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WEEKLY May 1-7, 2021

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The world's ageing population means that in some parts of the globe - including much of the Western world - the population aged 75+ is set to almost triple in the next 30 years.

Older people face not only the acute threat of COVID-19, but also the burden of chronic diseases including Alzheimers and diabetes.

At the same time the health of older people is one of the most underfunded and poorly resourced areas of research.

So, to stimulate fresh efforts to tackle the problems of old age, we're offering a NZ\$250,000 (£130,000) annual prize for the world's best discovery, development, advance or achievement that enhances quality of life for older people.

The Ryman Prize is awarded each year by the Prime Minister of New Zealand. It was first awarded in 2015 to Gabi Hollows, co-founder of the Hollows Foundation, for her tireless work to restore sight for millions of older people in the developing world.

Since then world-leading researchers Professor Henry Brodaty, Professor Peter St George-Hyslop, Professor Takanori Shibata and Dr Michael Fehlings have all won the prize for their outstanding work.

In 2020 Professor Miia Kivipelto, a Finnish researcher whose research into the causes of Alzheimers and dementia has had a worldwide impact, was awarded the prize by the Right Honourable, Jacinda Ardern, Prime Minister of New Zealand.

If you have a great idea or have achieved something remarkable like Miia and our five other prize winners, we would love to hear from you.

Entries for the 2021 Ryman Prize close at 5pm on Friday, July 16, 2021 (New Zealand time).

Go to rymanprize.com for more information.



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The first stars

We know precious little about the first billion years of the universe's life. Back then, a generation of stars shone that were hundreds of times bigger and a million times brighter than the sun. In this talk, Emma Chapman explains how we are beginning to get to know these lonely giants. Join us on 22 July at 6pm BST or watch on demand. Tickets available now.

[newscientist.com/events](https://www.newscientist.com/events)

Podcasts

Weekly

New Scientist Weekly was named podcast of the year at the Publisher Podcast Awards 2021. In the latest episode, to mark Earth Day, we assembled a special panel to discuss two tightly linked runaway crises that will make each other's effects worse: biodiversity loss and climate change.



Escape Pod

This week, the team escape everyday life and explore things unseen: from how bats echolocate to invisibility cloaks. This episode is the last in season one. You can stream the entire back catalogue for free online.

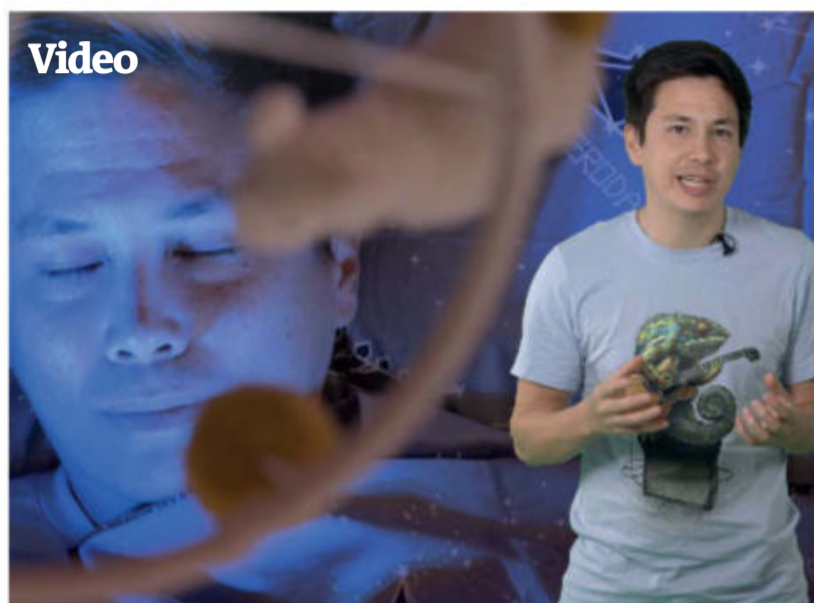
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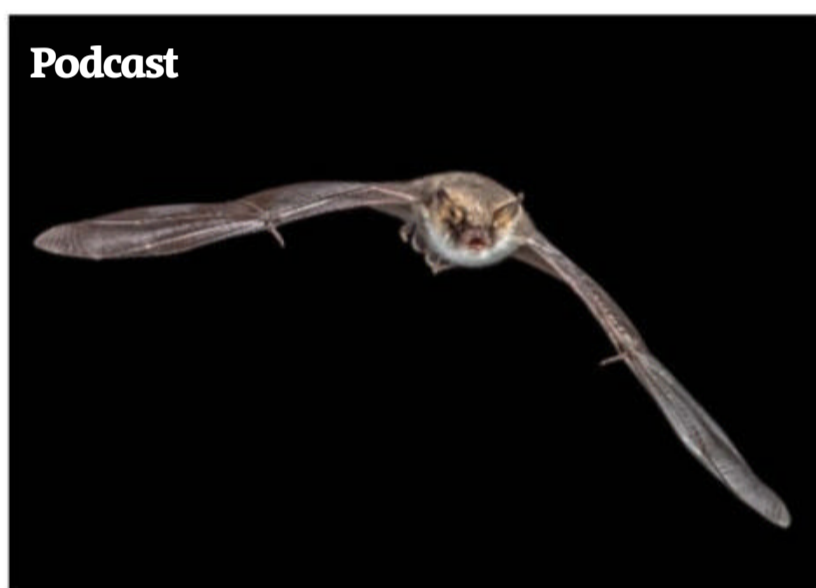
Parental Guidance

A twice-monthly dive into evidence-based parenting. This week, Catherine de Lange looks at babies born in the pandemic and what we know about its effects on them.

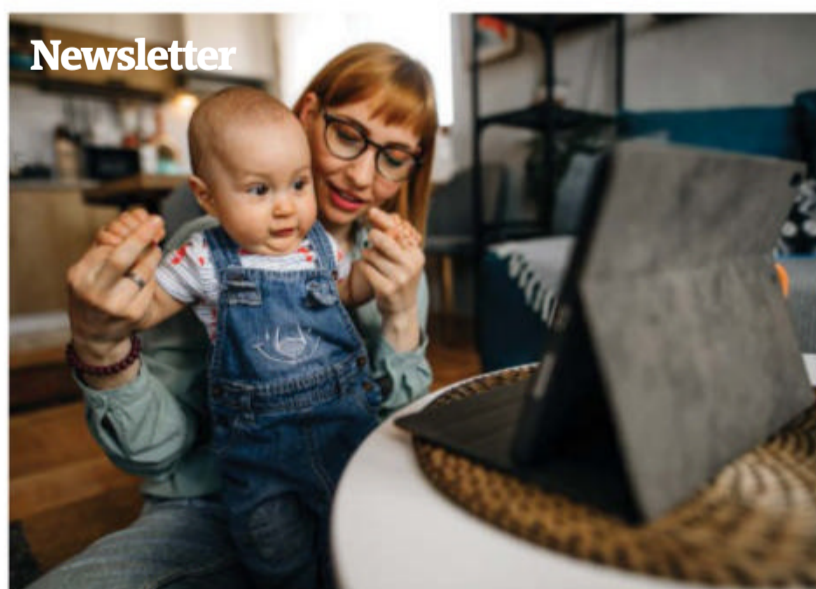
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Nodding off Sam Wong explains what happens when we sleep



Stealth hunter Bats use inaudible chirps to echolocate their prey



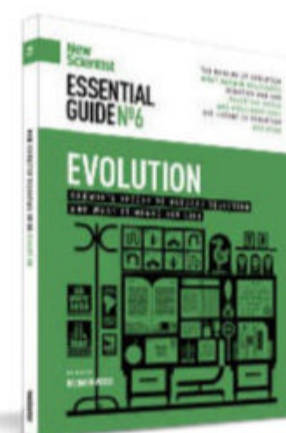
Children of our time How has the pandemic affected babies?

Video

Science with Sam

Our acclaimed video explainers return for a second season, starting this week. In the first episode, Sam looks at sleep. What really happens during your unconscious hours and how can you make the most of them? Subscribe to our YouTube channel to catch all the upcoming videos, covering everything from aliens to ASMR.

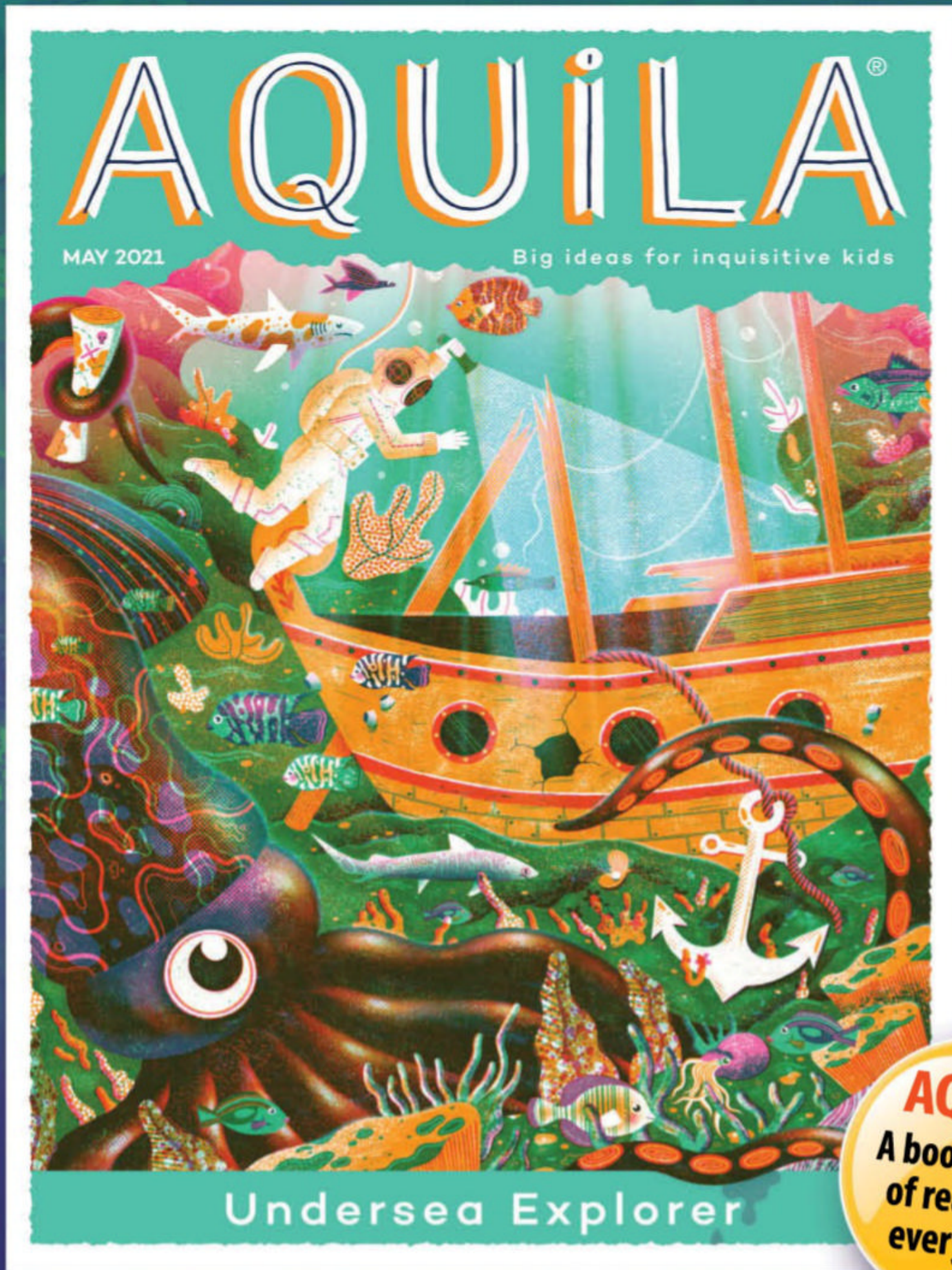
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India's crisis deepens

The unfolding tragedy should be a warning against covid-19 complacency

THE covid-19 situation in India is terrible and is likely to get worse. The country has set one new record after another for the most daily coronavirus cases reported in any country. Just as the world was hoping the worst of the pandemic was over, we are seeing its biggest outbreak.

Why is this happening now? The short answer, as with so many key questions about the pandemic, is that no one knows for sure (see page 7).

On paper, India's outbreak isn't that exceptional. It is reporting around 200 daily cases and two deaths per million people, which is similar to the current situations in the US, Germany and Canada. In January, the UK was reporting nearly 900 cases and 18 deaths per million people.

However, while the official figures in every country underestimate the true

number of infections, the gap is likely to be greater in India. The number of daily cases could be closer to 10 million than the reported 350,000, while media reports suggest the death toll is at least 10 times higher than the government data.

What's more, India has just two critical care beds per 100,000 people, compared

"Politicians failed to grasp what happens when exponential growth goes unchecked"

with 34 in the US. Its healthcare system has been overwhelmed.

The big mystery is actually why India avoided a second wave for so long. Just two months ago it seemed to have the virus under control.

There is no shortage of proposed

explanations for the current surge: dangerous new variants; a relaxation of restrictions; people taking less care; mass political rallies and religious festivals; and fading immunity from the first wave. A mismanaged vaccination programme also means that less than 9 per cent of the population has received at least one dose. All these factors may be contributing. Many were avoidable.

The alarm should have been sounded when case numbers began climbing in February and March. Instead, just as in the UK, politicians seem to have failed to grasp what happens when exponential growth goes unchecked.

As the country looks for help from outside, the crisis should be a stark warning to us all of just how quickly a seemingly good situation can change. ■

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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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Distributed by Time Inc. Retail, a division of Meredith Corporation, 6 Upper Pond Road, Parsippany, NJ 07054

Syndication Tribune Content Agency

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Post New Scientist, PO Box 3806,

Chesterfield MO 63006-9953

© 2021 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

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Coronavirus surge

India at breaking point

A lack of oxygen supplies for covid-19 patients is a national crisis as India hits record case numbers, reports **Puja Changoiwala**

“OXYGEN Express” trains are rerouting supplies across India to meet a severe shortage of medical-grade oxygen, as the country’s new coronavirus cases hit record peaks for six days in a row.

At Dr Zakir Hussain Hospital in Maharashtra, 24 people with covid-19 died due to disruptions in oxygen supply on 21 April. Many such deaths continue to be reported across the country.

“So many people, including my grandmother, died before my eyes,” says Vicky Jadhav, whose grandmother was at the hospital in Maharashtra. “I tried to revive her after borrowing an oxygen cylinder from a dead patient. But she did not live. I tried to do that for other patients too, but none of them survived. Many of those dead were young.”

India reported 352,991 new

coronavirus cases and 2812 deaths on 25 April. As a result of the surge in cases, the demand for medical-grade oxygen to support people in intensive care has jumped by 600 per cent in recent days. Many hospitals have had to turn patients away. Family members of those who are ill have taken to social media to plead for help, and there have been reports of “looting” of oxygen cylinders as they enter hospital grounds.

“Beg, borrow or steal. It is a national emergency,” justices from the High Court of Delhi told government officials at a court hearing on 21 April.

India has failed to learn lessons from its first wave of the

pandemic, when shortages of various essentials were reported, says Anant Bhan, a global health, policy and bioethics researcher at Kasturba Medical College in Karnataka, India. In August 2020, the World Health Organization created a forecasting tool to help countries predict their needs for essential supplies. “Our under-preparation has been exposed,” says Bhan.

In contrast to many other nations, India had only experienced one distinct wave of covid-19 infections by February 2021, with researchers hypothesising that a large percentage of the population may have already reached herd

Oxygen cylinders are delivered to Jaipur Golden Hospital in Delhi, India

immunity. Others suggested that India’s relatively young population – half are under the age of 25 – could mean fewer people are experiencing severe symptoms of covid-19, the risk of which increases with age.

