARS-CoV-2 is estimated to be about 70 per cent, a vaccination rate of about 78 per cent of the population could then produce herd immunity. But with vaccine hesitancy hovering at around 25 per cent in many countries, that might be a stretch. We also don't know if the vaccine works in older people or children under 12, which might push the threshold higher.

What is the state of play with other vaccines?
According to the WHO, there are currently 46 other candidate vaccines in clinical trials, seven of them in phase III.

But overall this is good news, right?
Yes. "Even a partially efficacious vaccine could have a really significant impact on the course of the pandemic," says Hodgson. ■

Transmission in animals

Mink could be just the start

The fact that the coronavirus can spread back and forth between humans and animals is bad news for all involved, reports **Graham Lawton**

ALL 17 million farmed mink in Denmark were put at risk of being slaughtered last week after the discovery that mutant forms of the coronavirus are spreading among the animals. The virus has already spread back to humans. Some reports suggest that at least one of the mutations makes the virus more dangerous, although the idea is highly disputed, and claims that it could hamper the development of a vaccine don't yet stand up to scrutiny.

The call for culling has now been dropped, but the human-mink-human transmission chain demonstrates the real and present danger of what virologists call "reverse spillover" and "spillback". The pandemic began with spillover of SARS-CoV-2, the virus that causes covid-19, from wildlife to humans. Reverse spillover means transmission from humans back into animals, both wild and domesticated. Spillback completes the circle, with the virus jumping back into humans again.

Threat to wildlife

This cyclical transmission represents a threat to both wildlife and humans. "The risk of SARS-CoV-2 infecting novel wild species is concerning enough to warrant preventative measures," says Alison Peel of the Griffith Wildlife Disease Ecology Group at Griffith University in Queensland, Australia. Anyone who is at risk of coming into close contact with wild animals should take precautions, she and others say: wear a mask, wash your hands and keep your distance.

SARS-CoV-2 is known to be a highly promiscuous virus. Research into its origins strongly suggests that it started life in horseshoe bats and may have passed through an intermediate host, possibly Malayan pangolins, en route to humans.

The virus's closest human-infecting relatives are similarly unfussy about who they get cosy with. The original SARS virus, SARS-CoV, which caused an epidemic of severe respiratory disease in 2002 and 2003, is also thought to have evolved in horseshoe bats and probably jumped into another species, either palm civets or racoon dogs, before infecting humans. The coronavirus behind MERS also originally probably came from bats but jumped into humans from dromedaries.

> "As long as viruses can move in and do their thing, they don't care what the host is"

This jumping between species makes it impossible to designate a given coronavirus as, say, a "bat virus" or "pangolin virus", says Samuel Díaz-Muñoz at the University of California, Davis. "I have an issue with defining viruses by their host. As long as they can move in and do their thing, viruses don't care."

This jumping around doesn't stop once the virus has reached humans. Onward transmission of SARS-CoV-2 into non-human animals has already been documented not just with mink, but also pet cats and dogs, and tigers and lions at Bronx Zoo in New York. Cat-to-cat transmission has also been confirmed and while there is no evidence yet of cat-to-human transmission, it cannot be ruled out. Even before the outbreak in mink farms in Denmark, workers at a Dutch mink farm were known to have been infected by the animals.

These animals are in the firing line due to their close proximity to humans, but wild animals are susceptible too. Lab experiments have shown that the virus can infect Egyptian fruit bats, as well as various rodents, monkeys, marmosets and tree shrews. Cell culture experiments and computer models of the molecular interaction between the virus's spike protein, which it uses to gain entry into cells, and potential host cells have added dozens more mammal species to the at-risk list, at least in theory, as well as a few birds, reptiles and even fish. Some animals, however, appear to be immune and attempts to infect them have failed, including house mice, pigs and domesticated birds such as chickens and ducks.

Unsurprisingly given the central

Mink at a farm in Denmark, where there have been calls for the animals to be culled

REUTERS/JACOB GRONHOLT-PEDERSEN

role they play in brewing up new coronaviruses, most research on reverse spillover has focused on bats. That is especially true in parts of the world where bats remain free of betacoronaviruses, the subgroup of coronaviruses to which SARS-CoV-2 belongs. That's because these bats' lack of prior exposure to similar viruses may make them uniquely susceptible.

17m

The number of mink that were almost culled in Denmark

One of these regions is the temperate zone of North America. This is home to 45 species of bat that occur nowhere else in the world and have had no contact with bats outside the Americas for tens of millions of years, as bats don't migrate across the Atlantic or Pacific oceans. Despite extensive surveys, betacoronaviruses have never been detected in any of these bats.

That may be because they aren't susceptible to betacoronaviruses, but that is extremely unlikely, according to a recent study by Paul Cryan of the US Geological Survey and Kevin Olival of the EcoHealth Alliance, a non-profit group that researches emerging diseases.

Endangered bats

While North American bats don't have betacoronaviruses, they are loaded with closely related alphacoronaviruses. Bats elsewhere readily carry both types.

The fear is that the North American bats will prove highly susceptible to SARS-CoV-2 and experience major mortality. At least eight and maybe as many as 14 of the 45 species are already at risk, and under increasing pressure from habitat loss and wind turbine strikes. Bat populations already weakened by a fungal disease called white nose syndrome could be wiped out by the virus.

Reverse spillover into bats is obviously bad for bats, but could be a problem for us, too. For one thing, bats provide useful ecosystem services, including pollination, seed dispersal and pest control, so losing bat populations would have a severe impact on nature and farming. It could also push the pandemic to become even more out of control than it already is. "Bats could become a reservoir source of infection for people," says Peel, with the virus then potentially spilling back into people. ›

Mammals at risk

Almost 60 species of mammal have so far been found to be susceptible, or probably/possibly susceptible, to SARS-CoV-2, while others probably aren't at risk. These include:

TIM BODDY

Susceptible
Domestic cat (*Felis catus*)
Domestic dog (*Canis lupus familiaris*)
Raccoon dog (*Nyctereutes procyonoides*)
Ferret (*Mustela putorius furo*)
Mink (*Neovison vison*)
Lion (*Panthera leo*)
Tiger (*Panthera tigris*)

ANUP SHAH/GETTY IMAGES

Probably susceptible
Chimpanzee (*Pan troglodytes*)
Western lowland gorilla (*Gorilla gorilla gorilla*)
Sumatran orangutan (*Pongo abelii*)
Red fox (*Vulpes vulpes*)
Leopard (*Panthera pardus*)
Cougar (*Puma concolor*)

Possibly susceptible
Domestic cow (*Bos taurus*)
Domestic goat (*Capra hircus*)
Domestic sheep (*Ovis aries*)
Horse (*Equus caballus*)
Orca (*Orcinus orca*)
Long-finned pilot whale, pictured (*Globicephala melas*)

NORBERT WU/NATURE PL

Probably not susceptible
Wild boar (*Sus scrofa*)
Black-capped squirrel monkey (*Saimiri boliviensis boliviensis*)
Sperm whale (*Physeter catodon*)
Tufted capuchin (*Sapajus apella*)
Brown rat (*Rattus norvegicus*)

Not susceptible
Western European house mouse (*Mus musculus domesticus*)

MICHELLE GILDERS/ALAMY

For a full list see: *Mammal Review*, doi.org/fhkd

This would make getting on top of the virus that much harder, as infected bats could reignite under-control epidemics in the same way that infected airline passengers arriving from abroad have done in New Zealand and elsewhere.

Bats could even become a crucible for a new deadly virus. In one possible scenario, SARS-CoV-2 mutates into SARS-CoV-3 as it passes from bat to bat in vast roosts where many different species are known to mingle and swap viruses. In another scenario, a process called recombination creates a hybrid of SARS-CoV-2 and another virus. Recombination happens all the time in coronaviruses because their genome-replicating enzymes are prone to jump from one bit of an RNA strand to another, so if a cell is simultaneously infected with two different coronaviruses they can end up being mashed together. Bats commonly carry multiple coronaviruses at the same time and recombination is plausibly how SARS-CoV-2 originated in the first place. It is also possible for coronaviruses to hybridise with other, unrelated, viruses.

"Bats could become a reservoir source of coronavirus infection for people"

Reverse spillover requires a fairly implausible chain of events, but there is precedent for all of them. For one thing, there are documented cases of viruses naturally spilling over from humans into bats. In 2013, a group of researchers including Olival analysed the overall viral load – or "virodiversity" – of a species of fruit bat called the Indian flying fox. They estimated 58 viruses in total, two – or possibly three – of which had a human origin. One of them was a coronavirus.

What's more, laboratory experiments show that another coronavirus that circulates in human populations, the common cold-causing HCoV-NL63, which probably also originated in a bat, is still capable of infecting lung cells cultured from the tricolored bat, one of those North American species.

Calculated risk

Spillback is theoretically possible (see "How humans and bats transmit to each other", left). But is it likely? "Determining whether or not it is likely needs to take into account three main factors," says Peel. "One, the covid-19 prevalence in the human population. Two, the contact rates between bats and infected people. Three, whether novel bats are susceptible to infection and able to transmit the infection to other bats." The latter factor has the most uncertainty, she says, but preliminary work suggests this is possible. "So we must focus our attention on the first two factors to avoid exposure in the first place," she says.

With all of this in mind, in April, the US Geological Survey and the US Fish and Wildlife Service convened an expert panel, including Peel, to try to put some numbers on the risk in the US.

Though working with very limited data, the panel concluded that the risk is "non negligible": for example, if a research scientist who was infected and shedding virus handled a little brown bat under current fieldwork protocols, it found there is a roughly 15 per cent chance of the bat getting infected. For each such reverse-spillover event, there is about a 33 per cent chance that the virus would become established in wild bat populations.

Using personal protective equipment such as masks, gloves and gowns would significantly reduce the risk, the panel concluded, though it noted that PPE for healthcare workers is in short supply in some places.

In April, the International Union for Conservation of Nature (IUCN) recommended a suspension of all fieldwork involving interactions with bats. It has since rowed back from a total moratorium, but does recommend stringent biosafety measures, such as wearing PPE, only handling bats when

How humans and bats transmit to each other

Bats and humans come into close contact frequently enough for viruses to pass between them.

According to the US Centers for Disease Control and Prevention, between 1997 and 2006, 17 people in the US caught rabies from bats. Most of these people reported handling a bat after finding it in or around their house, and two were bitten. But in three cases, they had no recollection of a bat encounter.

Rabies cannot be passed from person to person directly, but with a highly transmissible virus like SARS-CoV-2, it could take just one encounter to start a fresh outbreak.

Humans come into contact with bats in many other ways, including research, pest control, wildlife rehabilitation, wildlife tourism, recreational caving and when investigating disease outbreaks. Another contact is during guano harvesting, which is an important source of income in many parts of the world.

To pass viruses from humans to bats, actual contact may not be necessary. Since the virus is shed in human faeces and may remain infective for days in water, bats and other wildlife could pick it up by drinking sewage-tainted water.

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Nadia, a Malayan tiger at the Bronx Zoo in New York, tested positive for the coronavirus

absolutely necessary and never blowing on a bat, which researchers often do to examine its skin.

The IUCN has also issued guidelines to cavers, bat guano harvesters and bat rehab and rescue centres. In a nutshell, when possible, steer clear of bats.

Another country that has no experience of bat betacoronaviruses is Australia. "To date, there is no evidence of any SARS or MERS-like viruses in any Australian bat species," says Peel.

In August, she and her colleagues carried out a risk assessment for Australia's 81 species of bat. It concluded that the risk of reverse spillover was low, but there were such high levels of uncertainty that it recommended that people who know they are going to come into contact with bats should take precautions.

Bat backlash

The assessment also concluded that although the risk of Australian bats being sickened or killed by the virus are low, they are vulnerable to a "bat backlash" from humans spooked by the virus. SARS-CoV-2 has already led to politicians calling for bat culls and people illegally persecuting bats in Australia and elsewhere. The report warns that one species in Australia, the spectacled flying fox, which provides ecosystem services including pollination and seed dispersal, could be driven to local extinction this way.

The wildlife threat doesn't begin and end with bats. A recent review by a team led by Fabian Leendertz at the Robert Koch Institute in Berlin concluded that a wide range of distantly related mammals are susceptible to SARS-CoV-2 (see "Mammals at risk", page 11). Drawing on evidence from natural transmission, cell cultures and computer modelling, the researchers drafted a list of almost 60 mammal species that are definitely, probably or possibly susceptible, ranging from gorillas and chimps to foxes, yaks, giant pandas and koalas. Even some whales, dolphins and seals may be able to catch it.

"Yes, I was surprised by that," says Leendertz. However, he points out that seals or sea lions probably brought tuberculosis to the Americas long before Europeans arrived, "so it is not totally impossible to have spillover between marine mammals and terrestrial ones".

"Reverse spillover is something we have to keep an eye on. If we can avoid it, we should"

Leendertz and his colleagues also recommended that anyone at risk of coming into close contact with a wild mammal should take some now-familiar precautions: physical distancing, wearing a face mask and gloves, and frequent hand washing. The list of people who need to take such precautions is a long one, including wildlife researchers and conservationists, managers of protected areas, foresters, pest controllers, employees or volunteers in wildlife rehabilitation centres and wildlife tourism, and wildlife tourists themselves.

PUFFIN'S PICTURES/ALAMY

A wild spectacled flying fox in Kuranda, Queensland, Australia

The mink slaughter debate has brought the wider issues of reverse spillover and spillback into the public consciousness. How worried should we be?

"I think the risk is very small at the moment because we are the main reservoir of the virus and the main drivers of the pandemic," says Leendertz. "But consider a scenario where we have been able to control the virus and push it out of certain regions. Then you have to start thinking about the risk of reintroduction into the human population from secondary reservoirs in wild species. Reverse spillover is something we have to keep an eye on. If we can avoid it, we should."

The threats of reverse spillover and spillback are teaching us something profound. "We need to change our interface with nature," says Leendertz. "Especially with wild animals." ▮

Cybersecurity

European weather services in email storm

Adam Vaughan

MATTHEW LEANE/ALAMY

WEATHER services across Europe were caught in a storm of malicious email attacks last week.

People at meteorological services have received a mass of emails purporting to come from trusted contacts, with some of the senders spoofing European Commission addresses. The Met Office and European Centre for Medium-Range Weather Forecasts (ECMWF) in the UK, Spain's State Meteorological Agency and the Danish Meteorological Institute (DMI) are among the European services that were affected, *New Scientist* has confirmed.

The widespread attacks came after the laptop of an individual in the meteorological community was infected by malware, leading the user's mailbox to be acquired by a botnet, says the ECMWF. The botnet then used the email account to send messages with malware to contacts in the community, including to email lists used by international meteorological organisations.

"Whilst this attack has created disruption, we can confirm that the attack has remained at email level and that our systems were not breached, and our operations

Weather forecasts were unaffected by an email attack

were at no time jeopardised," says a spokesperson for the ECMWF.