It isn’t clear what is driving India’s delayed second wave, but it may be due to the appearance of the more transmissible B.1.1.7

“India has failed to learn lessons from its first wave of the pandemic, when shortages were reported”

variant from the UK, which is causing around 40 per cent of cases in Asia. Another 16 per cent of cases are due to the B.1.351 variant that evolved in South Africa, which can partly evade immunity from past infections or existing vaccines.

In response to the crisis, Indian Railways has created the Oxygen Express to distribute oxygen supplies around the country. Other countries have also sent aid: 23 mobile oxygen-generation plants from Germany, 10,000 oxygen concentrators from the US, high-capacity oxygen tankers from Singapore and ventilators from the UK and Europe. The US has also overturned an export embargo that ensured raw materials for vaccines were prioritised for its own population before being sent abroad, in order to send resources to India to help produce more vaccines.

Several obstacles remain, says K. Srinath Reddy, president of the Public Health Foundation of India. How quickly the problem can be overcome depends on how fast oxygen tankers can be moved across the country, and how much oxygen can be produced locally, he says. Meanwhile, only 8.5 per cent of the population has received at least one dose of vaccine. “We turned our backs on the virus,” says Reddy, “but the virus did not turn its back on us.” ■



Daily coronavirus news round-up

Online every weekday at 6pm BST

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

Respiratory infections

Children's immunity at risk

Young children who have spent much of their lives under coronavirus restrictions now seem more vulnerable to a number of other conditions, finds **Donna Lu**

THE coronavirus pandemic has left children vulnerable to other infections, in part due to reduced interactions as a result of lockdowns and social distancing.

In Australia, which has largely been covid-free for the past six months, there has been a delayed surge in cases of respiratory syncytial virus (RSV), a common, flu-like illness that causes a lung infection called bronchiolitis and often has the most serious effects in children under the age of 2.

RSV infections typically peak in winter, but in 2020, the RSV season in Australia was curtailed by covid-19 stay-at-home orders and public health measures.

In Western Australia, a recent analysis of hospital presentations shows that RSV cases dropped by 98 per cent during the winter months of 2020 compared with the same period in previous years, but began to surge in spring, in late September, eventually exceeding the median seasonal peak from 2012 to 2019 (*Clinical Infectious Diseases*, doi.org/f8s5).

Daniel Yeoh, an infectious diseases clinician at Perth Children's Hospital who co-authored the analysis, estimates that the proportion of children in hospital who tested positive for RSV jumped from less than 1 per cent in April 2020 to 70 per cent in the summer months.

Other Australian states have seen similar trends, most recently Victoria, which only recently relaxed mask-wearing rules.

"You've got a larger group of children who've never seen RSV before in their life, 18 months and below, and then older children who may have seen RSV 18 months ago but their immunity from that particular encounter with RSV might have waned," says Yeoh.

As northern hemisphere countries ease their lockdowns,



Wearing face coverings in schools could help avoid a spike of other infections

98%
Year-on-year reduction of respiratory syncytial virus (RSV) cases during Australia's winter

3 months
Delay in French peak RSV season

0-6 years
Key age for the development of a child's immune system

there is a risk they could also see surges in RSV, he says.

There are already signs of similar trends in other countries. An analysis of French data on RSV diagnoses in winter, which hasn't yet been peer reviewed, has found a delayed peak in the 2020-21 season. The epidemic began in February this year, 12 weeks later than in the previous five RSV seasons, in the Île-de-France region, which includes Paris, before spreading to other regions.

In the US, a study published in December used RSV cases from 2020 to model the impact of social distancing measures on the spread of other circulating infections. It concluded that "substantial outbreaks of RSV may occur in future years, with peak outbreaks likely occurring in the winter of 2021-2022" (*PNAS*, doi.org/gh9zv8).

Paediatric services in the northern hemisphere should be adequately staffed in preparation

for a potential surge, says Yeoh. While there is no vaccine available for RSV, monoclonal antibodies are used as a prophylactic treatment for high-risk children, including those who have heart conditions or were born prematurely.

"Based on the reports from Australia, services in the UK will be watching their numbers very closely with a view to maybe starting that sort of antibody preventative treatment for those high-risk babies, even though it's not the RSV season for them, if they do see a rise in their summertime," says Yeoh.

A gradual reduction in public health measures, instead of an instant return to pre-pandemic levels of social interaction, may mitigate the surge in countries with a high burden of covid-19.

A delayed surge in influenza infections may also be on the cards in future years, says Byram Bridle at the University of Guelph in Canada.



Yeoh advises that parents should continue to implement measures such as keeping sick children home from school and maintaining good cough etiquette and handwashing habits. “Those things can go some way to limit the spread of other respiratory viruses like RSV and flu,” he says.

Mystery solved

As for susceptibility to other pathogens, it is too soon to tell, says Yeoh. “In terms of immunity in general, there are a whole range of pathogens that children encounter in their first couple of years of life,” says Yeoh. “I think we probably don’t know enough to say for certain how reduced social interactions because of covid will affect the development of immunity to all those pathogens.”

What we do know, however, is that children don’t tend to get severe covid-19. This has been a key mystery of the pandemic, but more than a year on from its start, several possible reasons for this have emerged.

Statistics compiled in April by the American Academy of Pediatrics found that children represented about 14 per cent of the total covid-19 cases in the US, but less than about 3 per cent of reported hospitalisations. And a March analysis of child mortality in seven countries, including the UK, France and Italy, found that covid-19 accounted for 0.48 per cent of all deaths in children and adolescents up to the age of 19.

Other respiratory infections such as influenza often have the most severe impacts on very young and very old people, in a U-shaped distribution, says Amy Chung at the University of Melbourne in Australia. “We see a very different kind of trend in kids [for covid-19],” says Chung.

Studies of household transmission in different countries point to children being less susceptible to getting the virus than adults.

The virus enters host cells by binding to ACE2 receptors and several studies have found that children have fewer of these in the cells lining their upper airway.

“If there’s less of that receptor available on the surface of a cell, then it means that it’s a little bit

harder for SARS-CoV-2 to come in and infect them,” says Chung.

For children who are infected with the virus, there seems to be no difference in the amount of it they carry compared with adults, but there are differences in their immune response.

In general, children tend to have a more active innate immune system than adults, says Melanie Neeland at the Murdoch Children’s Research Institute in Australia.

The innate immune system is the body’s first line of defence. It rapidly responds to infectious viruses, and also primes cells of the adaptive immune system to produce antibodies targeted to attack a pathogen.

Neeland and her colleagues have monitored children and adults with mild covid-19, finding that in the acute phase of infection, children had greater activation of immune cells called neutrophils. “Neutrophils mop up infection and they secrete a lot of proteins that kill virally infected cells,” she says.

Another difference was that children had lower levels of other innate immune cells in

Asthma and allergies

It is too early to know for certain, but extended coronavirus lockdowns could have a long-term effect on the development of children’s immune systems, affecting allergic responses.

The majority of the components of the immune system go through a process of maturation between birth and the age of 6.

“Immune systems learn to regulate themselves during these early years,” says Byram Bridle at the University of Guelph in Canada. Regular exposure to the natural environment and a variety of microbes enables immune systems to learn to differentiate between things that are foreign but not dangerous and foreign

Hugging pets, and family members, can help the immune system mature



HELEN BENJANS

things that are pathogenic.

A failure to properly differentiate between the two may result in hypersensitivities including allergies and asthma.

Bridle suspects that for “covid kids” – children who have spent a significant proportion of their life under lockdown – there may be a higher eventual incidence of such allergies, asthma and autoimmune diseases.

Until covid-19 restrictions ease and pre-pandemic interactions resume, what can concerned parents of young children do?

“People should be very much encouraged to stay in close physical contact within the confines of their homes, especially if they have young children,” says Bridle.

“Hug them very regularly,” he says. “Sharing your microbes with your very young child is going to help with this development of their immune system.”

Even though the most beneficial interactions are with other human microbiomes, the presence of household pets is also a boon.

“When people have an opportunity, try and get out in the natural environment,” adds Bridle.

“Older people may be disadvantaged by their past exposure to other coronaviruses”

the blood. “This suggests to us that they were migrating away from the blood into the tissue, so that they could clear the virus more quickly,” says Neeland.

There are also key differences in adaptive immunity, which learns from past infections. Chung and her team have found that children mount less experienced but more effective antibody responses against the coronavirus. Older people may be disadvantaged by their past exposure to other common coronaviruses, those that cause the common cold.

“They preferentially induce antibody responses that are relevant for the common cold viruses, but aren’t actually very important for protection from covid-19,” says Chung.

Children, who have fewer past exposures to other coronaviruses, are better able to induce immune responses that specifically target the covid-19 virus, she says. ■

Correlates of protection

We'll soon be able to tell whether you are immune to covid-19

Graham Lawton

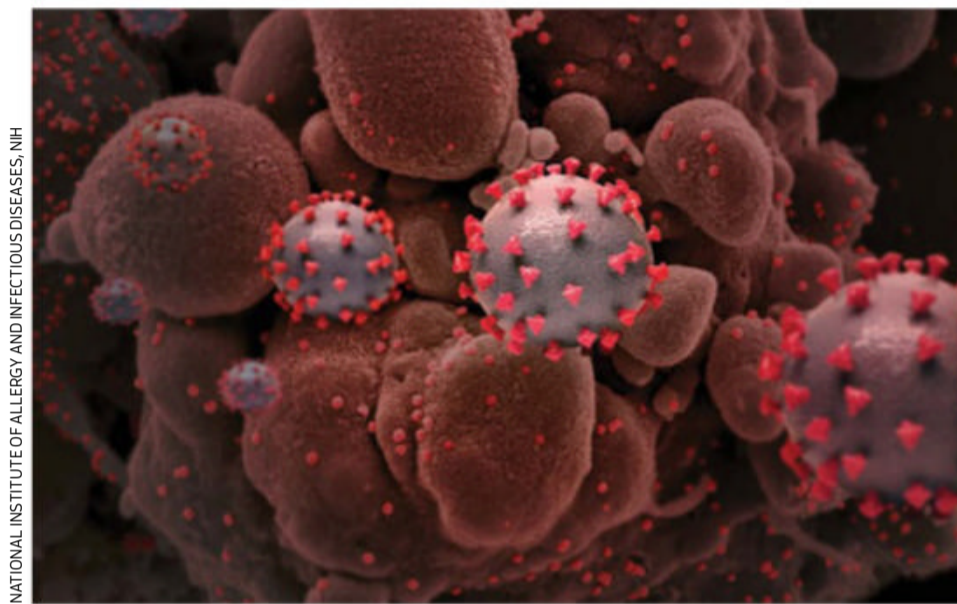
WE ARE getting closer to answering one of the most important remaining questions in the pandemic: how can we quickly test whether somebody is immune to the virus?

This elusive measurement of immunity is known as the correlate of protection: a simple, surrogate appraisal of the entire immune response that tells you whether somebody is protected against disease or infection. "So, for example, you measure the number of antibodies in blood and find that if you have a specific number you are protected," says Christine Dahlke at the University Medical Centre Hamburg-Eppendorf in Germany. That number is a correlate of protection, or CoP. We don't yet have one for SARS-CoV-2, says Dahlke, but we urgently need one.

"A measure that shows if we are immune to covid-19 would help us deal with new variants swiftly"

CoPs are a standard tool in vaccinology and, although difficult to nail down, we have established them for numerous conditions, including measles, influenza and hepatitis. Getting one for covid-19 would be a boost to our efforts to end the pandemic, says Dahlke. It would allow us to bypass big vaccine trials that compare a vaccine candidate against a placebo to see the difference in infection rates. Instead, we could do simpler and quicker tests that identify whether a vaccine elicits the CoP.

Finding a CoP for SARS-CoV-2 is a pressing issue because, despite the unprecedented success in developing covid-19 vaccines through large-scale clinical trials, there are growing fears that this approach has run its course.



NATIONAL INSTITUTE OF ALLERGY AND INFECTIOUS DISEASES, NIH

An artist's depiction of SARS-CoV-2 among human cells

protect against covid-19.

There is now a growing belief that finding a CoP is imminent. "The data we need is coming out of the various clinical trials for vaccines," says Amit Srivastava at Pfizer's vaccine development unit in Pennsylvania. Many of the trials are doing immunological assays on volunteers because the manufacturers also want to get CoPs as quickly as possible.

While we don't have the final answer yet, a CoP is likely to involve measuring the levels of antibodies and T-cells. Antibodies latch on to pathogens outside cells and get rid of them, while T-cells destroy virus-infected cells. Ideally, any immunity test would be based on the simplest possible measurement and be one that could be carried out by a family doctor.

As well as vaccine trials, an ongoing experiment that will help us get to this point is a "challenge study" at the University of Oxford, which will expose volunteers who have had covid-19 to SARS-CoV-2 in an attempt to reinfect them.

The point of this study is to determine what kind of immune response prevents reinfection, says chief investigator Helen McShane. "We'll look at antibodies, T-cells, every aspect of immunity we can study. At its simplest, if we find that it is not possible to reinfect volunteers who have a certain level of antibody, then we have a correlate of protection."

That would be a big step forward, says Dahlke. "The world does not have enough vaccines, we need new vaccines," she says. "Correlates of protection are urgently needed." ■

As the pandemic progresses, such trials become increasingly difficult to perform, for two reasons.

First, finding volunteers who haven't been vaccinated or infected and so are immunologically naive is hard. Second, giving unprotected people placebos when good vaccines exist is unethical. "We need a better approach," says Dahlke.

A CoP would also help us to deal with new variants swiftly, says Salim Abdool Karim, co-chair of the South African Ministerial Advisory Committee on covid-19. You would take serum from the blood of a vaccinated person that passes the CoP threshold, and see if it neutralises the new variant. If it doesn't, then we would probably need to tweak the vaccine. This saves time because we don't want to reformulate vaccines for every new variant of concern if the current ones are still adequate.

A CoP can also make it easier to estimate levels of immunity in the population, according to Fengcai Zhu at the Jiangsu Province Center for Disease Control and Prevention in Nanjing, China.

We have known for some time that it may be possible to identify a CoP for SARS-CoV-2, thanks to a ship called American Dynasty that

set out from Seattle on 13 May 2020 to trawl for hake in the Pacific Ocean. Although everyone was screened for covid-19 before departure, 104 of the 122 crew caught the virus at sea.

No one knows who brought the virus on board, but blood tests analysed by a team at the University of Washington in Seattle revealed that three of the people who didn't catch covid-19 had antibodies to the virus from a prior infection.

This lack of new infection in those people who already had antibodies was the first direct evidence that antibodies can

A technician analyses covid-19 antibody tests in Cascais, Portugal



HORACIO VILLALOBOS/GETTY IMAGES

Botany

Plants routinely swap DNA

Genes can transfer between grasses without any need for inheritance

Michael Marshall

SOME species of grass have been spotted doing what was once thought impossible: they routinely pass genes from one plant to another, even across different species. The finding adds to evidence that DNA can be transferred from one complex organism to another, rather than only being inherited.

Biologists have long known that single-celled organisms like bacteria pass genes in this way, a process called lateral or horizontal gene transfer. But as recently as 20 years ago, it was thought this didn't happen in more complex organisms called eukaryotes – the group that includes all animals, plants and fungi.

“People thought it was completely restricted to bacteria,” says Luke Dunning at the University of Sheffield, UK. “It’s probably only been 10 to 15 years that that’s really shifted.” Now, many eukaryotic examples are known, such as a plant gene that has crossed into insects.

To find out how widespread such gene transfer is, Dunning’s team studied the genomes of

17 grass species, some of which have been evolving independently of one another for 50 million years. These included food crops like Asian rice, common wheat and foxtail millet. The team found that 13 of the 17 species had laterally transferred genes, indicating that transfer is widespread (*New Phytologist*, doi.org/f78n). In total, 170 genes had been transferred.

“As more and more genomes

Grasses such as maize can acquire genes from other plant species



JOZEF SEDMAK/ALAMY

of eukaryotes are sequenced, we’re seeing so many examples of horizontal gene transfer,” says Julia Van Etten at Rutgers University in New Jersey. She co-authored a 2020 study estimating that single-celled eukaryotes called protists acquired about 1 per cent of their genes this way.

For every 10,000 genes in the grass genomes, Dunning’s team estimates 3.72 are detectably laterally transferred. “But that is a massive underestimate,” he says, because only some transferred genes will be favoured by natural

selection and become common. The team found lateral transfer was more common among closely related species, but it still happened in the least related ones.

Transfers were also more common in grasses with rhizomes, which are underground stems that can send out roots and shoots beneath the surface and allow plants to reproduce asexually. “If you get any foreign DNA into that rhizome, when the plant regenerates, it’s in every cell of that clone, including the flowers, and that’s how it gets into the germline,” says Dunning.

“The million-dollar question is to find out how it’s happening,” says Dunning. The grasses aren’t hybridising, as the DNA would look very different if they were. He suggests that in many cases pollination by wind might be a factor. It may be that lateral gene transfers underpin some of the traits found in domestic strains of crop grasses like wheat, says Dunning. That is speculation, but if it is confirmed, it will mean lateral gene transfer has helped us create the crops that now feed us. ■

Geology

Earth’s continents may have formed far earlier than thought

THE planet’s continental crust may have emerged 500 million years earlier than previously estimated. Pinning down when land emerged could help us understand the conditions in which life began.

Today, new oceanic crust rises at mid-ocean ridges where tectonic plates drift apart. Continental crust is usually much older, formed from volcanism where plates crash into each other, thrusting a thicker,

less-dense layer above sea level.

Weathering of continental crust adds nutrients to the oceans, which may have helped support primordial life. The big question is: when did continental crusts start forming?

To answer that, Desiree Roerdink at the University of Bergen in Norway and her colleagues analysed 30 ancient rock samples from six sites in Australia, South Africa and India. These contained barite, which can form in hydrothermal vents – fissures in the ocean floor where warm, mineral-rich waters react with seawater.

“Barites don’t really change. Their

chemistry contains a fingerprint of the environment in which they formed,” says Roerdink, who presented this work at a meeting of the European Geosciences Union on 26 April.

She and her team used the ratios of strontium isotopes in the barite deposits to infer when weathered continental rock started entering the oceans. They found this began around 3.7 billion years ago.

“The mineral barite contains a fingerprint of the environment in which it formed”

When Earth formed about 4.5 billion years ago, it was molten rock. Eventually, its outer layer cooled enough to start developing a solid crust covered by a global ocean. That kicked off the Archaean aeon around 4 billion years ago, which is when life is believed to have begun. There is strong evidence for microbial activity at least 3.5 billion years ago, but precisely when and how life started is far from clear.

The new findings suggest it could have emerged on land rather than in the oceans, says Aaron Satkoski at the University of Texas at Austin. ■ James Dacey

Nations' climate goals take shape

China and the US are the world's top two greenhouse gas emitters. Do they have what it takes to cut levels fast enough to slow global warming, asks **Adam Vaughan**

US PRESIDENT Joe Biden has committed the world's second-biggest greenhouse gas producer to cutting its emissions by up to 52 per cent by 2030, in a significant boost to the country's climate change ambitions.

The move was announced last week at the US-hosted virtual Leaders Summit on Climate, where Japan and Canada upgraded their targets and 40 heads of state agreed about the urgent need to rein in emissions.

The new US goal – a 50 to 52 per cent drop from 2005 levels – is part of a wider effort to elicit new pledges ahead of the UN's COP26 climate summit in Glasgow, UK, in November. One of the conference's key focuses is closing the gap between the Paris Agreement's goal of holding global warming to 1.5°C and the roughly 3°C the world is currently on track for.

So will the US plan make a difference? Biden's pledge is in line with experts' expectations and what US businesses were calling for. It marks a big upgrade to a previous US target of reducing emissions by 28 per cent below 2005 levels by 2025, which is now equivalent to around a 38 per cent cut. The independent Climate Action Tracker says the plan is "major progress" beyond the US's old target, but "not quite" in line with the 1.5°C goal. That would require a 57 to 63 per cent cut.

Biden opened his summit with a pitch to other leaders that tackling emissions presented a huge economic opportunity. "When people talk about climate, I think jobs," he said.

Other leaders welcomed the renewed US leadership on the issue, after the country withdrew from the Paris Agreement and largely abstained from international climate talks under Donald Trump's presidency. "It is



US president Joe Biden hosting the virtual Leaders Summit on Climate last week

50-52%
Pledged US carbon emission cut by 2030, from 2005 levels

so good to have the US back on our side on climate change," European Commission president Ursula von der Leyen said at the summit.

The US government was light on detail of how the new target will be achieved. However, in a formal version of its plan submitted to the UN, it said policies would spur a carbon-free electricity grid by 2035, along with incentives for electric cars and low-carbon hydrogen. Attention will now turn to what Biden can deliver, given domestic political challenges. Some measures are included in his recently approved \$2 trillion infrastructure plan.

Although the US's new commitment will be vital to keeping global emissions down, other countries still need to do more. Last week, the International Energy Agency warned that global carbon dioxide emissions from energy may rise by almost 5 per cent in 2021 after last year's

covid-19-induced dip. Thankfully, many nations made important new pledges at the US summit.

Coal-reliant Japan set a goal of reducing emissions 46 per cent by 2030 from 2013 levels, up on its old goal of a 26 per cent cut. Canada declared a target of a 40 to 45 per cent fall by 2030 below a 2005 baseline, short of hopes for a 60 per cent drop, but an improvement on its former 30 per cent target.

South Korea pledged to submit a bolder plan and South Africa said it was consulting on a more ambitious one. Patricia Espinosa of the UN Framework Convention on Climate Change tells *New Scientist* it is vital these countries come forward with new plans.

Brazilian president Jair Bolsonaro made a surprise pledge that his country would become carbon neutral by 2050, rather than 2060 as promised last December. He committed to end illegal deforestation in the Amazon by

Male parasitic wasps sense mates in a host

Ibrahim Sawal

2030, despite overseeing a surge in logging. India, the world's third biggest emitter, made no new pledge. Prime minister Narendra Modi noted that the average Indian's carbon footprint is 60 per cent lower than the global average.

Chinese president Xi Jinping also offered no new climate plan to improve on China's current pledge of carbon neutrality by 2060, although he did commit to reducing coal use from a peak in 2025. A study published last week laid out the challenge that the country, the world's biggest emitter, faces in decarbonising its economy (*Science*, doi.org/f8nh).

There is a growing consensus that China's electricity sector must be fully decarbonised by 2050. At the start of last year, coal provided around two-thirds of electricity supplies in the country, with renewables, including hydro, at around a quarter.

That picture needs to change radically, says study author Hongbo Duan at the University of Chinese Academy of Sciences. He and his colleagues suggest that wind and solar power must dominate the country's energy supply by mid-century, backed up by nuclear power and coal plants using carbon capture and storage (CCS) technology.

The team looked at nine models of how the Chinese economy needs to transform by 2050, finding that its CO₂ emissions must fall 90 per cent to do its share in meeting the Paris Agreement's 1.5°C goal. Most of this will come from reducing energy demand, says Duan, but untested negative emissions technologies, including CCS and machines to suck CO₂ from the air, are seen as delivering a fifth of the required cuts.

The modelled pathways for China's energy mix reveal the disconnect between ideal

trajectories and reality. For example, the models consistently found that CO₂ emissions needed to have started falling "steeply" last year. In reality, China was the only major economy where emissions grew in 2020, despite the coronavirus pandemic.

Such failure to cut emissions early will be more costly, says Chunping Xie at the London School of Economics. Yet China's

"The short-term reality is China is still growing. Energy demand is still increasing"

official short-term goal remains for emissions to peak around 2030, which is unchanged since it was set six years ago in the run-up to the Paris climate summit.

"The short-term reality is China is still growing. It's going to double the size of the economy, it's still urbanising, energy demand is still increasing. There is still an imperative for growth," says Michal Meidan at the Oxford Institute for Energy Studies, UK.

Sue Biniiaz at the US Department of State says action by China this decade is key to keeping the 1.5°C goal alive, and a joint US-China climate agreement on 17 April was a positive step. "[It has] lots of references to taking action now in the 2020s, which is the thing we've been most concerned about with China," she says.

Bill Hare at Climate Action Tracker says there is still time to turn around China's coal expansion and rising emissions. "One of the top-level messages here is the need to go hard and early on mitigation to start CO₂ emissions declining quickly," he says. "That will reduce the need for large-scale deployment of CCS negative emissions technologies." ■

MALES of a species of parasitic wasp can identify potential mates from chemicals they give off, even before the females have emerged from within their host fly.

Jewel wasps (*Nasonia vitripennis*) are found across North America. Females deposit eggs inside the cocoon-like casings of developing flies, using their ovipositors to inject each fly with a venom that paralyses it. The developing wasps remain in the host as they mature from egg to adult, only eating their way out to mate. Males emerge first, hanging around on the hosts to wait for females to appear.

"Males want to increase their mating success, so would benefit from finding hosts with females," says Garima Prazapati at the Indian Institute of Science Education and Research (IISER) Mohali.

It is possible for these wasps to up their chances. Males develop from unfertilised eggs and females from fertilised eggs, so some hosts hold all-male broods, while others house a mixture of males and females.

A false-colour image of a male parasitic wasp, *Nasonia vitripennis*



DENNIS KUNKEL/MICROSCOPY/SCIENCE PHOTO LIBRARY

Prazapati and her team collected jewel wasps from the wild and bred them. They isolated some females, keeping them from mating so their eggs would go on to create all-male broods. Next, they individually presented 26 male wasps with two Petri dishes: one holding a host containing male and female adult wasps, and one with a host containing only adult males.

The researchers found that the males spent around four times longer on the host with the females inside (bioRxiv, doi.org/gjrdv9).

Analysing the chemical compositions of both hosts, the team found that the one containing female wasps had a higher abundance of nine cuticular hydrocarbons – compounds that cover the wasp exoskeleton – than the host with males inside.

They then dipped adult wasps in a chemical solution that extracts these hydrocarbons and found that adult females also had a higher concentration of them than males.

Prazapati says this suggests that the males must be able to detect the abundance of female-specific chemical cues emanating from within the fly casings. "This is the ultimate mate-finding strategy," she says.

They are certainly good at finding the female wasps, says team member Rhitoban Raychoudhury, also at IISER Mohali. "But males being attracted to females isn't news."

Given the lifestyle of parasitic wasps, this strategy of searching for mates while they are still within the host is important for males to secure reproduction and may also be seen in other species, he says. ■

Archaeology

The original euro: Lumps of bronze were currency 2800 years ago

Michael Marshall

THE first pan-European currency may have existed more than 2800 years ago in the Bronze Age. There were no coins yet and no central bank, but people across Europe used fragments of bronze, the majority of which were of a standard mass or a multiple of that.

“You can actually think of some monetary union in Europe without public institutions,” says Nicola Ialongo at the University of Göttingen in Germany.

Bronze is an alloy of copper and other metals, usually tin, that was used widely in Europe from about 2300 to 800 BC, hence the term Bronze Age. This widespread access to those metals must have involved trade.

For one thing, “copper is not very common”, says Ialongo. It was mined at several sites, including in the Eastern Alps. A new study shows that it was also being smelted in what is now eastern Serbia between 2000 and 1500 BC, more than 500 years earlier than thought (*Journal of Archaeological Science*, doi.org/gjrz9n).

Tin is even harder to find: Ialongo describes it as “incredibly



VOLKER MINKUS/THOMAS TERBERGER

Metal scraps from a late Bronze Age battlefield in northern Germany

rare”. It was extracted in what is now Cornwall in the south-west of England, and there were also sites in eastern Europe and Turkey, says Ialongo. “It’s really difficult to get access to tin and yet it was everywhere.”

This continent-spanning trade was the ideal situation for a unified form of money to arise, he says. This was made possible by the spread of weighing technology

such as balance scales, which were invented around 3000 BC between Mesopotamia and Egypt and subsequently spread throughout Europe. The weights were often made of stone and the balance beam of bone or antler.

Ialongo and Giancarlo Lago at Sapienza University of Rome in Italy studied more than 3000 fragments of bronze from Bronze Age sites scattered around Europe. The fragments had been broken off larger objects, potentially from things like axe heads.

If they were used as money, they

should have been standardised. While they didn’t look alike, as modern coins do, they should have had regular masses. There should have been a single smallest mass, the equivalent of a single penny or cent. The larger fragments should have been multiples of this mass.

Ialongo and Lago found that the fragments conformed to such a rule. The smallest weighed about 9.8 grams, and larger ones were multiples of that (*Journal of Archaeological Science*, doi.org/f78q). That closely matched the smallest balance weights, which were typically 9.6 grams.

“I found that very convincing,” says Joanne Baron at the Bard Early College Network in Newark, New Jersey. Standardisation alone isn’t proof these were currency, but the fact they become more numerous over time bolsters the case, she says. This currency arose despite the lack of a central government, and before writing came to Europe. The question, she says, is whether small organised groups that did exist played a role in the standardisation of the money. ■

Technology

AI can read a cow’s face to tell if it is stressed or excited

AN ARTIFICIAL intelligence can detect nine emotional states in cattle and pigs by analysing their faces, and could lead to systems for improving animal welfare on farms.

At present, well-being efforts focus on reducing animals’ pain and distress, but automated systems could help boost positive states as well, says Suresh Neethirajan at Wageningen University & Research in the Netherlands. “There is a need

to move away from just eliminating negative emotional states to providing positive states, such as playful behaviour.”

He collected thousands of images and videos of cattle and pigs from farms in Canada, the US and India and classified them based on cues known from previous research to reveal particular emotions. For instance, when the white of a cow’s eye is visible, it is usually a sign of excitement or stress. A pig’s forward-facing ears are a sign of alertness or sometimes aggression.

Deep learning was used to detect the faces of animals in these images.

The system was then trained to identify 13 facial actions associated with emotional states like stress, aggression, frustration, neutrality, relaxation and excitement. When tested on another set of images, the system matched the human classification around 86 per cent of the time (bioRxiv, doi.org/f78m).

Neethirajan says it will take a couple of years to develop the system to a point where it could

“We need to move away from just eliminating negative emotional states to providing positive ones”

start to be used on farms. But he thinks continuous monitoring by cheap cameras hooked up to a cloud-based system could be far better than the occasional visits by welfare auditors that are required in some countries.

According to Neethirajan, the ultimate aim is to be able to predict and prevent problem behaviours, such as tail biting in pigs, which can lead to serious infections. Better welfare should improve health and yields, so Neethirajan thinks many farmers will embrace such systems. ■
Michael Le Page

China to make a home in space

The Chinese Space Station could have geopolitical ramifications

Leah Crane

CHINA is about to launch the first section of a new space station, beginning an orbital construction project that is expected to end in 2022 with an outpost about a quarter of the size of the International Space Station (ISS).

While the exact date hasn't been announced, China was expected to launch its 18-metre-long core module, called Tianhe, as *New Scientist* went to press. Tianhe will contain living quarters for up to three astronauts, along with the station's control centre, power, propulsion and life-support systems. It will be followed

2022

China is expected to complete its new space station next year

by two other main modules, both designed to house scientific experiments.

The Chinese Space Station (CSS) will be the 11th crewed space station ever built. It is China's third station, although the previous two were significantly smaller. The CSS will be slightly larger than Mir, the Soviet space station that preceded the ISS.