It is unclear whether the attackers were deliberately targeting weather services, which are considered national infrastructure in many countries, or simply got lucky by infecting the computer of an individual

"The attacks came after the laptop of an individual in the meteorological community was infected"

who was a member of several meteorological groups.

A spokesperson for the Met Office says the number of emails has greatly reduced in the past few days and it is confident that measures put in place, including blocking links and attachments and providing security guidance to staff, means no machines have been compromised. The new measures "created some challenges for our day-to-day work", but the impact on services had been minimal, they add. ■

Astronomy

The Milky Way could be home to 5 billion planets like Earth

Abigail Beall

HALF the stars in our galaxy that are similar to the sun may have a world a lot like ours that is capable of supporting life.

A team led by Steve Bryson at NASA's Ames Research Center in California analysed data from the Kepler space telescope. The researchers focused on signs of rocky planets in the habitable zone of stars the same size as our sun. The habitable zone is found at a distance from a star where it isn't too hot or too cold for liquid water to exist.

Based on detections of 4034 exoplanet candidates and their frequency around sun-like stars, Bryson and his team simulated how Earth-like planets should be distributed across the Milky Way. They found that 40 to 60 per cent of sun-like stars had rocky planets similar to Earth in their habitable zones, compared with previous estimates of 20 to 50 per cent (arxiv.org/abs/2010.14812).

With 10 billion sun-like stars in the Milky Way, this could mean around 5 billion habitable planets are in our galaxy.

"This is really impressive work," says Hugh Osborn at the Massachusetts Institute of Technology.

Bryson and his colleagues looked at exoplanets with a radius between 0.5 and 1.5 times that of Earth, narrowing in on those that are probably rocky. They also focused on stars similar in age and temperature, give or take about 800°C, to our sun.

"Outside of that temperature range, which is roughly centred on the sun's temperature, stars start behaving very differently from our sun in terms of the amount of radiation they put out, and in what part of the electromagnetic spectrum, and also how long they live for, and also how hard it is to find planets around them," says Jessie Christiansen at the California Institute of Technology, a co-author of the study.

There have been a lot of previous efforts to find the frequency of Earth-like planets in our galaxy, but this one is different, says Osborn. It used more data, simulated things in a new way, accounted for the possibility that some of Kepler's candidates aren't planets and only looked at small planets that receive a similar amount of light to Earth. "Taken together, these are all improvements over the

EURELIOS/SCIENCE PHOTO LIBRARY

Earth-like planets may be orbiting around half of the sun-like stars in our galaxy

various previous studies, and therefore all add credibility," he says.

This isn't the final result. In fact, the number could be even higher, says Christiansen. "At this point, our uncertainties are largely driven by the small number of candidates we truly have in the parameter space of interest," she says. "So until we get more data, it will be hard to truly reduce those error bars."

Either way, it is an exciting result. "It suggests there are many Earth-like planets orbiting nearby stars that we will be able to study in detail in the coming decades," says Osborn. "And it maybe lends weight to the idea that, if Earth-like planets are common, maybe life is common too." ■

Evolution

Which animals evolved first?

DNA suggests comb jellies were the first distinct animal group to appear on Earth

Michael Marshall

SPONGE or jelly? Though it sounds like a choice between desserts, it turns out that either sponges or comb jellies are the key to understanding the early evolution of animals and when the first brains evolved.

That is because one of them was the first animal group still alive today to split from other animals and begin evolving separately – but it has long been unclear which.

A new analysis points the finger at jellies. The study has been praised by scientists on both sides of the debate because it brings clarity to a confused area, but it isn't being interpreted as the definitive answer.

The first complex animals evolved around 600 million years ago. Unlike their ancestors, they had large bodies made of many cells, which developed into specialised organs, but we don't know what they looked like.

Soon afterwards, animals began splitting into the groups we recognise today – and by understanding the order in which these groups appeared, we can learn a lot about early animal evolution. One of two modern groups came first: comb jellies, also known as ctenophores, or sponges. Sponges have no nervous systems, while comb jellies look a little like jellyfish and do have nervous systems.

For many decades, it was assumed that sponges were the first to split, but recent studies have thrown that into doubt. In 2008, researchers led by Casey Dunn, now at Yale University, obtained DNA from 29 distantly related species. They found that the most likely group to have split first was the comb jellies.

Five years later, this claim was bolstered when researchers sequenced the full genome of a comb jelly, the warty comb jelly (*Mnemiopsis leidyi*) – but the debate continues.

In a bid to resolve things, researchers led by Dunn and Antonis Rokas at Vanderbilt University in Tennessee have reanalysed all the genetic data from comb jellies and sponges.

"One thing we've noticed over the years is that, very often sometimes, we talk past each other," says Rokas. The genetic data can be analysed in different ways, giving different answers, and this means the arguments over which study is right are often based on apples-to-oranges comparisons.

Rokas, Dunn and their team have now found ways to compare all the data and analyses within one framework. "We're able to interpret the behaviours of the different models in a way that's standardised and systematic," says Rokas.

600

million years since the first complex animals evolved

The team found that most analytical methods supported ctenophores as the first group to split (bioRxiv, doi.org/fg8j). That means it is less likely that sponges were the first group to branch off, says Rokas. "I would say this moves the needle towards [ctenophores] pretty robustly."

"This is an important advance, in terms of the clarity of the analyses, and the fact that everything is so well documented that it can be reproduced," says Nicole King at the University of California, Berkeley, who co-authored a 2017 analysis that supported sponges as the first group to split.

However, King and Rokas both say that the question will rumble on. A key problem is that only a handful of sponges and comb jellies have had their DNA sequenced. Many more genomes are needed.

"We have no idea how the models will start behaving as we start using more and more genomes," says Rokas.

"I've been a little bit disappointed in some of the rapid responses that I've seen on social media, which assert that this changes everything, because it doesn't," says King.

Resolving the question isn't just a minor detail – it could change our understanding of the evolution of the nervous system and brain.

If the brainless sponges were first to split, this implies that the first animals didn't have brains and that brains only evolved once, on the line that led to comb jellies and other animals. Yet if comb jellies split off first, this may imply that the nervous system evolved twice independently, says Rokas.

For Leonid Moroz at the University of Florida, this shouldn't be controversial. "The nervous system evolved multiple times, definitely at least twice, maybe three times or more," he says. Moroz compares the nervous system to complex eyes, which evolved independently in many animal groups. ■

JOE ELBERT/THE THE WASHINGTON POST VIA GETTY IMAGES

Comb jellies (Ctenophora) may have been the first animal group to evolve

Astronomy

Space mystery solved

Strange blasts of radio waves have been spotted all over the cosmos. Now we have finally tracked one to its source, reports **Leah Crane**

FOR the first time, we have tracked a strange blast of radio waves – called a fast radio burst (FRB) – back to its source, solving a major cosmic mystery. The burst came from a magnetar, a neutron star with a strong magnetic field.

"I think what's really surprising is that we saw anything at all in our own galaxy, given how rare these fast radio bursts are," says Christopher Bochenek at the California Institute of Technology, who helped observe the FRB.

The bursts are incredibly powerful flashes of radio waves that mostly come from distant galaxies. Since the first one was discovered in 2007, many explanations for them have been put forward.

However, because they tend to come from so far away, there was never enough evidence to determine what exactly was making them. Some FRBs have been tracked back to their host galaxies, but their source hasn't been pinpointed.

In April, astronomers found an FRB coming from within our own galaxy for the first time, allowing them to take a closer look at one of these relatively rare phenomena. Several teams of researchers examined the area where it arose and found that the burst originated from a magnetar called SGR 1935+2154 (*Nature*, doi.org/ghhw2m).

Although magnetars have been a favoured contender to explain FRBs, this is the first evidence that they can produce radio waves at high enough energies to account for the signals.

This particular burst, known as FRB 200428, came from about 30,000 light years away from us, whereas the others we have detected were millions to billions of light years away.

"It's bridging the gap between activity in our own galaxy and these strange events from many light years away," says Brian Metzger at Columbia University in New York, who wasn't involved with this research.

The proximity of this burst made it appear extremely bright. "It is much brighter than any other radio object in space, by a large margin," says Bing Zhang at the University of Nevada, Las Vegas, part of the team that connected the FRB to its magnetar source.

The burst had an energy about three times that emitted every second by the sun. It was also far brighter than any radio waves ever observed from a magnetar before, although it didn't release quite as much energy as any of the FRBs outside our galaxy.

That may mean that the other FRBs we have seen are produced by more active magnetars that can emit more powerful blasts.

"If all the FRBs are produced by magnetars, they cannot all be slow, old magnetars like this one," says Zhang. "Some must be young, meaning decades or centuries old instead of thousands of years or tens of thousands."

"It's still too early to say whether 99 per cent of the FRBs are from magnetars or 10 per cent"

However, it is also possible that not all fast radio bursts are produced by magnetars.

"When we talk about FRBs, we say it like it's an object, but they're not objects, they're bursts, and I think that we will be able to see these bursts from a whole host of other kinds of objects beyond just magnetars," says Amanda Weltman at the University of Cape Town in South Africa.

There have been hints that different kinds of FRB exist. Some of them seem to repeat, bursting again and again, while others have only been spotted flashing once. Plus, the few FRBs that have been traced back to their host galaxies seem to reside in a variety of environments.

"I think it's still too early to say whether 99 per cent of the extragalactic FRBs are from magnetars or whether it's 10 per cent," says Metzger.

This single burst won't enable us to answer the question of whether there are many types of objects that make FRBs, but it may help us understand the nitty-gritty of one type.

"Even if these are all coming from magnetars, there are multiple different ways a magnetar could produce this radiation and hopefully this will help us start to arbitrate between them," says Metzger.

Astronomers will be watching the other known magnetars in our galaxy for more flares of radio waves, says Weltman.

"To see a quick burst like this, you have to happen to have your telescope looking in the right direction at the right time – there's no end of luck involved," she says. "This is only the very, very beginning for FRB science. I think there will be tens of thousands observed in different galaxies within a couple of years."

Once we have a larger sample of FRBs and a better grip on the full breadth of their behaviour, it will become far easier to determine what is creating them all and how. Although much is still unknown about FRBs, this discovery is a sign that we may soon be able to put together the rest of the puzzle. ■

MCGILL UNIVERSITY GRAPHIC DESIGN TEAM

A magnetar emitting a blast of radiation known as a fast radio burst

Environment

Iceberg on collision course

Huge iceberg may hit a South Atlantic island and harm wildlife

Adam Vaughan

AN ICEBERG the size of Cyprus is heading towards South Georgia, posing a major threat to the remote Atlantic island's globally important penguin and seal colonies.

Icebergs breaking off from Antarctica often fragment in the South Atlantic. But the sheer scale of this 158-kilometre-long and 48-kilometre-wide chunk of ice, named A68a (near-centre in this image), is unusual, say researchers following it by satellite.

It could arrive at South Georgia within a month, potentially blocking access to offshore feeding grounds for the island's macaroni, gentoo, king and chinstrap penguins, as well as fur, leopard and elephant seals. This would make it difficult for the animals to feed their young.

Organisms on the seabed near the island would also be pulverised by the giant block of ice, potentially releasing their vast stores of carbon into the atmosphere.

SENTINEL HUB EO BROWSER, SENTINEL-3

Pollution

Most whales may have ingested plastic

MOST sea turtles, whales and fish may have plastic in their bodies.

To determine the prevalence of various forms and colours of this material in marine animals, Marga Rivas at the University of Almería in Spain and her team analysed data from 112 studies published in the past decade.

These looked for microplastics – fragments less than 5 millimetres in size – and larger macroplastics in marine specimens globally.

Of the studies, 80 examined the gastrointestinal tracts of animals to see what they had ingested. The others also looked at wider animal tissues to identify plastics that end up in other parts of the body.

After examining all of the data, Rivas and her team concluded that 66 per cent of sea turtles have white-coloured macro and microplastics in their systems, while 55 per cent have a distinct class of plastic called microfibres, which are shed by some fabrics.

The high prevalence of white plastic in turtles was unsurprising, says Rivas, given that plastic of this colour, particularly larger pieces, may resemble jellyfish, a large part of the animals' diets.

Microfibres were also present in 80 per cent of cetaceans – a group of aquatic mammals that includes whales and dolphins – and white macro and microplastics in 38 per cent of them.

The researchers also concluded that clear fibre microplastics are probably the most common form of this waste that is ingested by large marine animals globally.

Rivas and her colleagues also discovered that the animals with the highest rates of plastic ingestion were those in the Mediterranean and the north-east Indian Ocean (*Global Change Biology*, doi.org/fg8d).

MUSTAFA YILMIZ/ALAMY

Humpback whales are among marine life that is ingesting plastic

"The Mediterranean is the most contaminated sea in the world, so we expected to find these results," says Rivas.

Marine plastic pollution has increased roughly 10-fold since 1980, and Rivas says the problem is exacerbated by inadequate water treatment systems.

In parts of India and the south-east Mediterranean, wastewater isn't adequately treated or recycled, she says. This means that microfibres shed by fabrics in washing machines, and larger pieces of rubbish, enter the sea.

"It's possible to introduce management strategies to control these huge threats," says Rivas.

Donna Lu

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JAMES MCKAY

Palaeontology

Creature resembling a giant paper clip lived 200 years

AN ANCIENT squid-like animal with a shell that looked like a 1.5-metre-long paper clip may have typically lived for two centuries.

Diplomoceras maximum lived about 68 million years ago, making it a contemporary of *Tyrannosaurus rex*. It was an ammonite – a now-extinct group of tentacled cephalopods.

The creature's unusual shell shape makes it hard to unravel its biology, but Linda Ivany and Emily Artruc at Syracuse University, New York, believe individuals might have had very long lives. The evidence comes from chemical signatures locked away in samples taken at regular intervals along a 50-centimetre-long section of *D. maximum* shell.

When the pair examined the carbon and oxygen isotopes along the shell, they found a repeating pattern in the isotopic signatures that they suspect reflects the annual release of methane from the sea floor. This pattern tallied with the sculptural ridges, or ribs, perpendicular to the shell's length. This suggests *D. maximum* added one rib each year. "These shells grow by accretion, adding a new increment annually," says Ivany.

Given the large number of ribs in a 1.5-metre-long shell, that leads to an obvious conclusion. "The only scenario that seems to work is to make this thing 200 years old," says Ivany, who presented the research at an online meeting of the Geological Society of America.

Why *D. maximum* might have had such a long lifespan is unclear as all modern cephalopods live fast and die young. **Colin Barras**

Technology

Add some potassium for better batteries

INCLUDING a dash of potassium salt in lithium-metal batteries could make them safer and boost their charging efficiency.

These batteries are lighter and can store more energy than the more commonly used lithium-ion ones, but their widespread use has been limited by safety concerns, says Lauren Marbella at Columbia University in New York.