China, in a sense, is trying to catch up with the capabilities of other space powers that have already done this, says space analyst Laura Forczyk. "One of the things that helps China here is that their government is not democratic, so there isn't the infighting that we have in the US about what the priorities are and how to fund them."

That has allowed the nation to develop this technology relatively quickly, but Charles Bolden, who served as NASA administrator under President Barack Obama, says China will struggle to match US capabilities in space. "Technologically, I don't think

they're going to catch up as long as we keep up with the pace that we're going in terms of human space flight."

Another boon to the Chinese space programme has been a growing partnership with Roscosmos, Russia's space agency, which comes while NASA's historically strong cooperation with Roscosmos in space is waning. For the past decade, NASA has been reliant on purchasing seats on the Russian Soyuz spacecraft to reach the ISS, but now the US has its own crewed launch capabilities through SpaceX. In April, Dmitry Rogozin, chief of Roscosmos, said that the country plans to end its participation in the ISS in 2025, and will build its own space station, to be launched in 2030.

"We've seen China and Russia partnering quite a bit recently, because Russia has significant expertise in space and with space stations," says Forczyk. "China is capitalising on the expertise and experience of the Russian space sector while also providing a significant amount of funds,



STRINGER/CHINA OUT VIA REUTERS

The first module of the Chinese Space Station sits atop a Long March-5B Y2 rocket

which Russia does not have."

However, to some in the Western world, this partnership and the rapid growth of China's space capabilities have caused concern about military ambitions. A recent report by the US Office of the Director of National Intelligence on global threats includes a mention of the new space station. It warns that China is working "to gain the military, economic, and prestige benefits" of matching the US's capabilities in space.

"Nevertheless, historically, these space stations have been for the purpose of increasing human understanding, and we have no

An artist's impression of the completed Chinese Space Station



XIA YUAN/GETTY IMAGES

reason to suspect that China is using its space station for anything different," says Forczyk.

The China National Space Administration has already selected several experiments to be run onboard the CSS, including work with ultracold atoms to research quantum mechanics, materials science research and work on medicine in microgravity. It has several international partners that will send experiments onto the space station, including the Italian Space Agency and the United Nations Office for Outer Space Affairs.

NASA, on the other hand, won't be a partner – the US has laws restricting the agency from collaborating with China, which Bolden sees as a mistake because commercial and international partners could choose to work with China instead.

"We'd end up on the outside looking in. That's why I think we should be collaborating with the Chinese... I think the smaller nations look for the best offer," he says. "I think a pretty savvy commercial entrepreneur might in fact blaze a trail, might be able to work collaboratively with the Chinese, the Russians and the Americans and pull us together. That might not happen, but I'm the eternal optimist."

While this utopian vision of space collaboration may be unlikely, the launch of the CSS will almost certainly have an effect on the US's stance on Earth orbit missions because of its potential geopolitical implications.

"It will cause a reaction – what that reaction is remains to be seen," says Forczyk. "I don't know if we can say that this will provoke American politicians to fund the ISS for longer or to encourage commercial space stations or some third option." ■

Antistars may be lurking close by

Gamma rays offer hints that some stars may be made of antimatter

Leah Crane

THERE could be several stars made of antimatter in our solar system's neighbourhood. There have been small hints that these strange and unlikely objects, called antistars, could exist, and a search for the gamma rays that they are expected to produce has now turned up 14 candidates.

When matter and antimatter meet, they annihilate in a shower of radiation, including high-energy gamma rays. This is expected to happen fairly often at the surfaces of antistars – if they exist – as regular matter falls onto them.

Simon Dupourqué at the University of Toulouse in France and his colleagues examined data from the Fermi Gamma-ray Space Telescope for objects emitting the sort of radiation expected from these annihilations that weren't already explained by some other astronomical phenomenon.

From the 14 candidates that they found, they calculated that there could be as many as one antistar per 400,000 regular stars in our galaxy (*Physical Review D*, doi.org/f8m8).

"That may seem high, but it's an upper limit," says Dupourqué. "That's assuming that all 14 candidates are antistars, but they're probably not."

There is no formation mechanism for antistars that fits into our standard model of cosmology, so it is fairly unlikely that they exist – but there are models in which they are possible, and there is one small piece of

Matter and antimatter annihilate to create a burst of energy

observational evidence that suggests they might be real.

Since it was bolted to the outside of the International Space Station in 2011, the Alpha Magnetic Spectrometer experiment has detected tentative signals of eight antihelium atoms.

The simplest way to produce antihelium is in an antistar, which would fuse antihydrogen into antihelium in the same way that a star does with regular hydrogen to make helium.

Even though antimatter annihilates immediately when

it meets regular matter, space is so empty that Dupourqué and his colleagues calculated that an antistar could survive well beyond the current age of the universe without disappearing completely.

However, if antistars exist, they are tough to distinguish from afar.

"It's not like, 'oh my god they're green!' The anti-sun would probably look similar to the sun," says Vivian Poulin at the University of Montpellier, France.

Even up close, an antistar would behave just like a regular star, except when matter fell on to its surface and annihilated to produce gamma rays. That means that proving that these 14 candidates are truly antistars is next to impossible, says Dupourqué. It would be far easier to prove that they aren't antistars, perhaps by searching for less exotic explanations for the gamma rays they give off.

If even one of them is an antistar, though, we will have to reconsider our entire understanding of the early universe to figure out how it could have formed. ■



SAKKIMESTER/SCIENCE PHOTO LIBRARY

Human behaviour

Glancing at your phone prompts others to do it too

WHEN a person looks at their smartphone, around half the people nearby will start checking their phones within 30 seconds.

Such a rapid, automatic response is probably due to people mimicking each other without even realising it – something that scientists call the chameleon effect.

Such mimicry is thought to have evolved in human societies to help people bond with each other, but

mimicking phone use might have the opposite effect, says Elisabetta Palagi at the University of Pisa, Italy. "Smartphones can increase social isolation through interference and disruption with real-life, ongoing activities."

Palagi and her colleagues watched 88 women and 96 men in many different situations in natural settings – parks and public transportation, for example – to see how many would look at their phones if someone else nearby did.

These "trigger" individuals pushed buttons or swiped their screens for 5 seconds, either with

or without looking at the screen. The researchers themselves were usually the triggers, and the people they observed were strangers.

The researchers found that 50 per cent of people looked at their phone within 30 seconds of the trigger touching and looking at his or her phone, but just 0.5 per cent of people did so when the trigger touched the phone without looking at it. "It's paying attention

"Some 50 per cent of people looked at their phone within 30 seconds of researchers doing so"

to the phone that sets off the mimicry," says Palagi. Response rates were the same across all groups, regardless of age or sex (*Journal of Ethology*, doi.org/f764).

The mimicking behaviour wasn't just fast, but – at least anecdotally – it was also automatic and subconscious.

"One woman who was sitting across from me in a waiting room saw me check my phone, and within seconds she took out her phone and called someone and said, 'Hey, I just felt like calling you; I don't know why,'" says Palagi. ■

Christa Lesté-Lasserre

Air quality

UK coroner calls for air pollution action

Adam Vaughan

A CORONER has urged the UK government to impose tougher legal limits on air pollution in line with World Health Organization (WHO) guidelines, to prevent more deaths like those of 9-year-old Ella Kissi-Debrah.

An inquest last year by coroner Philip Barlow into the death of Ella in 2013 found that her exposure to dangerously dirty air in London had played a material role. She lived and walked to school in an area of south London that frequently breached UK limits for air pollution.

In a report about preventing future deaths, published on 21 April, Barlow made three recommendations. He said the government should bolster the UK's air pollution limits, noting that they are currently "far higher" than the WHO's guidelines. "Legally binding targets based on WHO guidelines would reduce the number of deaths from air pollution in the UK," he said.

Barlow added that doctors and nurses are failing to sufficiently communicate the health risks of exposure to dirty air, and professional medical bodies need

London's air quality frequently breaches legal limits



ALENA KRAVCHENKO/GETTY IMAGES



HOLLIE ADAMS/GETTY IMAGES

Rosamund Kissi-Debrah says the UK must adopt World Health Organization air pollution limits

to address this. Public awareness of local and national air pollution levels is low, which could be fixed by increasing the number of air-quality sensors, he said.

Rosamund Kissi-Debrah, Ella's mother, says she will ask the UK's environment secretary George Eustice to legislate to implement WHO air pollution rules in the wake of the report.

Failure by the UK government to adopt the stronger guidelines would be something she would take personally, Kissi-Debrah told *New Scientist*. "It would make me feel as if Ella's life and all this fight had been in vain. I can't contemplate it. People would continue to die and we'd do nothing. I just have to keep on hoping we'd get there."

A government spokesperson said in a statement: "We will carefully consider the recommendations in the report and respond in due course."

The UK's legal limit for a fine particulate form of pollution, PM_{2.5}, is an annual mean of 20 micrograms per cubic metre, twice the 10 µg/m³ in WHO guidelines. However, the gap is set to widen further, as Maria Neira at the WHO says an expert group at the body will soon publish new guidelines on particulate pollution.

"This year in November will be COP26 [the UN climate summit], so we need to make sure this health argument is penetrating conversations about climate change," says Neira. ■

Weather

The strange, elongated shape of hailstones

David Hambling

A TEAM of storm chasers spent years tracking down terrible weather across the US to establish this simple fact: hailstones aren't round. They have more complex shapes than previously thought and this knowledge could help meteorologists understand their formation and better predict the dynamics of hailstorms on weather radar.

"It's along the same lines as 'no two snowflakes are alike' – we can say the same thing about hailstones," says Matthew Kumjian at Pennsylvania State University.

He and his colleagues carried out a hailstone survey over the course of six years. The team chased hailstorms across the Great Plains of the US, positioning themselves in the likely paths of storms and using weather radar data to rush to the scene of each hail fall before it melted.

The researchers collected and measured more than 3600 hailstones from 42 storms. They determined the shape of the larger stones with a 3D laser scanner. Hailstones are generally assumed to be spherical, but the team found that the typical stone is technically a shape known as a triaxial ellipsoid or scalene oblate spheroid (*Journal of the Atmospheric Sciences*, doi.org/f738).

"The hailstone is only about half as thick as its maximum dimension, and only about 80 per cent of the maximum dimension across in the third axis," says Kumjian. He says each stone was similar in shape to a flattened American football or rugby ball.

The region of the US stretching from Montana in

the north to Texas in the south is known as Hail Alley for its powerful and frequent hailstorms, and the majority of stones the team measured there were 1 to 3 centimetres in length. The biggest were more than 1.2 centimetres across, with the shape becoming less regular at larger sizes.

"The larger hailstones tend to develop protuberances or lobes, which can give them very irregular or spiky shapes," says Kumjian.

The shape is determined by the growth process in which ice accumulates around a nucleus. The irregularity of the hailstones suggests that they don't tumble symmetrically during growth as researchers had previously assumed, but twist and turn randomly as they fall.

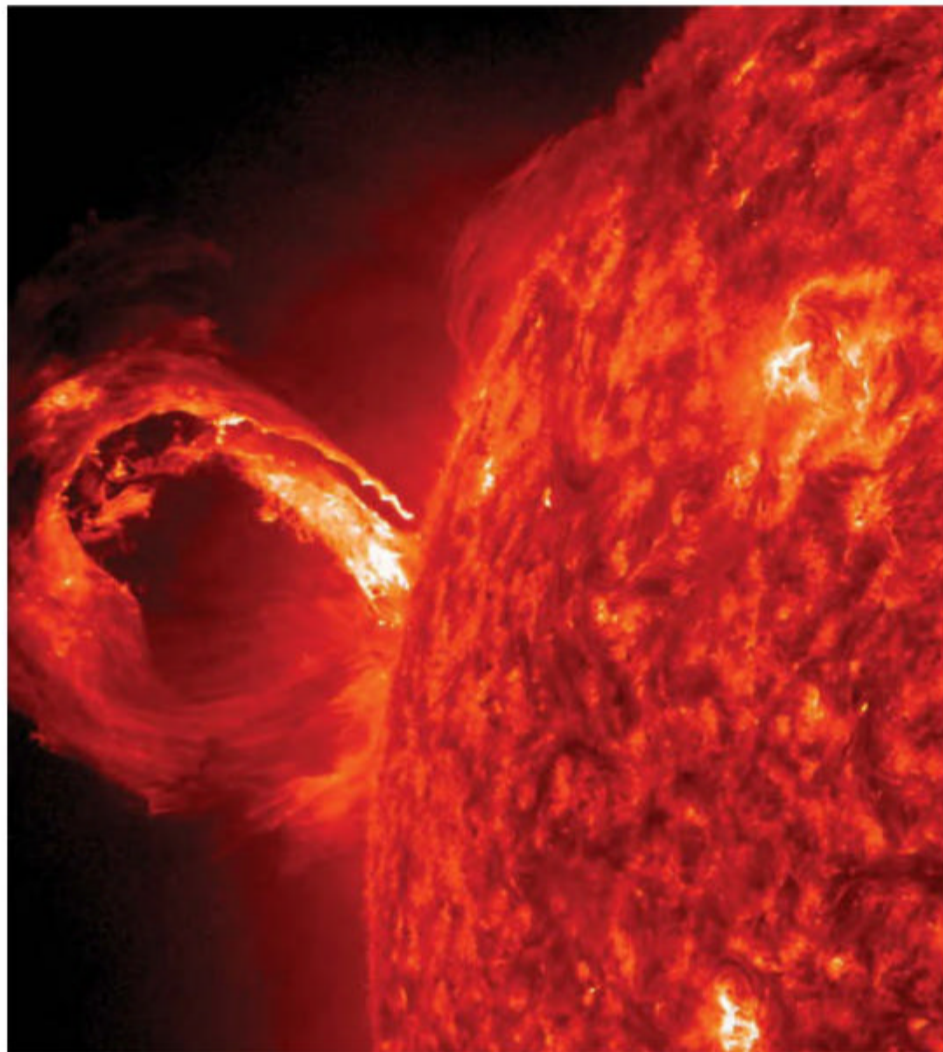
Weather radar may overestimate the size of hailstones in storms given the stones are irregular rather than

1.2 cm

The width of the largest hailstones from a six-year survey

round, and common weather models have been programmed assuming hailstones are simple spheres of ice. The way they form and melt depends a lot on surface area, which is much greater for the hailstones' actual shapes than for spheres of the same mass, so weather models may need to be updated.

The new findings could help meteorologists better estimate the force and path of hailstorms. The shape of hailstones also affects the speed at which they fall, so a better understanding of their formation and ultimate shapes could help predict the damage they might do. ■



NASA

Astrophysics

Stars spotted hurling vast bursts of matter into space

MORE stars than ever before have been observed ejecting huge streams of electrically charged particles into space. Learning more about the behaviour will be important for understanding whether planets orbiting the stars are potentially habitable or not.

Stars like our sun produce coronal mass ejections (pictured), eruptions of electrically charged particles from the outer atmosphere caused by instabilities in the star's magnetic field. They are often associated with solar flares, flashes of light resulting from the explosive realignment of twisted magnetic fields.

While we have been able to observe flares on other sun-like stars with relative ease, coronal mass ejections have been more difficult to spot as they are hidden by the glare of the star. But now

Astrid Veronig at the University of Graz in Austria and her colleagues have used a new method to spot 21 such ejections, more than found in all previous studies.

The researchers used historical data from three space-based telescopes to study the ultraviolet and X-ray emissions of more than 200 stars. In 13 stars, most of which were like our sun, the researchers saw dips in these emissions lasting up to 10 hours, with 21 such events spotted. They argue that these dips are the result of coronal mass ejections (*Nature Astronomy*, doi.org/f76w).