Unlike lithium-ion batteries, which contain an electrode typically made of graphite, lithium-metal ones have an electrode made of lithium. Because of how lithium-metal batteries charge, this can lead to tiny filaments of lithium being deposited on the electrode that can cause short circuits.

The result can be explosive, says Marbella. "Basically the whole system just goes into runaway failure," she says. "It's a recipe for disaster."

Marbella and her team found that adding a small amount of potassium salt to lithium-metal batteries stops these dangerous deposits. "Whenever we had the potassium in the battery, we had less of these microstructures growing and we also had a higher efficiency battery," she says.

The potassium boosted the batteries' charging efficiency from 84 to 88 per cent (*Cell Reports Physical Science*, doi.org/fg73). Even such a modest improvement can go a long way, says Marbella, particularly in applications such as electric vehicles.

A big barrier in the transition to electric vehicles is their limited range, says Marbella. "You're limited in how far you can go before you have to charge your battery again," she says. "The development of lithium-metal batteries would help eliminate some of the range anxiety because they last longer." **Layal Liverpool**

Artificial intelligence

Robot controlled with plain language

TELLING a robot where to go without having to speak like a robot is now a lot easier, thanks to a new model based on how people actually give directions.

Currently, many robots use simultaneous localisation and mapping (SLAM) to know where they are in a given landscape. With this they must concurrently keep track of their location on a map, while constantly updating their knowledge of the environment.

CYLONPHOTO/GETTY IMAGES

"The challenge for humans to interact with SLAM-based machines is we need to think on their terms," says Jason Corso at the University of Michigan. "The goal is to flip that and have the robot adapt to the human language."

Corso and his colleagues moved a robot around a tabletop maze. One person, a driver, remote-controlled the robot but couldn't see the maze. Another person, a navigator, gave directions on how to solve the maze from another room using an online chat.

As the robot moved around, a language processing model translated the navigator's orders to the driver. Once a list had been produced of the phrases used, a model that translates them was trained in a simulation – the team couldn't use a lab due to covid-19 restrictions. The model learned to follow plain-text commands (arxiv.org/abs/2010.12639). **Chris Stokel-Walker**

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Really brief

REUTERS/KAI PFAFFENBACH

Diets could cause 1.5°C of warming

An analysis of data on diets and population growth suggests that greenhouse gas emissions from food production alone will push Earth beyond 1.5°C of warming. Researchers say that both individuals and policy-makers can do their part to reduce the impact (*Science*, DOI: 10.1126/science.aba7357).

The fish with very sensitive fins

The round goby (*Neogobius melanostomus*) has fins that are as sensitive to touch as our fingertips. Nerves in the fins reacted even when they were exposed to surfaces with extremely fine textures – the kind our fingertips can respond to (*Journal of Experimental Biology*, doi.org/fg59).

Arctic animals now migrating earlier

Animals in the Arctic, including reindeer, are migrating earlier due to climate change, suggests a three-decade-long study. Migrating animals give birth earlier in the spring too. This can be dangerous in the Arctic because spring storms can kill newborns (*Science*, DOI: 10.1126/science.abb7080).

Archaeology

Ancient burial hints at modern bias

A WOMAN buried with stone tools 9000 years ago in what is now Peru probably hunted animals including deer. The finding may help overturn long-standing assumptions about gender roles in ancient hunter-gatherer communities in the Americas.

Randy Haas at the University of California, Davis, and his colleagues recently ran analyses including carbon dating on bones and teeth from a burial pit discovered in Peru in 2018. These provided confirmation that the remains belonged to a 17 to 19-year-old woman who was interred 8700 to 9000 years ago with a 24-piece hunting toolkit, including spearhead points, butcher knives and tanning blades. The butchered remains of deer and camelids at the site hint at the animals she hunted.

Rather than assuming that the teenager was a one-off case of a female hunter, the researchers checked for other published discoveries of humans buried with hunting tools anywhere "from Alaska to Argentina" at least 8000 years ago. Of the 27 burials identified, nearly half recorded the gender of the buried individual as female, says Haas.

However, faced with the unexpected discovery of hunting blades buried with female skeletons, in most cases the archaeologists who compiled the reports either questioned the accuracy of their own sex-confirmation analysis or declared that the knives and points must have been cooking utensils (*Science Advances*, doi.org/ghh2g2). **Christa Lesté-Lasserre**

Zoology

DAVID CHAPMAN/ALAMY

Wallabies spotted in the UK on nearly 100 occasions

THERE have been almost 100 sightings of wallabies across Britain over the past decade. "Everyone was surprised by the number and the spread," says Holly English at University College Dublin in Ireland.

She and Anthony Caravaggi at the University of South Wales, UK, trawled through environmental records and media reports to map all wallaby sightings between 2008 and 2018 (*Ecology and Evolution*, doi.org/fg8t).

The species in question is the red-necked wallaby, *Notamacropus rufogriseus* (pictured). This marsupial is native to south-east Australia including Tasmania, whose climate is similar to the UK's.

It is possible that these wallabies are breeding in the Chilterns of southern England and in Cornwall, south-west England. But most of the sightings are thought to be of escapees from zoos or private collections. "They are very good at escaping," says English.

There is also a small population on an island in Loch Lomond, Scotland, originating from animals released by the island's owner in the 1940s. Outside Britain, there has been a thriving population on the Isle of Man, where the photo above was taken, in the Irish Sea since the 1960s. Michael Le Page

Space

Europa may have an eerie green glow

JUPITER'S moon Europa may glow in the dark. Lab experiments show that the type of ice covering its surface glows under radiation, which could help us figure out the composition of its frozen plains and subsurface oceans.

Because of the effect of Jupiter's magnetic field, Europa is constantly bombarded by high-energy electrons. Murthy Gudipati at NASA's Jet Propulsion Laboratory in California and his colleagues investigated how Europa's icy surface might react to this by blasting electrons at ice samples enriched with molecules that may be found on Europa.

When the electrons hit molecules in the ice, the molecules fell apart and their constituent atoms absorbed some energy. The atoms then re-emitted that energy as light, causing an eerie, green-tinged glow (*Nature Astronomy*, DOI: 10.1038/s41550-020-01248-1).

NASA's Europa Clipper mission is planned to launch in 2024 to study this moon. It could potentially observe the glowing ice and use its brightness to help determine its composition.

Figuring out what the surface is made of could help us understand whether Europa's seas have the ingredients for life. **Leah Crane**

The columnist
How close are we to giving up cars, asks **Graham Lawton** p24

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Culture columnist
Sally Adee enjoys sci-fi anthology *Escape Pod* p32

Comment

Irrational restrictions

Care home rules to prevent the spread of coronavirus are too strict and not based on science. This could cost lives, says **June Andrews**

RESTRICTIONS to stop the spread of coronavirus are tightening across the UK, including a four-week lockdown in England. Care homes, however, may rightly start to go in the other direction. The previous rules made no scientific sense and have harmed many vulnerable people.

Almost 14,000 deaths in nursing and care homes in the UK were attributed to covid-19 between April and July 2020, and consequently residents in homes had severe visiting restrictions imposed. Many were isolated from usual family contact for months.

In Scotland, for example, visiting a care home is allowed only if the entire home is free of any covid-19 symptoms for 28 days, and even then there must be approval from the local director of public health. In Leeds, England, it isn't illegal to visit, but local government guidance says you must have a very good reason, and the example given is if someone is dying. The problem is that most people in care homes are in the last two years of life. The median length of stay for people admitted to nursing beds is less than a year.

Most people in care homes have dementia, and for them, the end-of-life phase can last weeks, months or even years, according to the Alzheimer's Society, even though the rules about visiting often prevent family contact until the last few days. It is well documented that social isolation accelerates deterioration in people with dementia. So, these restrictions are killing people.

MICHELLE D'URBANO

Last week, I and more than 60 experts and organisations issued a call for action demanding that restrictions on care home visits in the UK be lifted.

The rules were mainly intended to stop the spread of covid-19. But as infections are measured relentlessly, and many cases have been recorded as covid-19 without any test, this may mean the case numbers in care homes have been overstated. By comparison, the risk of people's conditions worsening and them dying because they are cut off from family and friends isn't measured.

The care minister, Helen Whately, has now updated the guidance for care homes in England, in an attempt to better facilitate visits. This gives the care home operators and public health officials who have the final decision on local visiting rules a real dilemma. Because of the reputational damage and legal risks that would arise from an outbreak, they feel forced to apply maximum visiting restrictions even where it separates families for months on end.

This isn't just an issue in the UK. International concern is increasing about the negative impact of visiting restrictions on the health and well-being of care home residents and their families, and a review of covid-19 in care homes led by the London School of Economics, which involved researchers in Australia and Canada, found no evidence of visitor impact on infections.

There is no scientific data suggesting that visitors have been the source of an outbreak in a care home. Some research is said to indicate that care home risk is related to the size of the care home, but more research is needed before that can be proved, including rigour in diagnostic definitions of covid-19 deaths.

Governments have denied that it is related to the discharge of large numbers of untested or covid-19 positive patients into care homes, although this seems intuitively probable. In truth, all the data is flawed and it is too soon to say.

It isn't yet clear how individual care homes will respond to the new government guidance and if similar relaxations will be recommended outside England. But with the right precautions, such as individual risk assessments and making sure meeting places are well ventilated, care home restrictions can be sensibly loosened. And that could save lives. ▮

June Andrews is the author of *Care Homes: The One-Stop Guide*

No planet B

Back behind the wheel

I ditched my car months ago in an effort to be greener, but it has been much harder than I expected and I'm reluctantly driving again, writes **Graham Lawton**

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

Graham's week

What I'm reading
I'm obsessively following the US election car crash. I hope it will be all over by the time this is published, but I doubt it.

What I'm watching
Series 2 of Ghosts *on the BBC. Delightfully daft comedy to distract from troubled times.*

What I'm working on
The search for a vaccine – I'm still on the covid-19 beat.

This column will appear monthly. Up next week: Annalee Newitz

IN FEBRUARY, before the coronavirus epidemic became a pandemic, I took the plunge and got rid of my car. I figured it would be no great sacrifice: I live in London within walking distance of three tube stations and countless bus stops. I own a bike. There are taxis and Ubers; supermarkets deliver. I joined a car-share scheme and earmarked the not inconsiderable sum of money I was spending on keeping my car on the road to fund my green transport future.

Then the lockdown happened and being car-free suddenly felt like a sacrifice. I couldn't get a supermarket delivery slot. I couldn't take my broken garden chairs to the recycling centre. A few days into lockdown, somebody stole my bike from a supposedly secure lock-up.

When lockdown eased, it just got worse. We yearned to escape to the countryside or beach, but taking public transport or a taxi felt like too much of a risk.

The car-share scheme turned out to be mind-bogglingly complicated – every London borough has its own rules about where you can and can't park, and taking a car-share vehicle beyond the city is practically impossible. I still couldn't get a supermarket delivery slot or a new bike. Hiring a car is phenomenally expensive and time-consuming. A 24-hour hire to drop my son off at university consumed more than two months of my mobility fund.

So last month I did a U-turn and bought a car. I felt guilt and failure, but also a sense of justification: I had tried, but the pandemic defeated me. Most of all I felt liberated. I've already put a few hundred miles on the clock. Don't get me wrong, I haven't converted to petrolhedonism (it is a petrol car, though a very efficient one. I looked into electric cars and hybrids, but they cost too much). I still aspire to be able to travel without spewing greenhouse gases and pollution and without having to possess a big contraption comprising metal, glass, plastic, rubber, fabric and oil that will one day end up on a scrapheap – or possibly become a wheezy rust bucket that is exported to lower-income countries.

Before I took the plunge back into car ownership, I decided to do my research, not just on keeping my emissions down, but also on progress towards a future that is less reliant on private vehicles.

> **"Unfortunately, the car is deeply embedded in our way of life as the core of a socio-technical system"**

Sure, the pandemic made it more difficult to go car-free, but I suspect that my failure was also down to structural factors. The world is still not geared up for car-free living. So I tuned in to an online seminar called "Automobility futures and COVID-19" by Peter Wells at Cardiff Business School in the UK.

Wells works on socio-technical transition theory, which aims to understand and explain major social changes. From this perspective, he said, the car is deeply embedded in our way of life as the core of a socio-technical system that also includes roads, garages, oil refineries, insurance companies and manufacturers. This system has been dominant for decades, but before the pandemic it was starting to creak under the weight of overcrowded roads and the environmental crisis.

The hope was that we would eventually shift to a shared fleet of autonomous vehicles powered by renewable electricity. In this scenario, nobody owns a car or even drives one. We just jump into the nearest available self-driving car and go. And then came the pandemic, and the whole dynamic shifted again. In what direction, however, is very hard to say.

Crises are often a trigger for socio-technical transitions, Wells said. That idea has become very familiar, with the pandemic often presented as an opportunity to rethink, reset and build back better. I have written about how it might change attitudes to hyperconsumption, for example.

That is possible with transport, Wells said. Life in a pandemic has drawn attention to some of the downsides of mass mobility, such as time and money wasted commuting to offices we don't need as much as we thought. It has also emphasised our need to recalibrate our relationship with the environment and get fitter, which might nudge us towards cycling and walking more. Infrastructure changes, such as new cycle lanes, are propelling us in the same direction.

Or maybe not. "For the car industry this hasn't been all bad," Wells said. "Problems with the public transport sector, the unwillingness of individuals to risk that trip, has meant that the ownership and use of a car has become quite a useful thing."

At the start of the pandemic, I bought into the idea that it could be a game changer for the environment. Now I'm not so sure, at least for private cars. Current circumstances have turbocharged the question of how far we really are down the road to that transition. I reluctantly submit my answer: not very, and driving in the wrong direction. ■

Must ~~Nice to~~ have this holiday season

The coming year will see the fight against coronavirus continue, make-or-break international agreements on climate change and biodiversity, and nations continuing to vie for supremacy in space.

And that's just the stuff we know about.

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Editor's pick

Is there a better way than having another lockdown?

24 October, p 23

From Robert Cluck, Reston, Virginia, US

In critiquing the Great Barrington Declaration – described as a call for a let-it-rip, herd-immunity approach to the pandemic – Graham Lawton notes that mainstream scientists see curbs on freedom as the only way to keep a lid on the virus for now.

A democratic, civilised nation needs to recognise that freedom is inseparable from responsibility. There are many norms that people follow, codified or not, that allow us to exercise freedom if, and only if, our actions involve self-restraint, in ways that limit or avoid harm to others. When a significant number of people flout the rules of society (or public health) and cause harm, then governments need to step in on behalf of citizens to enforce restrictions that minimise harm.

The pandemic is a compelling case for this intervention.

From Sam Shuster, Woodbridge, Suffolk, UK

While Lawton is right to question herd immunity, it is irrelevant to the strategy of targeted isolation of the susceptible, the purpose of which is to avoid overloading the health service and allow normal social and economic life to continue. That idea was taken up in *The Lancet* and more recently in the Great Barrington Declaration.