If a planet is close enough to a star that releases a very strong coronal mass ejection, "you can drive away the whole atmosphere from the planet", says Veronig. Jonathan O'Callaghan

Space exploration

Oxygen made using Martian atmosphere

A NASA experiment on Mars has turned some of the planet's wispy, toxic atmosphere into oxygen. The Mars Oxygen In-Situ Resource Utilization Experiment (MOXIE) landed with the Perseverance rover on 18 February and has now completed its first test.

The atmosphere on Mars is mostly made of carbon dioxide. It is also 100 times thinner than Earth's atmosphere, so even if it did have a similar composition to the air here, humans would be unable to breathe it to survive. If we ever send astronauts to explore Mars, they would have to bring their own oxygen with them.

Oxygen is also a key ingredient in most rocket fuels, so if those astronauts want to come back home, they will have to carry heavy tanks of fuel with them on their entire journey. NASA estimates that to get four

astronauts back from Mars would take about 25 tonnes of oxygen. It is extraordinarily expensive to carry anything to Mars and rockets have limited capacity, so every gram counts.

MOXIE is a step towards solving both of those problems by producing oxygen on Mars. It sucks in CO₂ from the Martian atmosphere and heats it to around 800°C, stripping oxygen atoms from the CO₂ and venting carbon monoxide. The first test, on 20 April, produced about 5 grams of oxygen, equivalent to about 10 minutes of breathable air for an astronaut.

MOXIE is only capable of producing about 10 grams of oxygen per hour, but future oxygen generators could be much larger and up this rate. Over the next year, MOXIE is set to run at least nine more experiments, testing its capabilities during different times of day and seasons, when conditions in the Martian atmosphere change. Leah Crane

Archaeology

AI solves a riddle of the Dead Sea Scrolls

ARTIFICIAL intelligence has helped solve a long-standing mystery concerning the Dead Sea Scrolls. The technology confirms that one of the ancient manuscripts – the Great Isaiah Scroll – was penned by two scribes who wrote with very similar handwriting, rather than being the work of a single person.

The Dead Sea Scrolls are ancient manuscripts unearthed in the

20th century and comprising Biblical and Jewish texts. Among them is the Great Isaiah Scroll (pictured), a copy of the Book of Isaiah that is found in both the Hebrew Bible and Old Testament. The scroll was finished around the 2nd century BC, and written using the Hebrew alphabet, but the number of authors was unknown.

So Mladen Popović at the University of Groningen in the Netherlands and his team used artificial intelligence to analyse digital images of the manuscript to see whether one person wrote the scroll or if multiple people with similar handwriting worked on it. They looked at variations in the shape and style of the letters that can't be spotted easily by the human eye and found that the scroll was separated into two halves, each written by a different scribe (*PLoS One*, doi.org/f77c).

Future analysis of the remaining Dead Sea Scrolls could tell us more about the scribes, says Popović. Krista Charles



THE PICTURE ART COLLECTION/LAMY

Really brief



Millions of bubbles in a glass of beer

When lager is poured into a glass, between 200,000 and 2 million bubbles of carbon dioxide form. The measurement comes from calculating the amount of CO₂ in 250 millilitres of lager and the fact the gas forms 0.5-millimetre-wide bubbles in beer (*ACS Omega*, doi.org/gjmgqj).

AI algorithms can sway decisions

Tests with software that mimicked the appearance of an artificial intelligence algorithm have revealed such algorithms might influence our decisions. For instance, people looking for a date preferred photos of a potential partner if the "AI" stated it had found a compatibility match (*PLoS One*, doi.org/f73w).

Tyrannosaurs may have lived in packs

Rocks in Utah have yielded the remains of five *Teratophoneus* tyrannosaur dinosaurs that died together 74 million years ago. The five include three juveniles and provide rare evidence that large carnivorous dinosaurs may have been social creatures (*PeerJ – Life & Environment*, doi.org/f73v).

Environment

Sustainable living is impossible for many

NEARLY three-quarters of people are in countries without enough natural resources for them to live sustainably – and without enough money to buy them elsewhere.

Biocapacity is the ability of an ecosystem to regenerate resources that people use. It compares the rate at which we use our natural resources with our ability to replace them and absorb waste.

To maintain its population, a country needs enough resources

to match the ecological footprint of its people and maintain a biocapacity surplus, or enough money to buy biocapacity to make up any shortfall.

Mathis Wackernagel at Global Footprint Network in California and his team looked at biocapacity in every nation for the years between 1980 and 2017, examining whether they had a deficit or surplus of resources. They also estimated average incomes.

In 2017, 72 per cent of the global population, or 5.4 billion people, lived in nations with a biocapacity deficit and below-average income.

The team's calculations show that the situation has deteriorated since 1980. For that year, they found that 57 per cent of the world's population lived in below-average-income countries with a biocapacity deficit (*Nature Sustainability*, DOI: 10.1038/s41893-021-00708-4).

There are some nations where average income is high and where there is a biocapacity surplus, including Sweden, Canada and Finland. Wealthy countries in severe biocapacity deficit include France, Germany and Japan.

Karina Shah

Technology



TOMOHIRO OHSUMI/GETTY IMAGES

Robot voices its thoughts to show how it makes decisions

INNER speech, where we talk to ourselves, helps us evaluate situations and make more-informed decisions. Now, a robot has been trained to speak aloud its inner decision-making process.

Arianna Pipitone and Antonio Chella at the University of Palermo, Italy, programmed a robot named Pepper to mimic human cognitive processes and handle text-to-speech. This allowed it to voice its decision-making while doing a task.

The researchers then asked Pepper to set a dinner table according to rules they had set.

When instructed to put a napkin on a fork with inner speech enabled,

Pepper asked itself what etiquette was needed, concluding the request went against the rules. It then asked the researchers if putting the napkin on the fork was the correct action. When told it was, Pepper said, "OK, I prefer to follow your desire," and explained how it would do this.

When asked to do the same task without voicing the inner speech, Pepper knew this contradicted the rules, so didn't perform the task or explain why (*iScience*, doi.org/f763). This type of programming could help the public understand robots' abilities and limitations, says Sarah Sebo at the University of Chicago. **Ibrahim Sawal**

Chemistry

Jane Austen quote stored in molecules

WORDS and other information can be encoded in synthetic molecules and then recovered by analysing the chemicals.

It means that tiny bits of plastic might hold much more data than is stored on today's computer hard drives, says Eric Anslyn at the University of Texas. He used compounds made of atoms including oxygen, hydrogen and nitrogen to represent symbolic values for storing information.

Various molecules built from these could become their own code language based on a rich "molecular alphabet" of 16 characters – a hexadecimal code. That is eight times the characters used in the binary system, making the approach particularly efficient for storing data. A type of mass spectrometry could easily analyse and sequence the molecules so data can be recovered (*Cell Reports Physical Science*, doi.org/f78f).

Inspired by the possibilities, Anslyn's team developed software that would encode regular text symbols into a hexadecimal "molecular language". Anslyn's team then used the method to encode into molecules, and later recover, a quote from the Jane Austen novel *Mansfield Park*.

Christa Lesté-Lasserre

7 days | 18 January 2022

Norway: Wonders of the Arctic

Norway boasts some of the most beautiful natural experiences, home to the northern lights as well as a rich diversity of marine life in its fjord coastline. On this New Scientist Discovery Tour, you will gain an in-depth insight into the science behind the Aurora Borealis and the behavioural ecology of the humpback and orca whales. Accompanied by marine biologist Helen Scales and plasma physicist Melanie Windridge.

You will explore Norway's iconic fjords by boat, where you can meander through the frozen forested valleys from the picturesque city of Bergen at their heart. You will travel north and stay in an observatory where you can witness and learn about the splendour of the northern lights.

Highlights

- Marine biologist Helen Scales will give evening talks and accompany you on a cruise from Bergen along the Osterfjord to the rugged Mostraumen fjord.
- Plasma physicist and STEM ambassador Melanie Windridge will accompany you during your two night stay at the Aurora Borealis Observatory on Senja Island. Here you will enjoy stargazing outdoors and talks about the northern lights and the science behind fusion energy where researchers are trying to replicate the nuclear reactions which take place inside the stars themselves.
- A walking tour of Bergen, the most beautiful city in Norway. Explore charming wooden streets, Vågen harbour and the Bryggen quarter, now a UNESCO World Heritage Site.

- Wildlife fjord safari by boat where, as you pass through the frozen coastline, you will get an opportunity to look for sea eagles, seals, elegant cormorants whales.
- Take a trip to Polaria, the world's most northerly aquarium, where you will see some of Norway's native species and enjoy a film about life in arctic Norway.
- Time to try snowshoeing or enjoy a talk on the benefits of ice-swimming and perhaps have a go at it yourself.
- Campfire talk by plasma physicist, science communicator, and STEM ambassador Melanie Windridge, about the science behind fusion energy, where researchers are trying to replicate the nuclear reactions which take place inside the stars themselves.
- Explore the Northern Norwegian Science Centre, a popular science experience centre containing almost 100 interactive installations.
- Take a cable car ride from Tromsdalen, where you will enjoy amazing views.
- Head to the wilderness to visit a husky kennel where you can learn about the Alaskan husky breed, dog sled racing and animal welfare. Then an experienced musher will take you sledding safely through the gorgeous landscape.

Covid-19 safety protocol includes:

- Pre-departure screening of all guests and tour leaders.
- Increased sanitisation of all accommodation and transport.
- Mandatory use of PPE where appropriate.



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Chanda Prescod-Weinstein confronts a physics anomaly **p22**

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Aperture
Revel in some of nature's most vibrant displays **p28**

Culture
Our Future Planet is a very timely climate exhibition **p30**

Culture columnist
Karina Shah tunes in to a new TV series on Greta Thunberg **p32**

Comment

Red alert

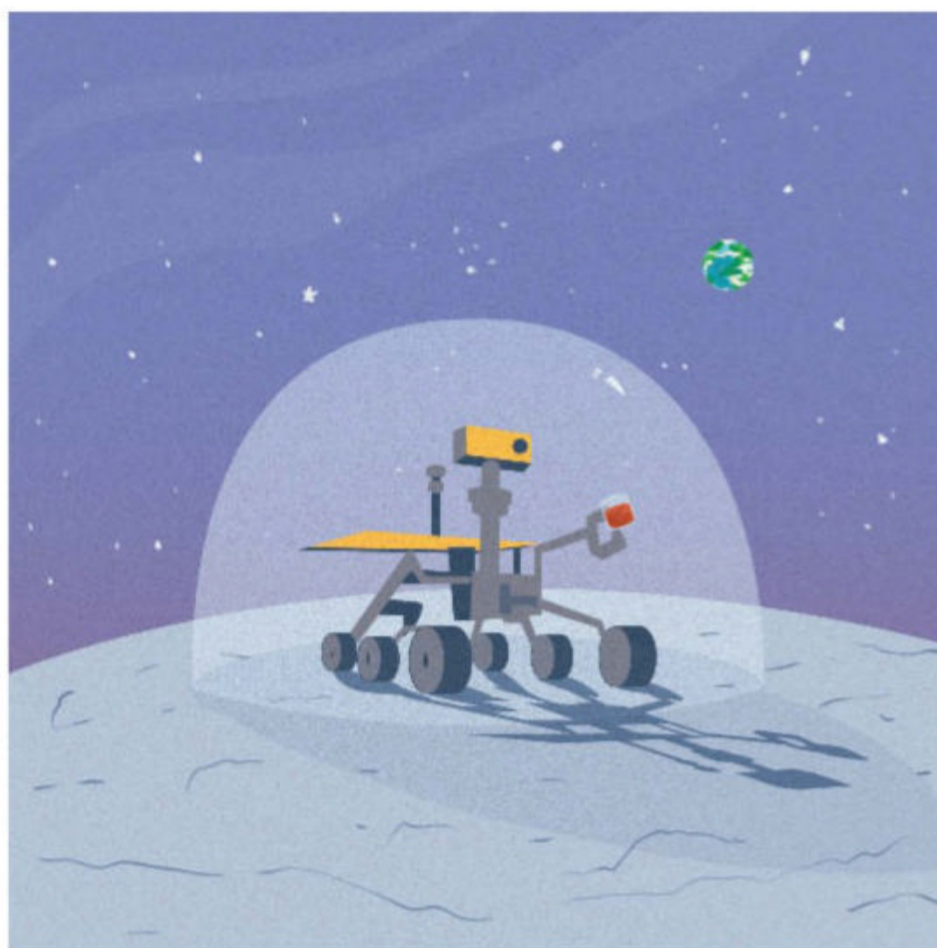
There are plans to bring rocks from Mars to Earth to check them for signs of life. We really shouldn't be doing this, says **Paul Marks**

AROUND a decade from now, astrobiologists from NASA and the European Space Agency (ESA) will be looking out for a ballistic delivery from the heavens: the first space capsule containing soil and rock samples from the surface of Mars.

Designed to thump into the Utah desert without so much as a parachute to slow it down, that sample return capsule will then be transported to a biosafety level 4 (BSL-4) lab, the highest biological containment set-up available – one used for pathogens like the Ebola virus. Being able, finally, to comprehensively test for signs of life, past or present, on Mars will make those samples a glittering scientific prize: “Returning pristine samples of Mars to Earth has been a goal for generations of planetary scientists,” NASA says.

But the space agencies are letting their quest for answers trump what is safest for life on Earth: no one knows if those samples – to be gathered soon by the Perseverance rover – could contain Martian pathogens to which we would have no defences. Nor do we know if the capsule could break on impact (NASA's solar wind sampler Genesis was breached when it crashed in Utah in 2004 after its parachute failed), risking contamination of wildlife, rivers, plants and fisheries as well as cities. While BSL-4 labs are highly secure, there have been lapses in the past, with human error usually suspected.

The risks, though small, are



there. Space agencies are working with the US Centers for Disease Control and Prevention in Atlanta and European Centre for Disease Prevention and Control in Sweden to try to mitigate them. But they can't deny they exist – and that is a problem, because the UN Outer Space Treaty bans contamination of worlds we visit and of Earth on return. Spacefarers, the treaty says, must avoid “adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter”.

At a time when covid-19 is showing the appalling impact of a pandemic, NASA and ESA surely

need to change tack. There is a clear new course: bring the samples back for analysis on a lunar orbiting space station, or to a lab on the moon itself, both of which may exist a decade hence.

This is a position supported by the International Committee Against Mars Sample Return (ICAMSR), which highlights Earth return risks. “We support a Mars sample return mission as part of the Lunar Gateway space station, if samples are brought to a specially designed biohazard examination module in lunar orbit, or which is part of a larger lunar base concept as envisioned in NASA's Artemis

programme,” says Barry DiGregorio, director of ICAMSR. “This is the only way to guarantee 100 per cent protection of Earth's biosphere.”

NASA and ESA say they need to bring samples back to Earth because of the sheer expense and difficulty of operating a complex BSL-4 lab in space, adding that microgravity “would compromise the way we analyse samples”. But that is a problem for the space agencies, not one they can expect the population of Earth to accept unknown risks over.

If the space agencies are serious about a crewed return to the moon as a stepping stone to Mars, they can surely work out how to analyse hazardous samples off-planet. And there is a window in which to do so, too, since the mission to fetch the samples collected by Perseverance isn't due to lift off for Mars until 2026 – and its design isn't yet final.

“Leaving the orbital samples in a stable Mars orbit is one of several alternative strategies which are possible after the samples are launched from the Martian surface,” ESA says. The space agencies should do that, and wait until there is a demonstrably safe, off-planet way to analyse them. It will be fascinating to know about life on Mars – but it mustn't cost us the Earth. ■



Paul Marks is a freelance journalist, editor and writer based in London

Field notes from space-time

Mathematical woes caused by muons The standard model of particle physics explains a lot, but we are still confused about how to use it to calculate things, writes **Chanda Prescod-Weinstein**



Chanda Prescod-Weinstein is an assistant professor of physics and astronomy, and a core faculty member in women's studies at the University of New Hampshire. Her research in theoretical physics focuses on cosmology, neutron stars and particles beyond the standard model

Chanda's week

What I'm reading

Lessons from Plants by Beronda L. Montgomery. *It challenges us to move past thinking of plants as unconscious, photosynthesising machines.*

What I'm watching

I'm very happy that the Formula 1 season has kicked off, and I'm on Team Lewis Hamilton, as I am every year.

What I'm working on

I'm hiring a research assistant to help me build a bibliography of papers by Black women and gender minorities with PhDs in physics.

This column appears monthly. Up next week: Graham Lawton

WE TEND to think that the three biggest problems with the standard model of particle physics are how it struggles to include gravity, the absence of a good dark matter candidate and (to some of us, at least) its inadequate explanation for the cosmic acceleration/dark energy problem. Otherwise, it is heralded as an incredibly successful model of physical reality that has, over and over again, been tested and verified through experiments.

Although it seems to describe only about 5 per cent of the universe's matter and energy content, the standard model does explain three of the four fundamental forces: electromagnetism, the weak nuclear force and the strong nuclear force. It does all of this with just one equation. Simple enough, right?

But have you ever looked at that equation? There are so many parts in it that I was actually too lazy to count them all while writing this column. Instead, I resorted to estimating by counting the number of lines it took up (about 40) and estimating the number of major parts, which we call "terms," that appeared on each line (about three). In other words, this is an equation with around 120 major components. Yes, that is 120 plus or minus signs.

It makes sense that the Lagrangian – the equation that describes the possible states of the standard model – is complex. After all, it is tasked with describing every fundamental particle we have ever observed in the lab: all six types of quarks, three types of neutrinos, the electron, the muon, the tau, the photon, the W and Z bosons, the gluon and the Higgs boson.

And it is easy to get the

impression that because we are able to write down the equation that describes all of these particles and how they interact with each other at the most fundamental level, it is therefore easy to make calculations using the equation.

This is the opposite of the reality that we particle physicists find ourselves in. Completely solving an equation with this many terms is essentially impossible, and we usually have to figure out the conditions that allow us to ignore certain parts of the standard model in favour of the ones that matter for the

“Completely solving an equation with as many terms as that of the standard model is essentially impossible”

calculation before us. Even then, we have to use special techniques to get actual numbers out.

The key question that comes up when we sit down to perform a calculation is whether we can apply a technique called perturbation. When we use a perturbation-based approach, we start with a simpler equation than our standard model terms.

This simpler equation can't solve our problem, but it can help. Using carefully thought-through assumptions, we solve our more complicated problem by making small changes to the simpler equation. Most parts of the standard model can be handled using perturbative methods.

However, there is one area of the model where this doesn't work so well: quantum chromodynamics (QCD). This describes strong nuclear force interactions, quarks and their mediating particles

(gluons). Because of its unique features at low energies, QCD isn't always amenable to perturbation.

As such, we have had to resort to other techniques. The most notable of these is known as lattice QCD. It is so named because instead of treating space as continuous with no gaps, in lattice QCD, space is treated as though it is a grid.

The specific challenges of describing QCD have recently become a bit newsworthy because of an exciting announcement from the Fermi National Accelerator Laboratory in Illinois. The researchers there looked at muons, which are electrically charged particles that spin when they are in a magnetic field.

However, rather than spinning at the speed predicted by the standard model, the measurements at Fermilab found that they were spinning a little too fast. This could suggest that there are particles beyond the standard model affecting the results, and it is therefore a tantalising idea!

But on the same day in April that the announcement was made, a paper was published in the journal *Nature* that proposed there is actually no mismatch between the standard model and current experiments. Instead, the authors propose a new approach to solving the equations that describe this particular phenomenon in the standard model.

In other words, they think that the experiments are fine and so is our model – the problem is our calculation techniques. Only time will tell who is right, but this prospect is a reminder that figuring out what is going on is more complicated than theorising beyond standard-model physics. We also need to fully understand how to calculate with the physics we have. ■

Signal Boost

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



Closing the gap in childhood cancer care

Most childhood cancers are curable. We know this because survival rates in high-income countries often exceed 80 per cent. But for the vast majority of the 400,000 children who develop cancer each year worldwide, the prognosis is bleak. For children in low- and middle-income countries, cancer survival rates are as low as 10 per cent.

World Child Cancer exists to address this inequality. Our vision is a world where every child with cancer has equal access to the best treatment and care.

In setting the UN Sustainable Development goals the international community made “no one left behind” their objective. The sad fact is that children with cancer are being left behind, as some of the most marginalised and vulnerable children in our world.

The solution already exists, but its distribution remains tragically uneven. In too many countries, public and professional awareness of childhood cancer is low. Opportunities for early and accurate diagnosis are limited. Referrals are delayed. And there are

not enough health workers with the specialist skills to diagnose and treat the disease.

With little to no social support available, it is children and families that pay the price. That is why World Child Cancer works with local, regional and international partners to support systems-based solutions in:

1. Improving the quality of childhood cancer care.
2. Increasing the numbers of children diagnosed with cancer.
3. Providing financial and psychosocial support to families and children.
4. Influencing policy and public opinion on the need to do more on childhood cancer.

At the core of our approach is working in partnership with health care providers, civil society organisations and generous donors

that support children with cancer across the world every day.

2020 has been the year of covid-19, which has changed our world in so many ways, and is by no means over as we write this. It has had a significant impact on our ability to fundraise, while putting our partner hospitals under substantial additional pressure. We are proud that all our programmes have remained funded, and our aim is to resume growth as soon as we are able. The signs are that the pandemic will result in a significant increase in poverty that may result in more families being forced to abandon treatment.

We could not do this without the drive, determination, and commitment of people like you. So thank you for taking the time to find out more about our work. We have a lot planned.

Will you join us? Together we can close the gap in childhood cancer care.

Want to help?

With your help we will give more children with cancer the care and support they need. Visit worldchildcancer.org/donate

Editor's pick

Animal intelligence isn't like ours, at least not yet

10 April, p 36

From Martin Sigrist,
Newbury, Berkshire, UK

A unicycle is a mode of transport. So, too, was the space shuttle. However, their similarities are dwarfed by their differences. The same applies to intelligence and its sibling consciousness when comparing animals with humans. That there is variation in terms of problem-solving capability within animal populations doesn't make them "like us".

That isn't to say that intelligence and consciousness are uniquely human traits. Should our species end, it is likely that, in the aeons to come, another creature will evolve these attributes and also be capable of writing an email like this.

However, crucially, it won't be an orangutan. This species will be something entirely different. Regardless of its physical features, it will, essentially, be far more "like us" than any non-human creature currently living on this planet.

From Rita Goddard,
Ipswich, Suffolk, UK

Your article "Clever creatures" reviewed research highlighting the intelligence of a range of animals. In the same edition, "Love meat tender" (p 51) advises readers on how marinades enhance the taste of meat – perhaps even the flesh of those clever, video game-playing pigs referenced in the first piece.

So, on the one hand, the intelligence of animals is extolled, while on the other, we are given tips on how best to eat them.

A plant-based diet is well-documented as a sustainable, healthy alternative to the normalised meat-oriented diet. While radical to many, surely it demands examination, being integral not only to any rethink of our relationship with animals, but also to the sustainability of life on Earth.

More efficient farming may fuel meat eating

10 April, p 41

From Duncan Craig, London, UK

In your look at biodiversity and the climate crisis, you write that if everyone shifted to a plant-based diet, we would only need a quarter of the farmland used now, while vastly reducing greenhouse gas emissions associated with food production. But, you say, with meat consumption rising rather than falling, it is vital to maximise yields on existing farmland.

This approach is doomed to failure. If more intensive farming increases meat yields, prices will fall and even more people will eat meat, increasing the demand even further. Just as we have to cut back on fossil fuel use to reduce carbon emissions, we must find ways to promote moving to a more plant-based diet.

Vaccine passports could have moral hazards too

10 April, p 24

From Bryn Glover, Kirkby
Malzeard, North Yorkshire, UK

I agree with all Graham Lawton writes on the moral hazards of covid-19 vaccination, and suggest that this could be extended to one of the worst downsides of proposed covid-19 passports.

Once issued, these documents will instantly assume much greater significance or relevance than they could ever merit. People will wave their passports as absolute proof of immunity or unsusceptibility, and all the still-necessary measures, such as mask wearing and social distancing, will go out of the window.

My fear is that commercial interests, such as airlines and package-holiday promoters, will be inclined to overstate the

significance of covid-19 passports in their eagerness to see the resumption of viable trading.

Are covid-19 disparities down to innate immunity?

3 April, p 40

From Helen D. Haller,
Pittsford, New York, US

As a well-off white person from the US who gets flu shots regularly and has had a lifetime of vaccinations (including BCG as a teenager), the article on the boost they may bring to innate immunity against the coronavirus made me feel very hopeful.

I wonder whether the large disparity in severe cases and deaths from covid-19 among some ethnic groups might be due to those affected not getting nearly as many of those jabs.

Dividends are only for the transition to green power

Letters, 17 April

From Catherine Dawson,
Devizes, Wiltshire, UK

Roger Elwell argues that, in a carbon tax and dividend system, people will expect the dividend to continue even when there is no carbon to be priced. But it is only ever intended to compensate for or offset the rising cost of fossil fuels during the transition to cleaner fuels (which the carbon fee incentivises), after which those extra costs should fade.

More wind power is no big deal here in the breezy UK

3 April, p 15

From Blaise Bullimore,
Tiers Cross, Pembrokeshire, UK

Your story comparing wind power requirements for a hydrogen-based vehicle economy with those for a battery-powered one implies that

the extra UK wind power needed for hydrogen would be a problem.

However, the UK has the lion's share of north-west Europe's wind and marine energy resources, and green hydrogen technologies are continuously improving. Ongoing growth of onshore and offshore wind, alongside green hydrogen production and storage, could see the UK become self-sufficient in energy – not just electricity – and a green hydrogen exporter.

Just reading this might give your brain a boost

17 April, p 38

From Alan Worsley,
Hull, East Yorkshire, UK

The article "How to keep your brain blooming" inspires me to suggest that on top of the seven points listed, "Read *New Scientist*" would be well worth adding. I have been reading the magazine since it started and I suspect my lifespan, health and general grasp of the human situation has increased as a result.

This bit of kitchen science finally made it to the lab

17 April, p 19

From Joe Oldaker,
Nuneaton, Warwickshire, UK

The extraction of a blue colouring from red cabbage will come as no surprise to many cooks – put red cabbage in a steamer and the water will emerge a deep green-blue. Curiously, if you steam broad beans, the water emerges crimson. I wonder whether this food-based colouring has also been exploited.

Keeping old age at bay with one simple trick

Letters, 10 April

From David Higginson,
Wokingham, Berkshire, UK

Further to the correspondence regarding mind over age, I follow the view that "old" is my current age plus 10. This has worked for me since the age of 12 – I am now 73 and feel great knowing that I can never be old. ■



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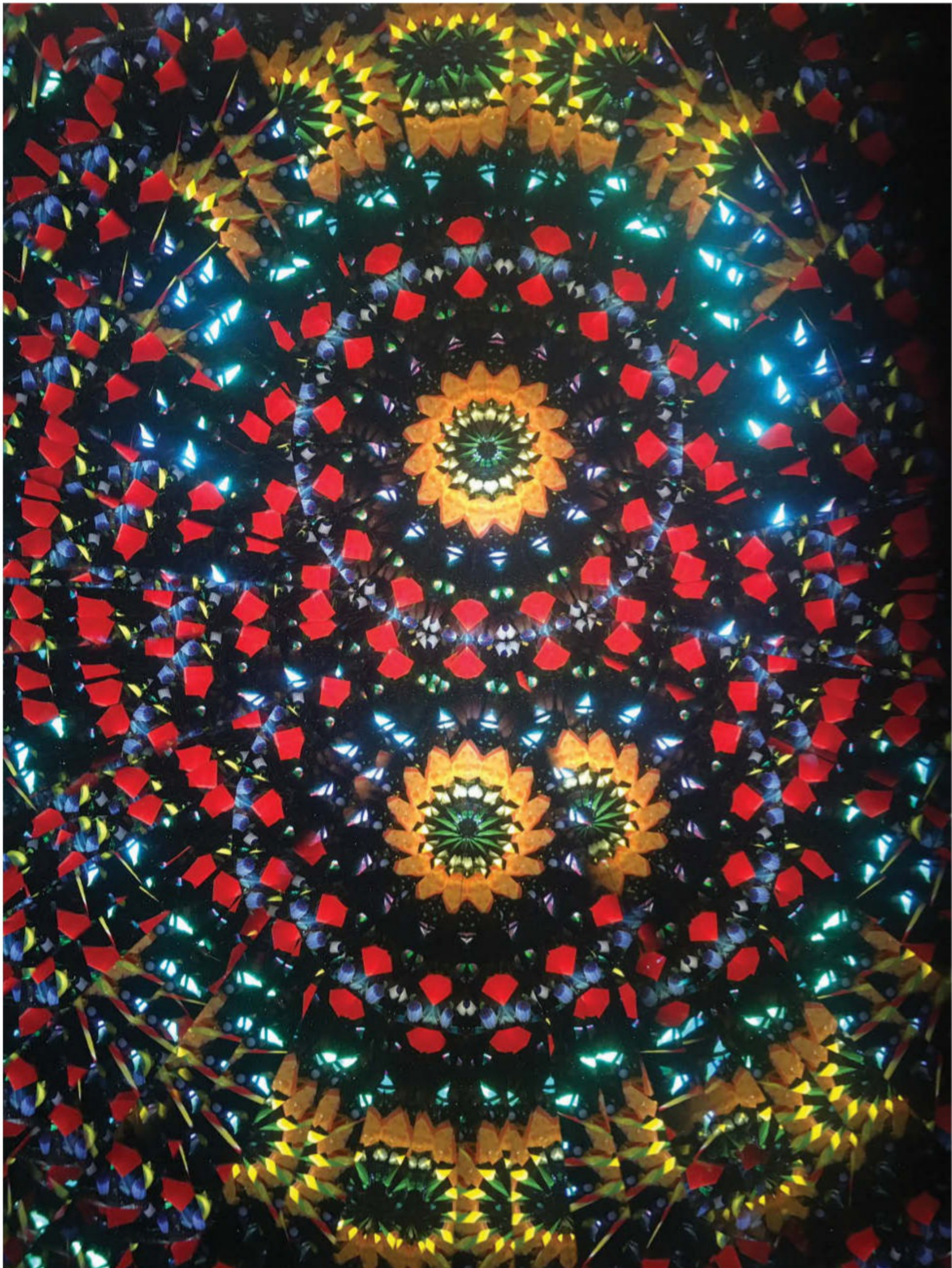
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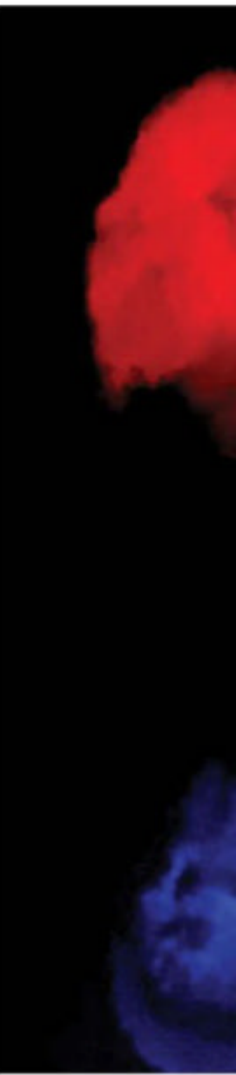
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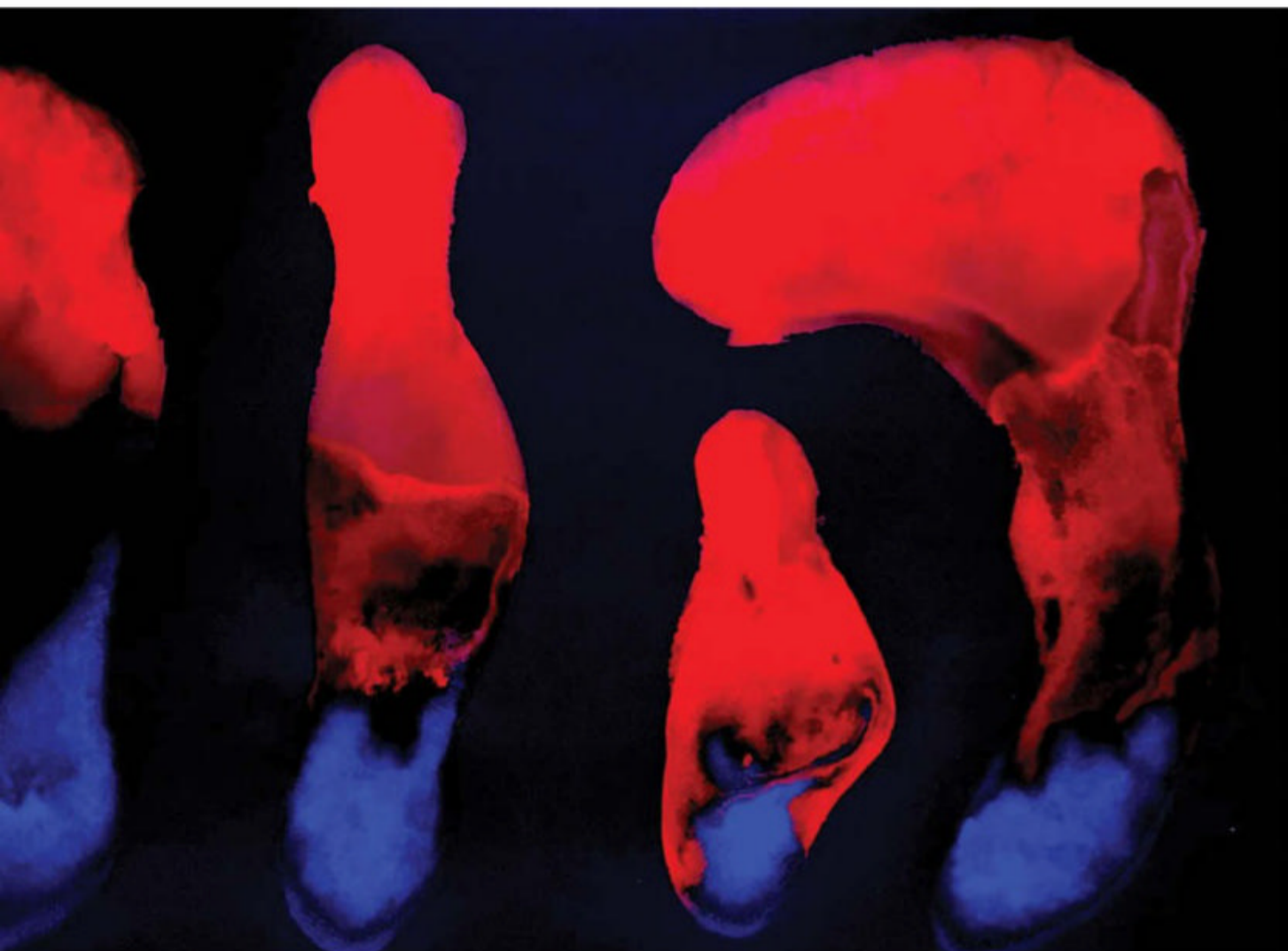
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Bright beauty