It is the core strategy of targeted isolation, not the role of herd immunity, therapy or vaccination, that needs urgent consideration.

The present, haphazard pseudo-policy of successive lockdowns merely postpones the inevitable and extends the disaster to social and economic life.

From Robert Peck, York, UK

Even in the worst-case scenario if the coronavirus were allowed to "let rip", the overall harm is likely to be less than that of lockdowns.

While covid-19 deaths may rise, those due to cancelled surgery, undiagnosed cancer, job loss and suicide will be averted. I have yet to hear an explanation as to why lives lost to covid-19 are more worthy of protection than lives lost to other causes. Until this year, concerns about the side effects of such overreaction to infectious diseases were seen as the mainstream consensus.

For example, a 2006 paper on managing pandemic flu co-written by Donald Henderson – the mastermind of smallpox eradication – concluded that, until a vaccine is available, communities "respond best and with the least anxiety when the normal social functioning of the community is least disrupted", and that hand washing and personal hygiene should form the bulk of pandemic mitigation methods.

From Andy Connell, Bristol, UK

An important point behind the call to ease lockdowns is that, unless the scientific advice is tempered by consideration of social and economic impact, it risks being labelled as myopic and self-serving.

If, at the end of this pandemic, the excess death rates turn out to be minimal and the economic and social costs extreme, society might be far more ambivalent about following the science when some future emergency strikes.

First, make sure that this strange lightning exists

24 October, p 46

From Ryan Turner, London, UK

I enjoyed Eric Canan's look at the potential causes of ball lightning. However, it made me think that before we introduce such exotic concepts as four-dimensional lightning or Gatchina plasmoids as explanations, surely the first step is to establish that ball lightning is a real phenomenon.

Canan points out that although ball lightning has been reported for centuries, there is only anecdotal evidence for it. So can we even be sure it exists? In this respect, it is no different from, say, ghosts or Bigfoot. Neither of these, like ball lightning, has ever been reliably captured on film, despite over a decade of people having phone cameras to hand pretty much all the time. If we have no evidence to define the phenomenon, how can anyone claim to explain its cause?

Kick your way to a better sense of balance

10 October, p 34

From Penelope Sucharitkul, Leeds, West Yorkshire, UK

As a medical student and an avid martial artist, I found your article on balance fascinating.

Karate is all about stability. For more than 10 years, I have trained in this martial art barefoot, honing my balance and mental focus. After training, my body feels more in tune with my mental state. I have always taken for granted the positive physical and mental effects of my training, but reading about the relationship between balance and mental health made me treasure this even more.

Martial arts weren't included in the "How to restore your balance" section, but what better way to do so than getting barefoot in a dojo and kicking things?

Doubts over Venusian life may save us a fortune

31 October, p 18

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

I would like to nominate Ignas Snellen and his four colleagues for a Nobel prize. By concluding there is no sign of phosphine in Venus's atmosphere, they may have saved millions of dollars, euros, pounds, roubles and I don't know what else that were going to be spent on missions there to look for life!

Cat food is the real ecological villain

31 October, p 42

From Hillary Shaw, Newport, Shropshire, UK

The most significant ecological impact of cats may not be what they kill, but what they eat. Each of the 373 million pet cats in the world consume an amount of meat similar to a human in many places, around 40 kilograms a year. Meat is the food with the biggest ecological cost in terms of land use, deforestation, water and energy consumption. Perhaps this is a cost the planet can ill afford.

Helicopter money may be the best answer

31 October, p 36

From Gordon Marks, Harrogate, North Yorkshire, UK

In your article on rebuilding economies after the pandemic, the thinkers you questioned were on the ball except when it came to quantitative easing and monetary theory. The latter is a failure and the former shouldn't be deployed in its usual form because the extra money it injects into economies ends up in quangos and in the hands of CEOs and shareholders. For a real boost, take a tip from former Greek finance minister Yanis Varoufakis and give every voter or householder £10,000.

From David Cannon, Exeter, UK

The most impressive book I have read this year is *The Deficit Myth* by Stephanie Kelton. It gives a brilliant exposition of an idea largely dismissed in your article, modern monetary theory. The essence of its argument isn't that nations should spend their way out of trouble, but that balanced budgets shouldn't be the primary aim of financial management. ▮

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Treetop herons

Photographer Dmitrii Viliunov, Drone Photo Awards

TAKEN 30 metres up in the air, this shot of a great white heron and grey heron in their respective nests also provides a bird's-eye view of Russia's expansive forests, which cover almost half of the country.

Dmitrii Viliunov took the photo near the city of Smolensk using a drone, which offered a unique perspective of this woodland landscape and a rare look into this aspect of the lives of these birds. Viliunov says he was surprised at how "absolutely calm" and unafraid the herons were of the drone, only giving it an occasional glance as they fed their chicks.

Herons are found in aquatic and wetland environments like rivers and lakes, but sometimes venture to mountains and even deserts in search of food. Despite often living near water, herons never nest in reeds or swamps, instead choosing trees. Sometimes, several herons make nests in the same tree, which often leads to fights between close neighbours.

This image, titled "Where Herons Live", won Viliunov first prize in the wildlife category of the 2020 Drone Photo Awards, a global aerial photography and video competition, and part of the Siena International Photo Awards.

The picture, along with the Drone Awards' other winning shots, will be showcased at the Above Us Only Sky exhibition at the Museum of Natural History of the Accademia dei Fisiocritici in Siena, Italy, until 29 November.

Gege Li

Hunting for fossils

Ammonite diligently shows the hard work involved in palaeontology, but its portrayal of Mary Anning isn't all it could be, says **Francesca Steele**

Film

Ammonite
Francis Lee
US cinemas 13 Nov, UK cinemas TBC

AMMONITE is unhurried in a way that won't be everyone's cup of tea. But then again, neither was the fieldwork essential to palaeontology in the 19th century.

Fossil collection can be a slow and sometimes boring business, which is presumably why so many men of learning left Mary Anning – poor, working class, self-educated – to do much of the work involved in excavation, then took all the credit when the items were displayed in London museums.

The film's opening is also a little slow at times, but it is right to pay heed to the labour-intensive nature of this vital work. We meet Anning (Kate Winslet) as she scales the cliffs at Lyme Regis in Dorset, UK. Her skirts are tucked between her legs and a harsh wind whistles by as she tugs at rocks lodged deep within the clay, often tumbling down the slope before she has secured anything worthwhile. It is hard, solitary graft.

Back in her studio, she brushes ammonites and other small fossils for tourists to buy. The 5-metre ichthyosaur skeleton she famously unearthed aged just 12 has long since been transported far away to the capital, its bones under glass, bearing someone else's name. Unlike many of her peers, Anning must earn a living, and because of her class and sex, she doesn't have access to the scientific societies that would elevate her position.

She lives alone with her crotchety mother in a tiny, freezing cottage. Their life is quiet, although crashing waves and harsh winds roar around her on the beach and creep in the window cracks – *Ammonite*'s sound design is one of its finest features.

NEON

Mary Anning (Kate Winslet) and Charlotte Murchison (Saoirse Ronan) in *Ammonite*

Into one of these quiet days come Mr and Mrs Murchison. Roderick (James McArdle) is a geologist who wishes to learn from Anning. Charlotte (Saoirse Ronan) has "mild melancholia", apparently brought on by childlessness. In reality, Charlotte was indeed friends with Anning, but was also a lively geologist and was in some ways responsible for her husband's successes. Here, she is a fragile creature, lonely in her marriage. We see her reaching for a husband who leaves her in Lyme Regis to recuperate as he goes off on his European tour, paying the Annings to watch over her.

Ronan and Winslet do some nuanced, career-best work here. Trussed up in their Victorian petticoats and cumbersome bonnets, the dialogue often painfully sparse, they must act predominantly with their faces. It would have been easy to overplay everything as a result, but instead it is their reserve that moves us – a discreet look of curiosity here, a secret smile there.

> **"This is a story about Victorian misogyny and female friendship more than it is about Mary Anning herself"**

Winslet's transformation from gruff loner to passionate lover is particularly fine. Initially unhappy at being lumbered with a frail gentlewoman, their connection takes her by surprise. She has convinced herself she needs isolation, even enjoys it, when in reality she has had no choice. Women at this time either had to be owned or alone. This is a story about Victorian misogyny and female friendship more than it is about Anning herself.

From here, the film departs from fact as Anning and her new friend become lovers. However, it isn't so much the film's pace or infidelity to the truth that is most likely to disappoint, but rather the scant attention it pays to Anning's actual achievements.

Anya Pearson, a trustee of Mary Anning Rocks, a charity campaigning for a statue of Anning to be built in Lyme Regis, praises the portrayal of the "horrendous slog of fieldwork" but says of the film: "I do think it uses Anning as a vessel. It could have been any two women in this romance. There's actually very little palaeontology."

Anning was born in 1799 in Lyme Regis. Her father, a carpenter, supplemented his income by collecting "curios" from the local cliffs and taught his daughter to do the same. As well as her childhood discovery of an ichthyosaur, she also found the first complete plesiosaur in her twenties. Although today she is sometimes credited with finding dinosaurs, the fossils Anning

discovered on the UK's Jurassic Coast were all marine reptiles, a separate prehistoric group.

It is a myth that Anning was a loner or underrated within her lifetime, says Tori Herridge, a paleontologist and co-founder of TrowelBlazers, a website that celebrates the forgotten stories of women in geology, palaeontology and archeology. "In some ways, her achievement is the very fact that she was acknowledged at the time, given cultural constraints."

In 1838, after Anning found herself destitute following a bad investment, the Geological Society (which didn't accept women as members and had previously excluded Anning from a meeting about her own plesiosaur discovery) actually granted her an annuity – a sort of pension, illustrating the high regard in which she was held.

She had plenty of friends too. Charlotte Murchison probably wasn't her lover in reality (and was actually older, not younger, as suggested in *Ammonite*), but the two did exchange many letters over the years. Indeed, many of Anning's friends were the wives of the men who came to consult her – Mary Buckland, for example, wife of the president of the Geological Society, William Buckland.

Numerous letters between Anning and Murchison, Buckland and Frances Bell, a teenager whom Anning taught to hunt for fossils and the person on whom her *Ammonite* lover was originally thought to have been based, can be read at London's Natural History Museum and elsewhere. Contemporaries described Anning as "shrewd", "a strong, energetic spinster" and "rather satirical". The antisocial person portrayed by Winslet seems a long way from the vivacious character of her friends' descriptions. ▮

Hearts of darkness

An undercover probe into white supremacy is troubling reading, finds **Donna Lu**

Book

Culture Warlords: My journey into the dark web of white supremacy
Talia Lavin
Octopus Books

TALIA LAVIN awoke one day to discover a group of white supremacists using encrypted messaging app Telegram to discuss if she was "too ugly to rape". A few weeks earlier, unknown to its members, she had joined the group.

The writer and former *New Yorker* magazine fact checker didn't feel prominent enough to warrant such vile comments. "I was mostly just a loudmouth on Twitter. Why was I taking up real estate in their heads?"

The ugly incident is recounted in Lavin's book *Culture Warlords*, about her attempts to get into the heads of white supremacists to understand the mechanics of online racism and how it overlaps with misogyny.

Her book is a well-researched overview of the ecosystem of online hate. Lavin walks readers through the histories of racial segregation, anti-Semitism and white supremacy in the US. She also covers more recent history, such as 2014's Gamergate, in which harassment of a female game developer metastasised into broader online trolling against people who criticised sexism in the games industry.

Most striking is how far Lavin will go. She lurks in anonymous forums, even posing on a white supremacist dating site as "blonde, gun-toting" Ashlynn. Such commitment is beyond mere anthropological curiosity. Lavin takes self-professed "glee" in enticing men to reveal personal details so she can out them as white supremacists.

Her intent is not without justification, but there is a problematic irony here. Lavin has had personal details shared online by harassers, yet she readily exposes the identity of a neo-Nazi in Ukraine. "It was sweet... and a bit perverse," she writes.

Her presence in far-right chat rooms, Lavin believes, has the effect of accountability: "If I'm there, I can tell you about it."

But awareness of a problem and finding practical solutions are very different.

Knowledge may have one beneficial effect, yet it is one Lavin understates. Scrutiny over sites and apps enabling hateful and violent views could bring reform or close them down.

That's despite the inaction of big tech. Facebook, Google, Twitter and Telegram, she writes, are responsible for turning US white supremacy into "a white-internationalist movement". Hate makes money, after all. It is, she says, "on us to demand more, and better". ▮

REUTERS/STEPHANIE KEITH

White nationalists marching in Charlottesville, Virginia, in 2017

Don't miss

Watch

Alien Xmas, on Netflix from 20 November, is the latest charming stop-motion animated adventure from the Chiodo Brothers. A tiny alien with plans to wreck Earth's gravity is mistaken for a Christmas gift. Easy mistake to make.

Read

The Mismeasure of Progress: Economic growth and its critics by historian Stephen J. Macekura tells the stories of the mathematicians, intellectuals and activists who realised that the conventional way of measuring growth isn't all it is cracked up to be.

Listen

Your Undivided Attention is requested as podcast hosts Aza Raskin and former Google design ethicist Tristan Harris expose the designs hidden in our technology and environment that are out to manipulate us.

TOP: NETFLIX

The sci-fi column

Flipping the narrative

Whatever you are expected to do, don't. That's a key theme in *Escape Pod*, a major new anthology featuring such luminaries as N.K. Jemisin, Ken Liu, Kameron Hurley and Cory Doctorow, says **Sally Adee**

Sally Adee is a technology and science writer based in London. Follow her on Twitter @sally_adee

GREMLIN/GETTY IMAGES

The image of the future we form in our minds shapes that future

Book

Escape Pod: The science fiction anthology
Editors: Mur Lafferty and S.B. Divya
Titan Books

Sally also recommends...

Book

The Light Brigade
Kameron Hurley
Simon & Schuster
If you enjoy Hurley's "Citizens of Elsewhen" in the Escape Pod *anthology, definitely don't miss* The Light Brigade. *In fact, don't miss it anyway – Hurley is so good at military sci-fi.*

Podcasts

Escape Pod
Escape Artists

Clarkesworld
Clarkesworld Magazine

"Every birth is a battlefield, a war between the life that exists and the life coming into being," says the midwife who narrates Kameron Hurley's "Citizens of Elsewhen", the opening story in the *Escape Pod* anthology.

Asa is not just a midwife, but also a time-warrior who shapes the future. She intervenes in the past to save influential women from dying in childbirth and thus protect the matriarchy 3000 years in the future. But Hurley could just as easily be talking about the revolutionary times to which we have front-row seats. If we are in a battle between the future and the past, science fiction is the midwife.

Before there were 1.5 million or so podcasts, there was *Escape Pod*. The sci-fi short story podcast turns 15 this year, and to mark this, its editors have curated a book with a mix of 15 new and previously commissioned works, including some from seriously big names like N.K. Jemisin and Cory Doctorow.