**Naturally Brilliant Colour,
Kew Gardens, London**

THESE beautiful, vibrant images are from a forthcoming exhibition exploring colour at Kew Gardens, London. The show highlights nature's most brilliant hues, as well as the brightest human recreations of them.

What we perceive as colour is normally the result of certain wavelengths of light being absorbed by the coloured molecules in pigments while others are reflected to our eyes. But some of the colours we see are created by light reflecting off microscopic colourless structures on animals and plants. These are called structural colours.

Mimicking this process could help industry to replace pigments that are hard to source ethically or sustainably.

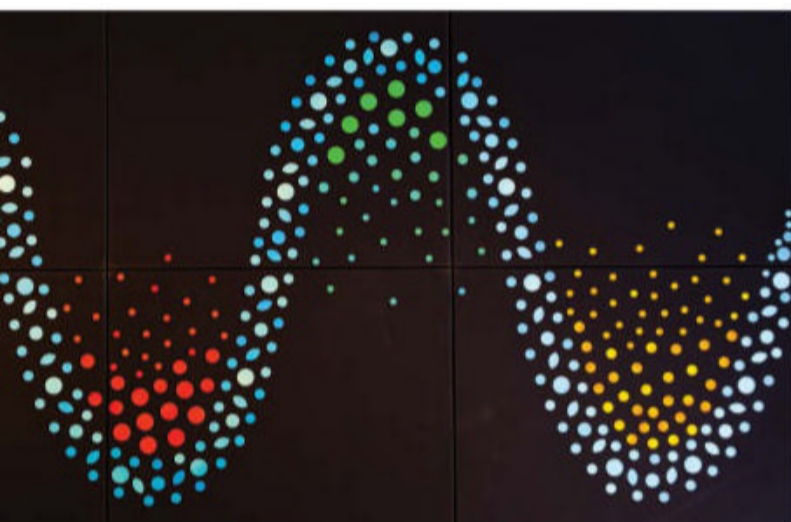
These images are from Lifescaped, the lab-studio of scientist-artist Andrew Parker. Lifescaped has reproduced structural colours in their most vivid form, using technology called Pure Structural Colour. This uses transparent materials to replicate colour-producing plant and animal structures.

The largest image shows a kaleidoscope of glass coloured with Pure Structural Colour. At top right is *Developmental Flow*, made using watercolour and gouache, and later digitally enhanced.

The pair of smaller images at middle right show dots of Pure Structural Colour on canvas, and the iridescent feathers of taxidermied hummingbirds. The final pair of images, at bottom right, show rainbow-like abalone shells, and lily flowers fluorescing under UV light.

Naturally Brilliant Colour opens at Kew Gardens on 17 May. ■

Gege Li



The carbon solution

A new exhibition demonstrates just how important carbon-sucking technology will be in tackling the climate crisis, says **Adam Vaughan**



Exhibition

Our Future Planet

Science Museum, London

Opens 19 May

FOR a device meant to represent the future, Klaus Lackner's mechanical "tree" looks more like a 19th-century machine than a 21st-century tool for scrubbing carbon dioxide from the air. Fortunately this prototype, the highlight of a new Science Museum exhibition on removing CO₂ from the atmosphere, will be superseded this summer by more elegant commercial versions akin to giant Alexa speakers.

Seeing the original up close brings home how desperate the climate crisis has become. Failure to cut our emissions fast and deeply enough means we need to remove so much CO₂ from the atmosphere that using forests alone won't cut it. We need technological and engineered approaches like this too.

The start of the Our Future Planet exhibition explains the basics of carbon emissions and climate change, and is devoted to natural solutions, featuring tree rings, videos of ancient forests and animations of how lidar can map carbon in trees. But the reason to visit – lockdown rules permitting – is the eye-opening second half, on the embryonic efforts to use technology to do the same job as trees.

"This is such an interesting area that's been relatively neglected. It has moved from being a bit of a joke, to a sinister way to get the fossil fuel industry off the hook, through to being, because we're in such a pickle at the moment, we'd be mad not to do it," says Roger Highfield at the Science Museum.



SCIENCE MUSEUM GROUP



SCIENCE MUSEUM GROUP

Alongside Lackner's 2017 tree is an SUV-sized machine resembling a cross between a jet engine and an air-con unit, made by Swiss firm Climeworks.

Although the technology is a little different to the mechanical tree, both use insoluble materials

“The reason to visit is the eye-opening second half, on efforts to use technology to do the same job as trees”

called sorbents to absorb the low-level amounts of CO₂ in the air.

The unit is a bit bigger than some that Climeworks is now deploying, but serves as a reminder of how much infrastructure we will need to build to reach goals of net-zero emissions.

Visitors can see the white threads of mineralised CO₂ in a cylinder of the basalt rock that Climeworks is using to store CO₂ captured in Iceland, plus products that have been made with captured CO₂,

Crayons and cutlery (and vodka) can be made from captured carbon

from vodka to a yoga mat.

There is also rock dust, which some researchers think should be sprinkled on farmland to speed up the rate that rocks naturally soak up CO₂. Carbon capture and storage (CCS) at heavy industry gets a brief video.

The exhibition explains why such engineered approaches will be needed in addition to the natural ones. There are only 0.9 billion hectares for more trees, according to one controversial estimate, plus the sheer scale of our emissions means we need all the methods we can get.

Curator Sophie Waring says she was aiming for “measured optimism”, and isn't trying to suggest that CO₂-removal technologies are heroic or will save us. “This has to sit alongside CO₂ reductions,” she says, adding that CO₂ removals will be best for hard-to-abate industries.

The exhibition mostly gets the balance right between pessimism and optimism, although it could have gone further in showing how expensive and small scale this stuff is.

Direct air capture of CO₂ costs an eye-watering £600 or more a tonne. And all the world's CCS facilities to date have only captured 260 million tonnes of CO₂. This is less than the UK emits in a year.

Nonetheless, it is an intelligent, thought-provoking and timely show. Our Future Planet provides a glimpse of objects and technologies that are alien to most of us today, but are likely to become as familiar as old-fashioned trees if we are to successfully tackle the climate crisis. ■



Not-so-unexplored depths

The deep sea has a reputation for being mysterious, but we are now learning so much about it, finds **Sandrine Ceurstemont**



Podcast

The Deep-Sea Podcast

Armatus Oceanic

IT IS hard to imagine what the deep sea actually looks like. There is practically no light in this lowest layer of the ocean, which starts at a depth of 1800 metres and reaches almost 11,000 metres at its deepest-known point within the Mariana trench in the western Pacific Ocean. Hence nobody has actually seen the deep sea close up, meaning we typically rely on colourful depth maps created with acoustic techniques to visualise it.

Furthermore, it is hard to make sense of the sheer scale of what lies underwater. The Pacific Ocean covers almost half the planet, for example. Due to its intangible nature, inaccurate analogies are often used to describe the deep sea.

Alan Jamieson at the University of Newcastle, UK, is renowned for his journeys to the deepest parts of the ocean. He has teamed up with Thomas Linley, a deep-sea fish expert, to co-host a podcast that portrays the deep sea as it really is, but without removing any of the wonder. Every episode of *The Deep-Sea Podcast* delves into both important issues, such as whether deep-sea mining should be allowed to happen, and more light-hearted angles, such as a Halloween special on why humans seem to intrinsically fear the deep sea.

The first instalment kicks off with one of Jamieson's biggest bugbears: comparing the deep sea with the moon. It is often said that we know more about the moon's surface than the deep sea, which he says is just plain wrong. "What other scientific discipline would start by saying how little they know about it?"

Jamieson thinks the analogy is unfair, firstly because the moon isn't

that big. The surface area of the Atlantic Ocean, for example, is almost three times larger than that of the moon. And while crewed missions to the moon have pretty much stopped, those to the deep sea have never ceased and have even ramped up. "We know so much more about the deep sea now than we did five years ago or 10 years ago," says Jamieson.

Each episode features an interview with a guest. Recent examples include director and producer James Cameron, who chatted about deep-sea tech and delved into the secrets of underwater lighting he learned while filming *Titanic*, as well as discussing ideas like walking on the seafloor by embedding consciousness in a robot.

The guests provide unique perspectives. For example, Alexandra Gould, a UK-based artist who accompanied scientists on a deep-sea expedition in 2019,

Wolf eels can be found more than 200 metres below the ocean surface



FRANCO BIANI/NATUREPL.COM

sketched almost all the crew, as well as sea life and moments that represented her interaction with the vessel when she was onboard. While marine biologists typically aim to analyse deep-sea creatures in detail, she says she prefers not to know too much about their biology as it can take away from the awe they inspire.

The Deep-Sea Podcast has many compelling moments, and the hosts provide expertise on aspects of the field. However, episodes are quite long, often lasting more than hour, and try to cover too much. They incorporate deep-sea news, for instance, which seems like it could merit its own podcast.

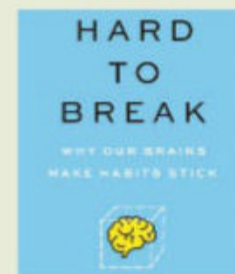
All in all, the show suggests that our relationship with the deep sea is becoming more complex. So far, it has been relatively untouched, apart from during scientific research. However, new ventures like deep-sea mining and tourism could soon change that, with the first leisure trips taking place last year. "Vast amounts of the deep ocean haven't even been looked at," says Cameron. "It would be nice if we understood it before we destroy it." ■

Don't miss



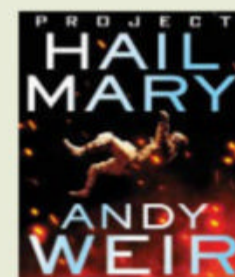
Watch

Jupiter's Legacy, on Netflix from 7 May, follows a generation of superheroes handing the torch of civic duty and personal virtue to their children, who are tasked with living up to their reputations. What could possibly go wrong?



Read

Hard to Break habits are no bad thing, says Stanford University psychologist Russell Poldrack, and instilling the right ones will be crucial for tackling threats to our species' future. The ability to change our unwanted tendencies will also be vital.



Read

Project Hail Mary by Andy Weir, author of the 2011 hit *The Martian*, once again pits a sole survivor against almost impossible odds. This time, however, the fate of Earth hangs in the balance and our protagonist has amnesia.

T: NETFLIX

The TV column

Greta Thunberg's year off A three-part BBC series follows the teenage climate change activist as she takes a break from school to learn from the world's top environmental scientists and economists, finds **Karina Shah**



Karina Shah is a news intern at New Scientist. Follow her on Twitter @karinashahh



BANFA JAWLA/BBC STUDIOS

Greta Thunberg spent a year exploring the science of global warming

equipped with solar panels, a wind turbine and hydro-generators.

We see her brave life-threatening storms on the 21-day transatlantic voyage. “It was a constant game of avoiding the next big storm,” says Thunberg. After she safely reaches Spain, the first episode finishes with the hard-hitting speech – fuelled by facts and figures – that she gives to COP25 delegates.

The series continues to 2020, and we see how Thunberg is challenged by the covid-19 pandemic and how it has brought the world to a standstill. As covid-19 makes mass protests unsafe, Thunberg investigates how we can all play a part in the fight against climate change closer to home – from rethinking our food choices to the clothes we wear.

She isn't the only person who sees the pandemic as a crunch point. The documentary features Jillian Anable, a professor of transport and energy at the University of Leeds, UK, who feels our approach to covid-19 could inform future climate action. “We've had a global crisis and we're in a situation where policy-makers have had to put the science at the forefront,” she told *New Scientist*. Indeed, the series clearly presents the scientific evidence and extremity of climate change without getting caught up in the politics of decision-making.

It can be difficult to demonstrate the urgency of climate change to those who see it as a threat for the distant future. But by showcasing Thunberg's journey in learning about the science behind climate change, we see that the evidence presents itself every day. ■



TV

Greta Thunberg: A year to change the world

BBC1 in the UK and PBS in the US

Karina also recommends...