In her foreword, Serah Eley, the podcast's founder, lays out her vision of science fiction as the literature of change in revolutionary times. It is those midwives of the future again.

Following Hurley comes "Report of Dr Hollowmas on the Incident at Jackrabbit Five" by T. Kingfisher. It is about a group of pregnant women on a colony planet whose difficult pregnancies are saved by a midwife space marine corps.

> **"If we are in a battle between the future and the past, then science fiction is the midwife"**

"Midwifing" the future is a basic play on the old cliché about sci-fi being the blueprint for what is to come, even if it does subvert the notion of which gender is responsible for shaping the future (think terraforming, rockets and so on – all very macho).

If this was the best insight in this anthology, it wouldn't be that astute. More promising is another theme that pops out of the curated mix: don't do the thing you are expected to do.

Flipping the expected narrative is a major motif as the anthology progresses. In Tim Pratt's take on the multiverse genre, "A Princess of Nigh-Space", a young heiress rejects a fight with a monster, instead making a cool-headed business deal.

And in "Give Me Cornbread or Give Me Death", N.K. Jemisin's protagonist refuses to accept the inhumanity of the things sent to destroy her and her people. In so doing, she thwarts the ruling caste in a way no amount of valiant fighting could have accomplished.

In many of the stories, rather than choosing combat, the protagonists rethink their strategy, with surprising consequences but similar endings. Enemies are unmade, not killed.

The myriad events that will unfold over the next few months are premised on many narratives about enemies. You know who you are expected to see in that way. But if we are to avoid more of the horrors of 2020, this won't work.

As the events of the past few years bear out, true stories and fiction work the same way in our minds, warns Eley. We are beginning to understand that in a world of competing truths, there is a battle to carefully curate those that shape our world.

The same understanding is needed for fiction. The image of the future we form in our minds shapes that future. So we must take care about the images we choose. If we choose fighting and enemies, the future will involve fighting and enemies. If we choose a cleverer, more subtle and humane way to deal with each other, maybe a better future can be born. ■

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The great population debate

Is the coronavirus pandemic just the latest indication that there are too many of us on the planet? **Richard Webb** investigates

IN THE once-seedy district of Soho, about 10 minutes' walk from *New Scientist*'s London offices, a pump, a plaque and a pub commemorate one of the greatest ever breakthroughs in human history: a decisive step made almost 200 years ago towards conquering infectious disease.

Our current global health crisis is a reminder of how little we want to return to the days when deadly infections carried away most of us. Yet also in some way, advances back then were a first step on a path towards planetary perdition. The success against infectious disease, alongside other major developments, dramatically improved our survival and set humanity's numbers soaring, from little more than 1.25 billion people back then to 7.7 billion now.

Now, climate change, biodiversity loss, the degradation of the biosphere and, yes, coronavirus are forcing us to consider the legacy of that success. The pandemic is becoming the latest focus for an old, uniquely contentious question: are there just too many of us on the planet?

The basic argument is hard to deny. With fewer of us around, there would be fewer greenhouse gas emissions, less pollution and waste, more space for both us and the rest of the natural world to survive and thrive.

So let's bite the bullet. Let's talk about population – where it is heading globally, what that means for the planet, and what, if anything, we should be doing to limit its growth. Be warned, however: finding answers isn't nearly as easy as posing questions. And with scenes of sexism, racism, nationalism, misogyny and eugenics, what follows at times makes for uncomfortable viewing.

The boom in our ranks over the past century or so has one source: progress. In 1854, when local doctor John Snow worked out how cholera was being transmitted through an infected water pump handle on Broad Street in Soho, more than a half of all deaths in England were caused by infectious disease. One in four children didn't live to see the age of 5. Average life expectancy hovered around 40.

But starting in the 19th century in rapidly industrialising economies, a series of leaps in health and sanitation began to depress mortality across the globe. Meanwhile, more efficient methods of agricultural production and improved nutrition allowed more people to live more comfortably, for longer, without extreme hunger. In 1860, the figure for child mortality worldwide was more than 40 per cent. Today, it is around 4 per cent, and a fraction of a per cent in advanced economies. In western Europe, life expectancy is now about 80. In sub-Saharan Africa, it is over 60, up from 44 half a century ago.

This change in death rates marks the first stage in the "demographic transition": a seismic change in which nations shift over decades from high birth and death rates to lower rates of both. Few people have a problem with its first stage. "Everybody is happy with mortality decline," says Diana Coole, a political scientist at Birkbeck, University of London.

But as more people live longer lives, populations skyrocket. The global population of around 1 billion in 1800 had doubled by the late 1920s. By the mid 1970s, it had doubled again, approaching 4 billion. Half a century later, it is about to have doubled again, standing conservatively at some 7.7 billion.

Humans are without doubt overexploiting the world's resources

KEITH SHERWOOD/GETTY IMAGES

And so it goes on. This year, more than twice as many people will be born as will die. Humanity's numbers will swell by something like 80 million, pandemic or no pandemic. The United Nations Population Division's most-favoured median projection estimates that 9.7 billion people will be on the planet in 2050 and 10.9 billion in 2100. These figures are based on the average global fertility rate, defined as the number of births per woman. Increase that rate by half a child, and you hit a "high variant" of almost 16 billion people at the end of the century (see graph, page 36).

"There's not a lot of difference in population projections over the next 30 or 40 years," says John Wilmoth, head of the UN Population Division. "But they start to diverge in the second half of the century and, honestly, nobody knows for sure. Nobody can know in that kind of time interval."

That's not exactly reassuring. "You can't read the high-population variant without thinking, 'Oh my God'," says Coole.

On the face of it, fewer people means less impact. Take climate change, perhaps the most immediately pressing of our many environmental problems. In 2017, Kimberly Nicholas and her colleague Seth Wynes at Lund University in Sweden studied the measures people in advanced economies could take to reduce their carbon footprint. Once they accounted for the generational effect – that every child a person has is likely to have children themselves – having one fewer child was the single most effective measure, saving 120 tonnes of carbon dioxide a year for the average US citizen. The next-biggest impact, living car-free, came in at 3 tonnes of CO_2 a year for the average person in the US. Trailing in behind that were avoiding flying, buying green energy and switching to a plant-based diet. "Having a child is a huge life decision personally and professionally and financially and every other way," says Nicholas. "It has a huge impact on the carbon legacy that we leave in the atmosphere."

80 million

The expected global population growth in 2020

It isn't just carbon emissions. "Declining biodiversity is both an issue of increasing human number and unsustainable consumption," says Edu Effiom at the Cross River State Forestry Commission in Calabar, Nigeria. She was lead author for the Africa section of the 2019 UN-backed report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, which detailed our unprecedented global impact on the natural world. That human numbers are a major driver in this too seems undeniable: you can draw a graph showing human numbers and species extinctions growing in lockstep. Our ravaging of safe spaces for nature is thought to provide new avenues for "zoonotic" diseases such as the new coronavirus to jump over from other species to our own.

"The bottom line is, there is an overshoot in our demand for nature," says economist Partha Dasgupta at the University of Cambridge. Our environmental impact is ›

primarily determined by three things, he says: how much each of us consumes, the efficiency of our technology in converting natural resources into products we consume and how many of us there are. But we don't tend to talk about the final point. "We miss out this one factor, number," he says.

Public discourse hasn't always been so coy. Concerns about the ability of the planet to sustain so many of us date back at least two centuries, to the writings of the English cleric Thomas Malthus. In the 1960s, the first wave of the environmental movement brought soul-searching about global population numbers when they were barely half what they are today. In 1972, the Club of Rome, a grouping of prominent politicians, economists, scientists and diplomats, published *The Limits to Growth*, a report that used computer modelling to predict the collapse of global systems in the mid-to-late 20th century if then-current trends of population growth and resource consumption were to continue.

They did continue, and civilisation hasn't so far collapsed. The "green revolution" in agriculture began to kick in from the late 1960s, allowing more people to be fed more securely. And the second phase of the demographic transition began in earnest, as birth rates started to fall worldwide. The drivers of this process are complex, but relate to increasing urbanisation, education and material progress. Rising levels of education lead to more people having fewer children and at a later age. Healthier, better educated women are more likely to stake their rights to opportunities beyond bearing and caring for children. Widespread availability of abortion and contraception assist those trends.

10.9 billion

The UN's median world population projection for 2100

If we are looking for reasons why the mid-20th-century wave of population worry receded, it is that, from a high point of well over 2 per cent a year in the late 1960s, the global rate of population growth has now fallen to a little over 1 per cent. Across large swathes of Europe and South America, fertility rates are at or close to the "replacement rate" of 2.1 children per woman, the level that ensures a stable population. In some parts of the world, notably Japan, South Korea, Russia and some nations in eastern and southern Europe, fertility is below this rate, and population is declining. But even in those places where it is still increasing – South Asia, Africa, the Middle East – fertility is going down.

One basic problem in talking about human population is not knowing where those trends are going next. UN projections are largely based on applying models of the second phase of the demographic transition, the fall in birth rates, in places that have already been through it to places that haven't.

Wolfgang Lutz is a demographer at the International Institute for Applied Systems Analysis in Austria, and one of 15 scientists selected by the UN to produce its latest *Global Sustainable Development Report*, released in September 2019. He is an outspoken critic of that approach. "I call it blind statistical extrapolation," he says: modelling with insufficient real-world data from the countries in question.

Lutz and his colleagues argue that developing economies are transitioning faster than the now-advanced ones did, and the UN models are too crude to take account of that. "We've seen this in every Asian country, and now we're seeing it again in every African country," says Lutz. "Virtually everywhere, women with higher education have a lower fertility, lower birth rate, than the less educated," he says. And nowhere, at least before the pandemic, has access to education been improving faster than in parts of Africa.

Ups and downs

Lutz's latest model of population growth, published in 2018, traces future possibilities according to five "shared socioeconomic pathways" for global development. They look very similar to the UN scenarios up to 2050, but then diverge rapidly – downwards. In all but one, world population peaks before the end of the century; in the "median assumptions scenario", at around 9.5 billion in 2070. In two cases, it ends up below where it is today.

This optimistic picture has acquired some traction, with books such as 2019's *Empty Planet: The shock of global population decline*. So could it be that population is a problem that is about to solve itself?

Not according to Wilmoth. "There's really no argument for saying that change in the future will be faster than it was in the past," he says. "If anything, I think what we worry about at the UN is that the pace of change may be slower than what we're predicting."

The worsening climate crisis would certainly seem to suggest caution: rising population is still rising population. Coole is also sceptical that we are reaching the closing scenes of a grand historical narrative that ends inevitably with low mortality and fertility rates. In fact, she is worried recent trends might be about to go into reverse. Everyone is happy about mortality decline, but it is a different story with fertility decline.

There are many reasons why people and groups across the world adopt "pronatalist"

Billions and billions

UN projections for world population diverge in the second half of the century

SOURCE: UNITED NATIONS. WORLD POPULATION PROSPECTS 2019

positions arguing for higher fertility. One is that, while environmental considerations might suggest that lower fertility rates are good, economic considerations often suggest they aren't, at least on models of economic growth based on more people creating more demand for goods and services. Developing economies are certainly reaping the rewards of young, dynamic populations as their workforces boom – just as today's advanced economies did earlier. "If you go to India, it's incredible the change in 10 years," says Coole. "You can see why they feel this is something they want to have."

Nations further along the demographic transition, where fertility rates are bumping along at replacement level or below, are grappling with the opposite problem. With fewer people around, economic growth, stable finances and societal cohesion become harder to maintain. In states with highly developed welfare systems, this becomes a slow-burn issue of a growing "dependency ratio": a large, ageing, economically inactive population supported by tax receipts from a dwindling band of working people.

The solutions to these problems – higher taxes, less generous welfare provision, later retirement – have themselves turned into political hot potatoes in many advanced economies. One alternative – higher levels of immigration to maintain working-age populations – is even more fraught. Japan has gone down a different route: pursuing robotics as a way of replacing people not being born.

The challenges associated with ageing populations are a big factor in the success of nationalist populist movements in many parts of the world. Certainly, rhetoric advocating population growth as a matter of national destiny is on the rise in countries including Hungary, Italy, Iran and elsewhere.

Another such nation is Turkey. Under president Recep Tayyip Erdoğan, it has pursued policies in favour of population growth and has been trying to roll back women's rights to achieve it. Access to abortion, although still a legal right until the 10th week of pregnancy, has been de facto limited in many places, says Azer Kılıç, a political scientist at Bilgi University in Istanbul. "This period has also witnessed a political emphasis persistently put on the family as a social institution in a way which puts women in a secondary position, defining them as mothers and caretakers, and threatening their individual rights and capabilities," she says. In Poland, which also has a vocal pronatalist contingent, a high court just ruled to ban nearly all abortions.

CHARLES MCQUILLAN/GETTY IMAGES

The debate over population is inextricable from women's rights

> **"Rising levels of education lead to more people having fewer children and at a later age"**

This is a depressingly familiar story, says Coole. "Right across the world, we see women's rights being curtailed by people trying to increase population." That has a certain irony about it, because a desire not to interfere with women's reproductive rights is another reason why, starting in the 1970s, talk about population control receded.

Pronatalist sentiment does bring together often bizarre coalitions of otherwise irreconcilable interests. Populists who dream of national glory are united with pluralists who support the right of all countries to develop as they see fit. Free marketeers who reject notions of state regulation share common cause with advocates for comprehensive social welfare systems worried about the effect of ageing and declining populations. Social and religious conservatives who oppose abortion and contraception find their interests aligned with those of feminists fighting for a woman's right to choose how many children she has.

The influence of religion is worth dwelling on a while. In 1968, Pope Paul VI condemned artificial contraception. This interdiction, while widely disregarded, still stands for the planet's 1-billion-plus Roman Catholics. Meanwhile, under pressure from religious and social conservatives, every Republican president in the US since Ronald Reagan has ruled out giving funding to any aid ›

organisation that supports abortion, even in principle – including the UN Population Fund.

Those who suggest there might be a case for reducing population growth must certainly be prepared for a sometimes personal backlash. Nicholas stumbled onto this thorny territory with her study of the carbon effects of having one fewer child. Some, mainly male, critics, including the right-wing shock jock Rush Limbaugh, openly questioned her own reproductive choices, while some feminist critics suggested she was attempting to shift the blame for climate change from corporations and governments to women's reproductive choices.

"The decision to have a child is a deeply personal one, as it should be," says Nicholas. "Our study provided information to inform choices, but people react very strongly and emotionally if they feel their decisions are being threatened or attacked." Coole says she has had similar experiences if she seemed to imply limiting reproductive freedom: "If I mentioned it, say, in the States, feminists would treat me as if I was some kind of Nazi."

"Talking about population control is dogged by an association with eugenics"

That word is extreme, but it crops up a lot in discussions that touch on limiting human numbers. The genocides committed by the Nazi regime followed on from a long history of Western scientists advocating eugenics to "cleanse" populations of supposedly undesirable traits. That history dogs the conversation today. "It really caused problems among Western intellectuals," says Dasgupta. "The moment you talked about population, you were talking about coercion."

No one who talks thoughtfully about population today is advocating that. In 1967, the UN recognised individuals being able to decide whether they have children, and how many, as a fundamental human right. Anti-natalism via coercion has been tried several times, with generally disastrous consequences for human rights. Sterilisation programmes across the US during the 20th century disproportionately targeted women from minority communities. China's infamous one-child policy, in place from 1979 to 2013, led to widespread selective abortion of female fetuses, as well as the enforced sterilisation of women. In some parts of India, more than 6 million men with more than two or three children were forcibly sterilised during a state of emergency from 1975 to 1977. Partially funded by aid money from the US and elsewhere, it was widely seen to have had an anti-Muslim agenda. The spectre of eugenics, again.

"Sometimes countries have reacted with such aggressive measures that they became violations of human rights," says Wilmoth. "They became convinced that it was necessary for the collective good and invading people's bedrooms and women's wombs was justified to control population growth."

So talking about population is fraught. But it is at this point that we need to take a closer look at the trap we have been skirting for some time while doing just that. Call it the "them" versus "us" trap.

Most of us, when asked to think about our own lives and those of the people around us, would probably find ourselves taking an instinctively pronatalist position. I don't have children myself, but I certainly wouldn't tell a relative or friend that they shouldn't have a child if they want to. I would be even less happy if any third party, state or otherwise, were to start telling me or anyone close to me how many kids we could have.

Yet if we say that global birth rates are too high and need to be brought down, we are sailing dangerously close to saying something similar would be OK elsewhere.

TOSHI SASAKI/GETTY IMAGES

How we behave may influence the climate more than how many of us there are

160:1

The relative climate impacts of average citizens from the US and Ethiopia

"The discussion is almost always: we want to see fewer people of the other kind, of the other race, of the other nationality," says Lutz. "You always want to see fewer of the other and more of your own."

Back to basics

It is the case that in places like the UK, fertility rates bump along below the replacement rate – and would be even lower were it not for higher fertility rates among women born outside the UK. Meanwhile, in parts of the globe, notably parts of central Africa, fertility rates are still running at three, four, five or more children per woman. In the UN medium-variant population scenario, half of the global population increase by 2100 comes from just nine countries, eight of them developing economies: India, Nigeria, Pakistan, the Democratic Republic of the Congo (DRC), Ethiopia, Tanzania, Indonesia and Egypt. The US, with high levels of immigration and a relatively young population for an advanced economy, comes in at number nine.

But for Lutz, arguments based on raw numbers alone are flimsy. "People are focused way too much on world population size, which is in a way a figure that affects nobody's life, because what you experience is the population growth in your neighbourhood, or at most in your country," he says.

It is here we need to go back to basics. The justification for talking about population in the first place is our concern about humanity's impact on the planet, so we have to look at where that impact is coming from. In the case of climate change, that is pretty clear. "If you look historically over time at what has driven the increase in carbon emissions in the atmosphere, sure, population growth has been an important factor, but a larger factor has been the change in per-capita emissions," says Wilmoth. "Depending on how you measure it, over which time period, for which population and so forth, it's something like two-thirds versus one-third: two-thirds behaviour and one-third human numbers."

That switches the spotlight away from fertility rates in "other" parts of the world back to the consumption levels of people sitting in relative prosperity in advanced economies. "Poor people in Africa where the population is growing most rapidly are not contributing at all to greenhouse gas emissions," says Lutz.

Let's put some numbers on that. The World Bank says that, in 2014, the last year for which comprehensive figures are available, averaged global CO_2 emissions amounted to 5 tonnes per capita. For China, it was 7.5, for the US, it was 16.5, for Australia 15.4. For the average member of advanced-economy club the Organisation for Economic Co-operation and Development, that figure was 9.6. The equivalent numbers for the eight developing economies projected to have the largest population increases according to the UN's figures are these: India 1.7 tonnes per capita, Nigeria 0.5, Pakistan 0.9, the DRC 0.1, Ethiopia 0.1, Tanzania 0.2, Indonesia 1.8 and Egypt 2.2. To take, admittedly, the most extreme of those numbers, around 160 citizens of Ethiopia or the DRC have a lower climate impact than one US citizen.

Such simplistic calculations have flaws, of course. Emissions from advanced economies have been declining or flatlining in recent years, whereas those from developing economies are rising as they develop and gain a consumption-hungry middle class. The lifetime difference in emissions between the average person born in India and the US today, for example, may be smaller than the numbers suggest.

Nor do greenhouse gases say everything about our impact on life's support systems. And while not all of the destruction of the Amazon rainforest, say, is down to rapacious multinationals satisfying the demands of Western consumers, a basic equation holds: while the number of people on the planet is important, says Effiom, "unsustainable ›

Consumption, not population

The biggest factor driving global carbon emissions is per-capita consumption and this varies hugely across the world

SOURCE: WORLD BANK

The biggest way to cut emissions?

In advanced economies, having an extra child has a hefty climate footprint, suggesting that the number of children people have should be part of their carbon emissions calculations

SOURCE: doi.org/gbvnvs

Japan's low birth rate has led to increased use of robots

FRANCK ROBICHON/EPA/SHUTTERSTOCK

> "Having fewer children won't allow us to get emissions down fast enough"

120 tonnes

Reduction in annual carbon dioxide emissions by an average US citizen having one child fewer

consumption by the developed region of the world is a major factor in biodiversity decline".

As for pandemics, while our destruction of nature and encroachment on wild habitats undoubtedly doesn't help, it is difficult to pinpoint a causal link between their likelihood or severity and the number of us on the planet: deathly pandemics have, after all, occurred throughout recorded human history, Coole points out. Nor is it easy to argue that more people living cheek by jowl in cities necessarily spurs them. The John Snow story shows how urbanisation has over history provided people with access to modern sanitation and medical knowledge and care that can limit the spread of disease. One facet of high consumption, meanwhile – criss-crossing the world on planes – almost undoubtedly did facilitate the virus's spread.

The looming climate change emergency gives us another reason to hold back from suggesting population control as the solution to the world's woes. Given the impact of having more children extends over generations, having fewer of them won't help us in the decade or so we have to get emissions down and avoid catastrophic global warming. "Population is an important long-term factor in how much warming we eventually experience, but for the climate we live out our lives in, as well as what future generations inherit, it is absolutely critical to stop today's climate pollution," says Nicholas. That suggests the emphasis for people in advanced economies should be rethinking their consumption-fuelled economic models, while helping people elsewhere to develop more sustainably.

The number of children we have is part of that consumption calculation. "Just as people are thinking more about their diet and about flying around the world, the good thing would be for people to appreciate the impacts before they start thinking about reproduction," says Coole.

But there is a limit to how far we can take those discussions. "We have to accept population trends to a certain degree," says Wilmoth. "We have to accept the changes that are going to take place, and the world has to adapt its ways of living. Unless you stop people from having babies entirely, and that would have enormous consequences we don't even want to think about."

Instead, we need to press for more of what works in reducing population growth where population growth is high: education, and support for family planning and gender equality. "It means supporting programmes to give people access to modern contraceptives all round the world," says Wilmoth. Effiom agrees, citing the importance of, for example, stronger measures against polygamy and forced marriage. "It's about enhancing girls' education and empowering them to make choices for themselves," she says.

That doesn't mean we shouldn't talk about population. But if we do, perhaps we should ask ourselves a series of questions first. Is our motivation concern about the fate of the planet and the impact of humanity on it? If so, are we taking steps to limit our own impact, and supporting public efforts to do the same? Do we accept that humanity's impact is an "us" problem, not just a "them" problem? Do we support the right of individuals, especially women, to choose how they live their lives, and aren't tacitly advocating draconian measures being applied to people that we wouldn't accept being applied to ourselves? If we can sincerely answer "yes" to all those questions, then let's talk – while acknowledging there may be more productive ways to move from our path of planetary perdition. ■

Richard Webb is executive editor of *New Scientist*

We crave physical contact with family to reaffirm our bonds

WILLIE B. THOMAS/GETTY IMAGES

Greetings!

Evolution holds the key to why social distancing is so difficult, finds **David Robson**

ON 9 MARCH, Mark Rutte, the Dutch prime minister, called a press conference to discuss his country's response to the covid-19 pandemic. "From now on, we stop shaking hands," he declared – before promptly reaching out his hand to greet an expert on infectious diseases.

Many of us can empathise. Social distancing sounds innocuous, but this year we have discovered how hard it can be in practice. Touchy-feely greetings, such as handshakes, hugs, kisses and nose rubbing, are deeply embedded in many cultures. These gestures aren't merely learned, however. Look to the animal kingdom and you will see that many species – especially highly social ones – perform physical rituals when they approach each other. If our urges to touch one another in greeting seem instinctual, it is because they are.

Greetings adopted by animals can be very different to our own – they include eye poking and other gestures that might make you squirm – but understanding these behaviours can give us an insight into human salutations. Examining the evolution of greetings throws light on the subtle ways they lubricate social interactions and also helps to explain why they are so diverse. As we are a super-social species, it isn't surprising that many of us are struggling to adjust to the new normal. But the good news is that we are proven masters at adapting our greetings to fit new situations.

Animal encounters

Mammals tend to use scents to suss each other out, which explains why their greetings are so intimate. A new encounter often entails sniffing another individual's face, flanks and genitals for volatile chemicals that reflect its hormonal state. This offers cues about strength and fertility, allowing animals to size up potential opponents and mates.

Like our own greetings, the duration and intimacy of such exchanges reflect the nature of the relationship. Subordinate rats, for example, submit to prolonged sniffing from more dominant individuals but risk a fight if they become over-friendly themselves. They seem to be offering some kind of "appeasement signal" that de-escalates tension – and it's not just about the chemical signals in their body odour. Daniel Wesson at Case Western Reserve University in Ohio has found that rats that have lost their sense of smell still sniff one another, suggesting that the behaviour itself is also important in establishing the social hierarchy.

"Greetings help individuals test their trust in each other and build alliances"

Will our greetings change for good as a result of covid-19?

ANDREU DALMAU/EPA-EFE/SHUTTERSTOCK

Cats and dogs behave similarly, with a characteristic rub of the head to exchange smells on greeting. There is evidence that such gestures can even spread goodwill across the species barrier. A study of cats and dogs living in the same household found that 75 per cent regularly engage in nose-to-nose sniffing, a gesture that appears to help them live side by side. This can be accompanied by other physical signals: a cat's raised tail signals friendly intent, while a dog may crouch and look upward to show that it has no intention of fighting.

For more elaborate greetings, however, we need to look to our fellow primates, many of which appear to use ritualised signals as a way to navigate social relationships. In certain species of baboon, for example, greetings range from lip-smacking and head-bobbing to touching buttocks or genitals. Some baboons even engage in a kind of conga dance. "They have this very peculiar greeting, during which one male approaches the other one, and he takes the hind quarter of the other and then they start walking," says Federica Dal Pesco at the German Primate Center in Gottingen.

Many of these behaviours – particularly those involving genitals – include an element of risk and vulnerability. "It's really important that they don't get injured there because of their future reproductive success," says Dal Pesco. From an evolutionary point of view, such behaviours should be a serious taboo, unless there is a significant benefit to outweigh the danger. But what could it be?

The answer, Dal Pesco believes, lies in the structures of baboon societies. She points out that riskier and more intimate behaviours are more common among highly cooperative

BLAINE HARRINGTON/AGEFOTOSTOCK/ALAMY

The sharing of breath symbolises unity for New Zealand's Maori

species like Guinea baboons, in which males form closely bonded coalitions. Greetings, she suggests, help individuals test their trust in each other and build alliances that could improve their chances of survival in the future. "The greetings allow you to touch base with many individuals in your society, and in different ways depending on the relationship you have," says Dal Pesco.

Similarly intricate behaviours are found among white-faced capuchins, whose rituals include finger-clasping, embracing and the toe-curling practice of sticking a finger into one another's eye sockets, sometimes up to the first knuckle. Like baboons, capuchins have a complex society in which groups of males band together – again suggesting that risky interactions allow the monkeys to test and affirm their relationships. "It clearly can't feel that good to take somebody's dirty claw and finger and stick it in your eye socket," says Susan Perry at the University of California, Los Angeles, who has spent thousands of hours observing these interactions. "The fact that they can pull this off really says a lot about their trust."

So what can these animal interactions teach us about ourselves? We too live in complex societies in which trust and cooperation are paramount. Of course, our greetings are imbued with a deeper symbolism and meaning and they have enormous variety, from the namaste bow in India to the hongi of the Maori, in which two people press their noses together, as well as handshakes and cheek kisses (see "A very brief history of greetings", page 44). Yet however much more sophisticated we may seem, the latest research suggests that many of our gestures serve the same functions as those in other animals.

Sniffing you out

Any greetings that involve bodily contact may offer us a way to pick up chemical cues. Although the existence of human pheromones is controversial, research suggests that we may be able to assess someone's physical fitness and fertility from compounds in their saliva – a possible rationale for the strange phenomenon of romantic kissing. What's more, there is evidence that body odour can communicate someone's emotional state and even their sexual arousal. Our greetings can allow us to sample this aroma without overtly sniffing someone's body, according to research by Idan Frumin, then at the Weizmann Institute of Science in Israel.

Frumin was inspired when, at a conference, he noticed that people often ran their hand under their nose after shaking hands with someone else. He wondered whether the purpose of this "weird ritual" was to get a whiff of the other person's natural perfume. To test the idea, his team covertly filmed visitors to the lab as they waited to take part in an experiment. About 3 minutes into the wait, a scientist of the same gender entered the room, introduced themselves and then left. The footage revealed that people were more likely to bring their hand to their face if the scientist had shaken it; many directly touched their noses after the encounter. To make sure that people were actually sniffing their hand, Frumin fitted another group of volunteers with a sensor that measured ›

nasal airflow. This doubled when the participant's shaken hand was near their face.

This supports the idea that formalised greetings offer a covert means of checking someone's scent. "We're not very different from rats, in that sense," says Frumin. If he is right, the idea can also explain why we find it so hard to stop touching our faces – another no-no in today's pandemic.

Like the baboon and capuchin rituals, our tactile greetings also allow us to assess someone's character and to establish our trust in them. One study found that the strength and duration of a handshake offers a fairly accurate prediction of personality traits including extraversion, neuroticism and open-mindedness. Francesca Gino at Harvard University, meanwhile, has found that students engaged in a simulated real-estate negotiation were more honest about the quality of the property if they had been encouraged to shake hands before the task.

Signals of trust

Although these studies looked solely at the handshake, many other physical gestures could serve a similar purpose. An analysis of players in the US National Basketball Association, for example, found that teams that regularly engaged in fist bumps, high fives, hugs and huddles at the start of the 2008–2009 season tended to perform better in the following months. Such open body language renders us physically vulnerable, signalling our willingness to work with the other party in good faith.

Unfortunately, as we are now discovering, there is a downside to tactile contact. No matter how much we trust someone, a close-up interaction runs the risk of transferring pathogens. In fact, the threat of disease appears to have influenced the greetings adopted by many cultures long before covid-19 came along.

Damian Murray at Tulane University in New Orleans and his colleagues combed an ethnographic database for records of greeting etiquette in 186 cultures, which they then rated for physical contact, from

A very brief history of greetings

Physical greetings may be part of human nature, but they also vary hugely from culture to culture. The origins of some are a little murky. The oldest evidence of the handshake, for example, can be seen in an Assyrian relief from the 9th century BC, which shows King Shalmaneser III sealing an alliance with a clasp of the hand. Handshaking can also be found in ancient Greek literature as a sign of hospitality.

Evidence of kissing is even older. References to romantic kisses can be found in some of the world's earliest texts, including the Vedic scriptures and ancient Sumerian poetry, as early as 3500 years ago. The social kiss dates to at least the Roman Empire, where it was seen as a greeting between equals. The emperor Tiberius, who reigned from AD 14 to 37, banned the practice at court receptions, since it was believed to spread a dangerous facial infection. The ban didn't last for long; cheek-kissing has remained particularly popular across southern Europe.

Some cultures touch noses as a greeting. This is known as the hongi to New Zealand's Maori population, to whom the "sharing of breath" is considered to symbolise the unity between two people. It can also be found in some Inuit cultures, though it isn't as prevalent as the cliché of the "Eskimo kiss" would suggest.

Many cultures prefer socially distanced greetings, such as bowing, to symbolise trust and cooperation – and these, too, are ancient. The Indus Valley Scriptures depicted the namaste bow more than 4000 years ago, and bow greetings are still common in countries such as India, Japan and Thailand. In Tibet, people will stick their tongues out of their mouth to show their friendly intentions.

These distanced greetings remain the safest option for anyone who wants to convey good wishes without getting too close and personal. However, some more recently invented greetings might serve as alternatives. There is evidence that the fist bump, which emerged in the 1960s, lowers the risk of transmitting a disease compared with a more formal handshake. Along with the elbow bump, which seems to have originated in the 1980s, it may become much more common now that the covid-19 pandemic has increased our awareness of the disease-transmitting potential of more intimate greetings.

DERICK E. HINGLE-USA TODAY SPORTS/REUTERS

Basketball teams that hug and huddle more tend to perform better

0 to 5. A handshake was rated as 2, a hug was 3 and exchange of saliva in a kiss or "spit shake" scored 5. They found a small but significant correlation between these ratings and the local pathogen prevalence. Where the risk is high, people have evolved distanced greetings that symbolically convey the wish for cooperation and trust, says Murray. Similarly, the researchers found that romantic kissing – previously considered to be universal – was absent from 58 per cent of the societies that had above-average pathogen prevalence. "They balance the costs of physical contact versus the benefits," says Murray.

These findings chime with other research on the "behavioural immune system" – the idea that part of our defence against infection is an evolved tendency to adapt our actions in response to a threat. Studies reveal that the mere thought of disease can influence our attitudes and interactions with others. For example, people are less likely to exhibit extraverted behaviours when they are more conscious of the risk of infection. "Just like physical contact, extended social contact is associated with a higher threat of contracting disease," says Murray.

The behavioural immune system may also explain why we find it especially difficult to avoid hugging or kissing our friends and family. Research indicates that we are primed to assume that people in our "in group" are less likely to transmit diseases to us than outsiders. In our evolutionary past, after all, strangers were more likely to carry pathogens we hadn't encountered before. This means that our intuitive sense of the risk of bodily contact is much lower when we are among friends and family members – even though they are just as likely to be carrying the virus responsible for covid-19 as anybody else. The problem is compounded because these are the people with whom we crave the most physical contact to reaffirm our bonds.

"The threat of disease seems to have influenced the greetings adopted by many cultures"

Given the competition between our behavioural immune system and our desire for physical contact, it is little wonder that many of us – including our leaders and heads of state – have found it hard to navigate the new social norms. Of course, human behaviour is flexible and we are learning fast.

Whether these habits will stick, once the immediate threat is over, remains an open question. "It's something that we'll have to watch in real time," says Murray. But he suspects that they could linger. "Time and time again we see that institutional requirements on behaviours have changed underlying cultural norms," he says. He points out that it is now considered morally objectionable to smoke on a plane or to drive without wearing a seat belt, for example – behaviours that were once widely accepted. Likewise, handshaking and hugging may come to seem as inappropriate as poking someone in the eye or grabbing their buttocks. ▮

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

Mystery of the shifting sands

We are closer than ever to solving the riddle of why sand dunes exist. **David Adam** investigates

THE Israeli city of Ashdod has all the features found in a modern metropolis. Shopping malls, theatres, nightclubs, bars, plenty of good schools. But there is something else, too. Every weekend, at least in normal times, its citizens grab their buckets, spades and quad bikes and head for the city's most unexpected attraction: the biggest urban sandpit in the world.

Ashdod's Big Dune, up to 35 metres high and with the footprint of a dozen football pitches, dominates the city's largely undeveloped neighbourhood 14. One of the last remnants of the region's original coastal landscape, it isn't just a much-loved urban talking point, but also a dramatic example of a long-standing mystery. As bizarre as it sounds, scientists aren't sure how it got there – or indeed why any of the world's sand dunes exist.

On one level the answer to that question is obvious: the wind blows individual sand grains into piles. But exactly how and why dunes form in the way they do still eludes us. Now efforts to get to the bottom of this are taking on a new urgency, and not just because they could solve what Nathalie Vriend at the University of Cambridge explains is a "fundamental physics problem". As more human developments push into desert terrain and parts of the world grow drier due to climate change, the race is on to better predict the paths of shifting sands.

Think of sand dunes and the Sahara desert might spring first to mind, its endless expanse of golden sand in undulations of all shapes and sizes blown by the wind and shape-shifting constantly. There are of course many other dunes to behold – including one patch known as the Seven Coloured Earths in Mauritius, which has tones of red, orange, lilac and more thanks to the underlying geology. Dunes form underwater as well, and can even be found on other planets (see "Space dunes", page 49).

But those seas of differently sized dunes characteristic of the Sahara are especially puzzling. We know from comparing aerial photos that dunes migrate. Small ones travel quickly – up to 100 metres a year – and larger ones more slowly. If the dunes are moving around at different speeds, however, they ought to hit each other occasionally, at which point one of two things could happen. They could exchange material, in which case all the dunes would eventually be the same size. Or they could merge, which would produce bigger and bigger dunes – and ultimately one giant dune. The first big mystery of dunes is why neither of these things happen.

The second is how sand dunes grow to begin with. We see ripples in the sand a few centimetres high and we see small dunes about a metre high, but nothing in between. This leads some to say that dunes have a "forbidden wavelength". It is unclear how ›

The Ibex Dunes in Death Valley, California, are stereotypical shape-shifting, wind-blown golden dunes

ALEX NORIEGA

"Exactly how and why sand dunes form in the way they do eludes us"

dunes overcome it, as they must surely do.

One of the first to look seriously at the way wind-blown sand dunes behaved was a British soldier and geologist called Ralph Bagnold. He learned first-hand about the difficulties sand dunes can present during his years leading expeditions across the deserts of Egypt and Libya in the 1930s. Bagnold was so curious about these mysterious transformations that he ultimately built a plywood wind tunnel in London to watch and photograph how different sized sand grains were blown and bumped along. He derived some of the first equations to explain these interactions. His 1941 book *The Physics of Blown Sand and Desert Dunes* was the go-to text for decades.

Modern sand dune experiments tend to take place on a grander scale, either on beaches or using vast, artificially flattened stretches of desert. Many occur in China, where developers are working to reclaim land from swathes of the inhospitable Taklamakan desert in order to build new homes and communities for its increasing population.

On highways built across Taklamakan dune fields, engineers face a constant battle to stop blowing sand turning this new Silk Road into a silt road. "For the social and economic development of China, they have to find a way to deal with sand dunes," says Clément Narteau, a geophysicist at the Institute of Earth Physics of Paris in France.

The dunes don't give up their secrets easily. In 2007, Narteau, together with Lü Ping at the Chinese Academy of Sciences in Lanzhou, flattened an area the size of 16 football pitches in a remote part of the Tengger desert in Inner Mongolia, China. They wanted to track the very early stages of dune formation to see how they cross the forbidden wavelength. But when the researchers returned three months later to take their first measurements, they were too late. Sitting in the sand was a series of neat and repetitive dunes, each about 1 metre high. As the scientists wrote, no-doubt through gritted teeth, when they reported their results in 2014: "It is clear that the characterization of the early growth phase requires more frequent measurements, particularly at the beginning of the experiment."

There was excitement among dune researchers in 2018, however, when Klaus Kroy at the University of Leipzig in Germany and his colleagues spotted proto-dunes in the forbidden wavelength. It was the first time such formations, about 10 centimetres high, had been seen, and they received a suitably awesome name: megaripples. But megaripples only form in specific circumstances. Instead of being blown into shape, they emerge when larger sand grains roll off a dune and hit and disturb a surrounding smooth surface. So the broader mystery remained.

Meanwhile, the bulldozers had started up again in China. In 2013, Ping and Narteau's team flattened a smaller, 100 metres by 100 metres area of the Tengger desert. This time, they watched carefully from the start. "We used a laser scanner and we took many more topological measurements," says Narteau. He says these new results "completely solve the

ROOM THE AGENCY/ALAMY

KAROL BACIK/UNIVERSITY OF CAMBRIDGE

Top to bottom: the Seven Coloured Earths dunes in Mauritius; the sand dune racetrack at the University of Cambridge, which is used to study the underlying physics of these features

Space dunes

Saturn's largest moon Titan could almost be an idyllic holiday spot. It is the only other place in the solar system to have liquid lakes on its surface and it has huge unspoilt ranges of sand dunes. Granted, the lakes are filled with liquid methane and the dunes are made from frozen hydrocarbons. But, strictly speaking, "sand" refers to any particle between 0.06 and 2 millimetres across.

Dunes made of exotic materials actually appear across the solar system and observing them helps us assess the local environment. "As long as the physics is the same then the same laws should apply, whatever the grains are made of, whatever the gravity or what the atmosphere is like," says Serina Diniega, a planetary scientist at NASA's Jet Propulsion Lab in California.

Take Pluto, which we learned in 2018 also has dunes on its surface. This barren world has such a tenuous atmosphere that you wouldn't expect there to be any wind-blown features. The fact that there are suggests that the frozen nitrogen on Pluto's surface can sublime into a gas, creating gusts powerful enough to shape dunes.

We have even spotted dunes on the comet 67P/Churyumov-Gerasimenko, which is too small to support a whiff of an atmosphere.

To widespread astonishment, the European Space Agency's Rosetta probe photographed dune-like features on the surface in 2014. Vapour that escaped from the comet's interior perhaps blew sand particles along the exterior and into the distinctive ridges, driven by the strong thermal gradient between cold parts of the comet that are in shade and those warmed by sunlight.

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problem" of how dunes cross the forbidden wavelength, but they are still finalising the details to submit them to a scientific journal.

Those tantalising findings could cap a productive few months for sand scientists. Earlier this year, Vriend's team took a stride towards answering that other mystery of why sand dunes of different sizes can coexist. They did this by building a "dune racetrack", a ring-shaped tank in which miniature sand dunes can move. Rather than wait months and years for the dunes to shift with the wind, the researchers accelerated things by using pumped water to move the sand. The physics, Vriend says, is mostly the same.

The team found that dunes communicate with each other. When in the real world an upstream dune deflects air, it generates turbulent swirls that push a downstream dune away, even if it is larger and slower. "The front dune gets a kick from the back dune," says Vriend. This finally explains why dunes don't coalesce.

It is becoming increasingly important to understand such dynamics, Vriend says. "Dunes are becoming more and more prominent because of desertification and drying of our world."

In places like Morocco, rivers have dried up and exposed sandy sediment that is now blowing onto what was previously rich farmland. Towns and cities across the Sahel region of Africa, including Nouakchott, the capital of Mauritania, frequently have to dig buildings and roads out from encroaching dunes. "We really need to know how dunes move and how they behave to see if we can influence that behaviour," says Vriend.

Building walls won't do it. "That's the worst thing you can do," says Vriend. As the wind blows over the wall it creates a low-pressure wake that allows sand to deposit there. "So you end up with the object you're trying to protect actually being swamped with sand," she says. The best option is to model where dunes will go next and so make better decisions about where to build, or plant vegetation to stabilise a dune. Failing that, dunes may just have to be removed.

The shifting of dunes is a problem that city planners in Ashdod are wrestling with. The Big Dune is creeping towards built-up areas at up to 3 metres a year. "Having a dune in the middle of the town is a big problem," says Haim Tsoar, a geologist at Ben-Gurion University of the Negev, Israel. If they cannot find a way to manage the dune, eventually Tsoar wants bulldozers to move in and destroy it. Already the trampling of feet and grinding of quad bike tyres have denuded the sand of vegetation and ecological value, he points out. Without action, the Big Dune will overwhelm an area of new development known as the special neighbourhood.

Tsoar estimates it will be about 50 years before it reaches this part of the city and starts to engulf it. That leaves time to try to exploit new scientific insights and find an elegant solution to the shifting sands. ■

David Adam is a science writer based in Hertford, UK. His most recent book is *The Genius Within* (Picador)

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Stargazing at home

See new suns being born

In November, you should be able to use your eyes to spot a place where stars are still forming, says **Abigail Beall**

Abigail Beall is a science writer in Leeds, UK. She is the author of *The Art of Urban Astronomy* @abbybeall

What you need

Binoculars
A stargazing app, such as SkyView Lite

SPACE is full of clouds of dust and gas called nebulae. Some are the aftermath of a supernova, when a giant star has gone through the explosive end of its life. Others, like the Orion Nebula, represent the opposite end of the stellar life cycle: they are cosmic nurseries in which stars are being born.

The Orion Nebula, or M42, is visible from most parts of the world from November to February, which is when the constellation of Orion (pictured) is in the night sky. To first locate this constellation, look for the three stars in a row that make up its well-known belt.

These sit between the bright, red-coloured star Betelgeuse and the blue star Rigel, Orion's brightest member. But do remember: their position in the sky changes depending on where you are.

Take a closer look at Orion's belt and you will see a line of stars that appears to be falling down from it, known as Orion's sword. The nebula can be found halfway down this "sword".

From the UK, the constellation rises at about 9 pm GMT at the moment, getting earlier as the days pass. It remains visible until dawn. If your skies are dark enough, and there is no moonlight, you can see the nebula with the naked eye. However, on a clear night, even a fairly standard pair of binoculars will give you a much more detailed view.

Nebulae like Orion form stars when gravity forces the material inside them together. To witness the next stage of stellar evolution, we can look for a star cluster, which is a group of young stars sitting close together.

DREW BUCKLEY/ALAMY

One of the most recognisable of these clusters is the Pleiades. It can be seen with the naked eye. In fact, computer simulations have shown that this cluster probably started out looking like the Orion Nebula. The Pleiades can be found near Orion in the night sky, in the constellation of Taurus.

To locate it, just follow these steps. From Orion's belt, draw an imaginary line from left to right in the northern hemisphere, or right to left in the southern hemisphere. Extending this with your eyes through Orion's bow, you will see a bright star that is close to the line.

This is Aldebaran, which is the brightest star in Taurus. (Look in the wrong direction and you will just find Sirius, the brightest star in the night sky.) Once you have found Aldebaran, just keep going and you should spot a small cluster of five bright stars together. You have reached the Pleiades.

And don't forget, you can easily confirm what you have identified using a stargazing app. Although five of the stars in the Pleiades cluster stand out clearly, it is possible to see up to 14 of them with the naked eye when you are watching the sky in areas with no light pollution.

Grab some binoculars and you will see a whole lot more, though you would be pushed to see all of the 3000 stars in the cluster. ▮

Stargazing at home appears every four weeks

Next week

Citizen science

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

Cryptic crossword #44 *Set by Wingding*

Scribble zone

Answers and the next quick crossword next week

ACROSS

1 Hypochondriac aims to disguise health food (4)
3 Birds nibbled by snake at first, having eaten grain of rice (8)
8 Electric car stopped abruptly in front of journalist and became fitter (7)
10 Home where extreme disease goes after every blood type (5)
11 Time limits with little potential to kill (10)
14 Clinical study recruits bachelor with strong in-group bias (6)
15 Dog injected with adenine beginning to evolve and undergo genetic change (6)
17 Trick our subject to show sense of morality (10)
20/23 Academic leader in Dominica developed protein component (5,4)
21 One location heartlessly rejected catches fire (7)
22 Rabbit and that man, according to Spooner, are sweet food producer (8)
23 See 20 Across

DOWN

1 Neat code deciphered, a weak form of evidence (8)
2 An idealist extracting nitrogen from benzene derivative? (8)
4 I eat under Jupiter's moon (6)
5 Type of fat, an energy source, as medical treatment (11)
6 Cover sample of kangaroo faeces (4)
7 Observe and briefly describe embryonic plant (4)
9 Goon vocally bashed geophysical research (11)
12 Attractive short guy with hereditary lack of energy (8)
13 Late last month, relaxed (8)
16 Have high hopes for snake with passion (6)
18 Key cannabis product (4)
19 Almost destroy new oven (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #77

1 Amenorrhea is the absence of what?

2 In forest ecology, what is a snag?

3 Barium chloride is used in fireworks to produce which colour?

4 Which is the smallest of the Galilean moons of Jupiter?

5 Neuroscientist Giulio Tononi first proposed which mathematical theory of consciousness in 2004?

Answers on page 55

Puzzle
set by Peter Winkler
#85 Chopping Board

The Board of Overseers of the Bottlecap Preservation Society has grown to an unwieldy 10 members, who have agreed to the following procedure.

The board will take a series of votes on whether to reduce its size. A majority of "ayes" results in the immediate ejection of the newest board member. Then another vote is taken, and so on.

If at any point, half or more of the surviving members vote "nay", the session ends and the board is fixed at that level.

Of course, each member's highest priority is to remain on the board, but given that, everyone agrees that the smaller the board, the better.

If logic prevails, how big will the board be when the voting comes to an end?

Answer next week

SCIENCE PROVES LONELINESS IS A KILLER?
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Frizzy issue

I straighten my hair and my friend curls hers with a heated hair wand. Humidity, sweat or washing instantly reverses the process. My wavy hair goes frizzy in humidity, but her straight hair doesn't. What is happening?

Barry Stevens
The Trichological Society, London, UK
Human hairs are hygroscopic, meaning they absorb atmospheric moisture. Stretching wet hair shafts during a drying process sets them into a desired configuration, be that straight or curly. This is fundamental to hairstyling.

It is a temporary structural change though, only remaining until moisture is absorbed, whereupon the hair shafts return to their natural state. Certain hair types are more prone to this, such as those with frizzy, finely structured hair shafts. Hair that has undergone thermal or chemical processing, such as relaxing, permanent waving, bleaching or tinting, is also more prone. These processes compromise the structure of each hair's outer protective layer, or cuticle, exacerbating permeability and moisture absorption.

JENNY DETTRICK/GETTY IMAGES

This week's new questions

Seeing small **What is the smallest animal with eyes and could it see a molecule?** ***George Illingworth (age 8)****, Louth, Lincolnshire, UK*

Now is the time **Buddhists recommend living in the present moment. How long is this gap between the past and the future?** ***Derek Johnson****, Moreton-in-Marsh, Gloucestershire, UK*

Shedding tears

What is the biological advantage of crying when emotional?

Ad Vingerhoets
Tilburg University, The Netherlands
Tearful human emotional crying evolved from the separation calls or distress vocalisations made by the offspring of all mammals and several bird species when they are separated from their mother.

Crying in animals is mainly limited to vocal activity and to infancy, but humans continue to produce emotional tears for their whole lifespan. When children grow older, the importance of the auditory component diminishes, whereas the visible element – the tears – gains prominence.

Human crying can be triggered by many things. Lovesickness, helplessness and grief are significant antecedents throughout life. Other triggers change with age, reflecting changes in emotional, cognitive and social development. For example, physical pain and discomfort are often triggers for infants and toddlers, but tend to lose their importance after late adolescence. On the other hand, empathic crying, which occurs in response to the suffering of others, increases with age. A similar pattern is seen for tears triggered by extraordinarily positive or moving situations.

Tears help observers recognise the need to provide support and comfort. They are an evolved adaptation that promotes helping behaviour in others by inducing feelings of empathy and social connectedness.

> **"Crying in response to the suffering of others increases with age, as do tears triggered by extraordinarily moving situations"**

Barbara Finlay
Cornell University, New York, US
Members of social species benefit in many ways by communicating their internal states to each other. Recognition of need, and consequent protection and provisioning of weaker or younger individuals, has been observed in various primates, meerkats, whales and elephants outside immediate parental bonds.

Humans, though, are "hypersocial" and routinely help injured or ill group members, independent of age or relatedness. Even the subjective experience of pain and the performance of "sickness" behaviour may be amplified in humans in situations like childbirth or viral infection, compared with other less social species. The descendants of those who complained effectively and received help are more likely to be with us than those of the stoic!

But how do humans recognise cries for help? In the absence of obvious physical damage, what are the main ways of communicating pain and distress? Mammals normally produce tears due to chemical or physical irritation, but humans also produce emotional tears. These are part of a suite of physical changes in humans employed for communication.

Together, these changes extend the avenues available to communicate our internal states and emotions. For example, studies show that the addition of tears to faces previously described as sad made them seem sadder, acting as an intensifier.

Of the many instruments of the orchestra of expression, tears come in at moments of high intensity, pulling the observer in more strongly.

Michael Trimble
University College London, UK
Homo sapiens are the only living species to cry as an emotional expression. The development of the capacity to cry in our hominid ancestors depended on many biological adaptations. These include the development of the facial muscles – especially around the eyes and mouth – and the size and connectivity of the brain that allowed the development of "theory of mind": the ability to recognise the behaviour

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Tom Gauld
for New Scientist

and feelings of another person. The brain had such adaptive connectivity to draw together areas concerned with memory, language (including the language of music intonation), theory of mind and the nerve centres that lead to the release of tears.

Tears evoke prosocial behaviours and enhance bonding. Nowhere is this seen better than between a mother and infant.

Ada Mournian
Wellington, Somerset, UK
At a fundamental level, crying is an excretory process. It is one of the ways the body self-soothes (though it may not feel like that initially) by the release of the hormones oxytocin and various endorphins.

What the body is getting rid of is an interesting part of the answer. It could be stress hormones or other "feelings" such as fear. Manual therapists have reported patients who cry, often profusely, when their network of connective tissue, or fascial system, is manipulated. This may sound a bit "woo-woo", but I experienced the release of fear trapped in my body for over 20 years when scar tissue from an operation was massaged. The feeling rushed up my spine and resulted in a flood of tears. The release provided recognition of an emotion that I hadn't consciously known about previously.

"I still remember the reaction in the supermarket when I bought their entire stock of ketchup for my experiments"

Small torque

How do food packaging companies decide how tight to make the lids on jars? Has this increased over time or am I just getting older? (continued)

Alistair Borthwick
Vancouver, Canada
Regarding the difficulty of cap removal, it may be possible to obtain an empirical answer. About 50 years ago, while working for an engineering consulting firm, I was asked to determine the average torque needed to remove the cap from a bottle of ketchup, an assignment resulting from a lawsuit involving attempted cap removal, a broken glass bottle and a severely injured hand.

I still remember the reaction in the supermarket when I bought their entire stock of ketchup, and the thanks my co-workers expressed when the experimental materials were later distributed.

Mike Vandeman
Berkeley, California, US
I feel compelled to respond to the two most recent suggestions from readers for opening a difficult jar lid. I have tried both methods – tapping the side of the lid on the counter and placing the lid under a very hot tap – and these aren't the most effective techniques.

What works every time is to carefully use a knife blade or flat screwdriver to push the lid up while pushing down against the top thread of the glass jar. ▮

Answers

Quick quiz #77
Answers

1 Menstruation

2 A standing tree that is either dead or dying

3 Green

4 Europa

5 Integrated information theory

Quick Crossword #70 *Answers*

ACROSS 1 Dark web, **5** Railway, **9** Facet, **10** Occlusion, **11** Sea urchin, **12** Ridge, **13** Ague, **15** Lead-free, **18** Tertiary, **19** Neon, **22** Canon, **24** Number one, **26** Red Planet, **27** Ilium, **28** Breadth, **29** Yucatan

DOWN 1 Defuse, **2** Rectangle, **3** Water, **4** Biophilia, **5** Ricin, **6** Ibuprofen, **7** Weird, **8** Yankee, **14** Entangled, **16** Asymmetry, **17** Ecologist, **20** Scarab, **21** German, **23** Nudge, **24** Ninth, **25** ENIAC

#84 Squarebot
Solution

Since Squarebot was kind enough to draw its shape on squared paper, we can assume that the dimensions are integers. So we might ask "What is the square of the height?" and Squarebot will give an exact answer. Unfortunately, if Squarebot says 289, the shape could be a 17x17 square or a 17x18 rectangle, for example. We need to ask a question to which the answer for a square would be 0, such as "what is the difference between its height and its width?" If it isn't a square, Squarebot would give an answer of at least 1.

Box of delights

Feedback isn't yet on TikTok, but we can only assume our bite-size attempts at what passes for humour would go down a storm on the social media platform for the hard of attention, if only we could work out how to open the box.

Actually, opening the box is apparently a thing on TikTok, at least if a PR puff shoved under our door by a colleague with a bemused mien is anything to go by.

"One of social media's biggest trends is a simple phenomenon known as 'unboxing' whereby influencers present packaged products before carefully unpacking them via meticulously crafted videos," it trills. This provides businesses with "endless opportunities for their brand's packaging to be showcased to a potential audience of millions".

The science bit is apparently combining unboxing with the craze for gentle whispering videos designed to elicit the brain-tingling "autonomous sensory meridian response", or ASMR. Feedback remembers reading about ASMR in these very pages (3 November 2018, p 35). Many fruitless hours of trying to induce a "brain orgasm" by watching videos of people folding towels followed.

But here we have an iteration. "The idea of combining the relaxation of ASMR and the satisfying feeling of seeing a product being unpacked from its packaging sounds like – and looks to be – a recipe for success," our source continues.

We unsuccessfully resist the urge to be reminded of our literary hero and muse, the old grey donkey Eeyore, when he was presented with a burst balloon and a Useful Pot on his birthday following a series of implausible accidents only possible when you live in a rather boggy and sad place. "Eeyore wasn't listening. He was taking the balloon out, and putting it back again, as happy as could be..."

Feedback's stationery cupboard isn't boggy, at least, and it does provide ample material to join in the new craze. Expect our TikTok debut soon, sensuously unpacking A4 padded envelopes and removing ink cartridges from their boxes. If you are lucky, we may pop some bubble wrap for you, too.

Twisteddoodles *for New Scientist*

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

Pushing pencils

Talking stationery, an alarming sign has been spotted in the Derwent Pencil Museum in Keswick, UK: "14,000,000,000 pencils are made every year and these would be able to circumnavigate the world 62 times." Our correspondent is right to say many questions spring to mind, such as "In what?" and "Who, or what, stopped them?".

Barring a hastily arranged defensive shield of sharpeners to arrest the march of the pencils, we suspect they simply got worn down over time. But licking the end of our pencil with more than usual circumspection, we do some quick calculations of our own on the back of an envelope (A5, non-padded). If the width of a pencil is 5 millimetres, and Earth's circumference 40,000 kilometres, then 14 billion pencils circumnavigating the world upright in lockstep would form a front that would circum... errrm... scribe? the world one and three-quarter times. True fact.

For that one, our thanks to Jane, whose pencil was presumably up and out the door to see the world with a handkerchief tied around its end before she could write her surname.

Catch 'em if you can

Carl Zetie writes in pointing to the website of Neutrino Energy, which he uncharitably, if perhaps not entirely wrongly, describes as the "fruitloopiest website of the year", a possibly unique collaboration of German precision engineering and Brahma Kumaris World Spiritual University that promises to solve the climate crisis and break our dependence on fossil fuels by generating energy from the "trillions of neutrinos wastefully sleeting through our planet every second", as Carl puts it.

"Stop. Think. Reflect.", the website urges. Alright then. Regular readers of this magazine will have noted that mention of the word "neutrino" within these pages rarely comes without the attendant adjectives "ghostly" or "elusive". Our current attempts to capture their essence come largely in the form of vast detectors that represent a significant net burden on the global energy system, not that Feedback is complaining.

That suggests an ambition in Neutrino Energy that, while noble, may be overreaching, a suspicion not diminished by the company also promising "immortal awareness, victory over death, and new non violent technological attainments" and a new age of "shared mental, intellectual & material abundance".

"Many groups worldwide are working quietly to harness this energy source," the site assures. This is certainly the loudest assertion of the viability of neutrino power that we have seen.

While we don't discount the possibility that somewhere up there, some civilisation may have mastered the dark arts of neutrino capture, we are forced to the conclusion that it isn't yet one for us. Best stick to photons for the moment: there are more of them, and we know where they are.

Because you insist...

Too many of you have now drawn our attention to Digby Growns, senior plant breeder at the Botanic Gardens and Parks Authority in Perth, Western Australia. Over and out. ▮

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