Film

There's Something in the Water

Directed by Elliot Page and Ian Daniel

An examination of environmental racism and the disproportionate effects of pollution on Black Canadian and Indigenous communities in Nova Scotia.

Book

Brown Baby
Nikesh Shukla

A beautiful memoir in which the author finds hope in a world of racism, sexism and the impending climate crisis.

“I DON'T want you to listen to me, I want you to listen to the science,” says Greta Thunberg in the first episode of a three-part documentary series about her life.

It is a message we have heard before from the 18-year-old. But in *Greta Thunberg: A year to change the world*, we follow the activist as she takes a year off school to learn more about herself, get hands-on experience of the consequences of climate change and further explore the science of global warming with the help of the world's leading scientists.

Thunberg has been the figurehead for young climate activists across the world ever since she started protesting in front of the Swedish parliament building in 2018, aged just 15. Since then, she has inspired thousands of people and challenged policy-makers in her fight against climate change. Her impact has even been dubbed “the Greta Thunberg effect”.

The first episode of this BBC documentary focuses on Thunberg and her father, Svante, in late 2019 as they travel through North America on their way to the

UN COP25 climate conference in Chile. They stop at locations that reveal how the environment is changing as a direct result of warming temperatures.

At one point, the first episode starts to resemble something out of a horror film when it introduces real footage of Californian wildfires, which were among the deadly blazes that ravaged the west coast of the US between 2018 and 2020.

“Greta Thunberg investigates how we can all play a part in the fight against climate change close to home”

With just over a month until COP25, Thunberg receives news that the event is being relocated to Madrid following social unrest in Chile's capital, Santiago. “I've been going halfway around the world the wrong way,” she says. As she famously opposes air travel, she hitches a ride across the Atlantic Ocean with a family, making the trip in a carbon-neutral catamaran

**New
Scientist
Podcast**



The New Scientist Weekly podcast

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Episode 64

Earth Day rescue plan:
climate change and
biodiversity special

Episode 63

Musical spider's webs, magic
mushrooms for treating depression
and the sound of coronavirus

Episode 62

Synthetic life,
rescue plan for Earth and
muon g-2 new physics

Episode 61

Worse allergies,
black hole in our backyard
and new flavours of vanilla

Hosted by *New Scientist's* Rowan Hooper, new episodes are out each Friday.
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Taming big tech

The recent conflict between Facebook and Australia is just one skirmish in a new battle to control the web, finds **Chris Stokel-Walker**

STAND-OFFS between nations are nothing new. But a very public spat between a government and a commercial company, in which each accused the other of taking citizens hostage and threatened sanctions, certainly seemed novel when it broke out this February.

This was the case of Facebook versus Australia, in which the tech giant briefly cut off access to some parts of the web through its platform for its 17 million Australian users, in response to a proposed law that would force it to pay for linking to news stories. Opinions are still divided on the rights and wrongs – but this skirmish looks like just a foretaste of bigger battles to come.

Across the world, governments are concluding that tech giants such as Facebook and Google exercise too much power and are undermining the public good by allowing hate speech and misinformation to proliferate. Not only in Australia, but also in the UK, the US, the EU and elsewhere, plans are afoot to bring them to heel.

That determination brings with it risks, though. Clamp down too hard and you can damage freedom of expression, and send out the wrong signals to authoritarian regimes worldwide. Bring in different rules in different places and you risk Balkanising the internet, destroying the universality on which it is built. Not even the tech companies deny that something should be done. The question is, what?

Big tech has certainly become big. Facebook, Google and other tech companies' incomes have ballooned as they have benefited from the changing ways we communicate and

access information and services. If Facebook's \$86 billion revenue in 2020 were a nation's GDP, for instance, it would rank 66th in the world, with an economic output roughly on a par with Sri Lanka's.

The success of these firms is built on data about our interests and predilections gleaned from keeping our eyeballs glued to their platforms. The basic business model is advertising. The longer and more exclusively we use big tech's sites and services to communicate, search or shop, the more the learning algorithms that underpin them find out about what we like and think – the better then to place ads we are likely to click on.

The tech companies have largely had free rein to do that. Initially, governments saw the sector as too complicated to regulate. Then it was too fast-growing a success to slow down. But that view is now changing in many parts of the world. "We're reaching a point of maturity in these markets, and with that maturity comes the various policy debates you get to now," says Max Beverton-Palmer at

the Tony Blair Institute for Global Change, a think tank set up by the former UK prime minister to promote a more globalised world.

That, plus the sense of something going seriously awry. It is often the most outrageous content that hooks us and keeps us clicking. The tech companies stand accused that their algorithms push people to peddlers of fake news and extreme content, poisoning public discourse. The algorithms also often reflect the biases of their designers, sometimes drowning out minority voices.

"The last 12 months have really demonstrated – with QAnon and the attempted insurrection at the US Capitol, and the problem of anti-vaccine conspiracy theories and disinformation around covid – that this content exists in ever-growing quantities and is influencing real-world behaviours," says Damian Collins, a UK MP and former chair of the House of Commons's Digital, Culture, Media and Sport Committee.

Facebook, the world's biggest social network, with 2.8 billion monthly active users, often faces the brunt of criticism. Its response has been attempts at self-regulation, including introducing content moderators and last year establishing a nominally independent Oversight Board to review controversial decisions (see "Who watches the watchers?", page 36). That doesn't satisfy Collins, who is a member of the Real Facebook Oversight Board, a group of academics, politicians and civil rights activists set up to put further pressure on the company. "The model is holding people's attention," says Collins. "It's not suited them to try and change the way they regulate the platform." ➤

“Big tech was first seen as too complicated to regulate, then too successful to slow down”



MARCUS MARRITT

Who watches the watchers?

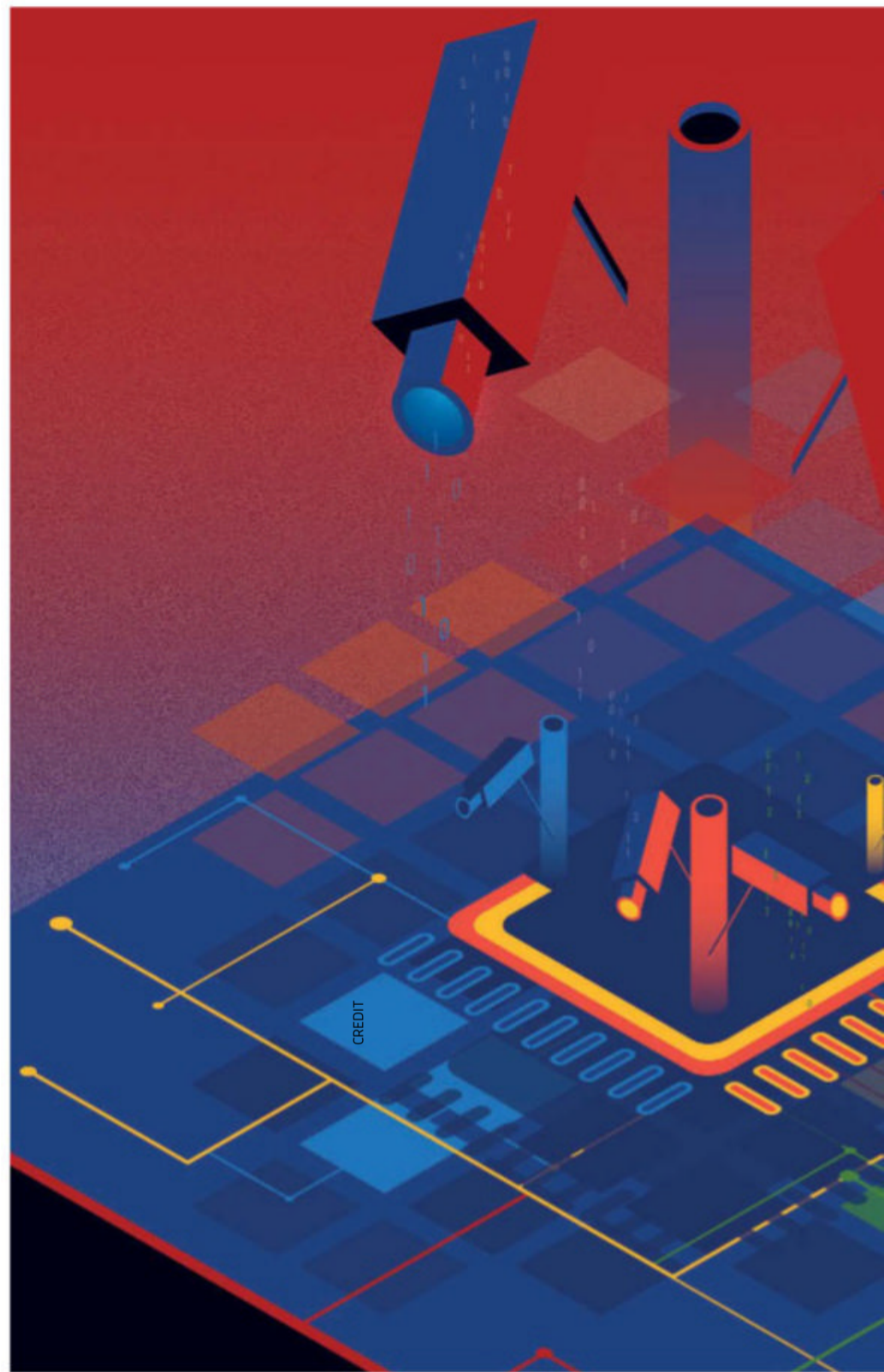
Faced with the threat of increased government regulation (see main story), big tech companies often argue that self-regulation is a better answer. Yet two of the biggest tech titans, Facebook and Google, have both faced issues in recent months with internal systems of checks and balances they have set up.

Facebook's introduction of a board of outside figures paid to review contentious decisions about content on its Facebook or Instagram services has received a mixed response. In January, its newly constituted Oversight Board ruled on five decisions the company had taken to ban individual posts on grounds ranging from hate speech to adult nudity. It found Facebook had misstepped in four instances, and proposed nine recommendations for the company to improve its policies.

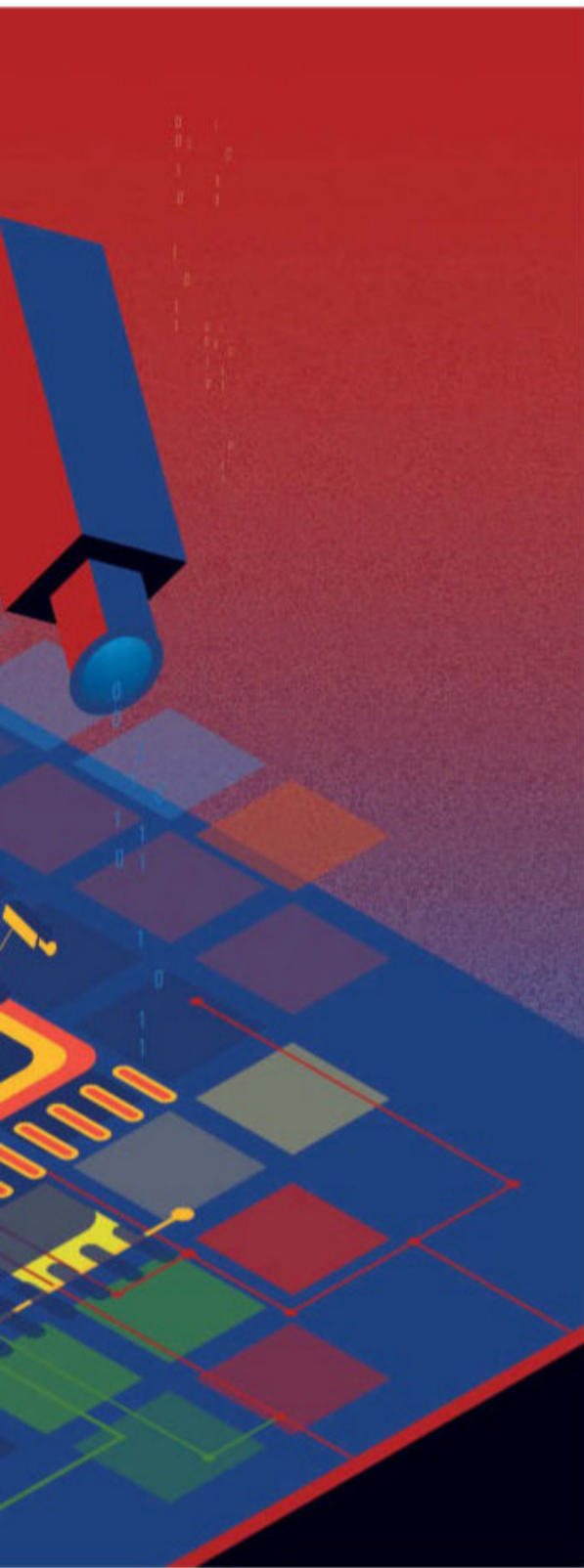
But the activist-led Real Facebook Oversight Board called the decisions "oversight theatre", criticising the lack of transparency in how they were reached and saying they would do little to address the spread of hate speech and disinformation. "Facebook desperately needs oversight," it said. "This is not it."

At Google, meanwhile, the problems have centred on its artificial intelligence ethics unit. To serve up the best search results and target ads better, the company's algorithms need to know you – but algorithms can often accentuate biases. In December 2020, Timnit Gebru, who jointly led this unit, left the company after it asked her to withdraw a paper warning of potential biases and negative environmental impact of an AI algorithm used to learn what we search for and type, and she refused. Google claims she resigned; she claims she was sacked.

In February this year, it fired the unit's other leader, Margaret Mitchell, who had criticised the company over Gebru's departure, for an alleged code-of-conduct breach. It brought 10 teams within the company, including the AI ethics unit, under the control of Marian Croak, a prominent black vice-president at Google, to try to "turn around the situation", Croak said to staff in a leaked recording.



“Bring in different rules in different places and you risk destroying what the web is built on”



Technology Initiative at the University of Cambridge, goes even further in her critique of big tech's business model. "They think of it as freeing up markets and freeing up things," she says. "I think of it as destroying or undermining existing things and rebuilding them in a way that relies on these new services."

Perhaps surprisingly, Facebook itself doesn't deny a need for some change. A spokesperson told *New Scientist*: "We recognise our significant responsibilities as a company and have actively called for more government regulation." They added: "By updating rules for the internet, we can preserve what's best about it – the freedom for people to express themselves and for entrepreneurs to build new things – while also protecting society from broader harms."

Detrimental effects

The fear from big tech and its defenders is that politicians trying to claw back some balance will end up tipping the scales the other way. Overly censorious laws on big tech could reduce freedom of expression, while leaving platforms so liable for the content posted on them that they can't be effectively moderated.

So what of Facebook versus Australia? Nominally at least, the spat related to a small but unusually sensitive area of the wider concerns: how big tech's platforms are, while amplifying those who promote hate speech and unreliable information, also undermining genuine journalism. Money that advertisers might once have paid newspapers and the like to place against their journalism, providing them with a large chunk of their revenue, now goes to the tech giants whose sites direct them to it, but who pay little or nothing towards making it. "The way private sector, laissez-faire regulation has driven technology companies is sometimes at odds with healthy discourse and has had some detrimental effect on local, independent media sources, which are also essential to a vibrant and healthy democracy," says Lindsay Gorman at the Alliance for Securing Democracy, a US think tank.

Voluntary revenue-sharing agreements

between big tech and media companies have been trialled, but increasingly governments have stepped in. In France, a "link tax" introduced this year, based on the EU's new copyright directive, will compel Google to pay \$22 million a year to French news publishers for the next three years to feature their stories in Google search results.

Google also signed a stand-alone deal on 17 February with the media business News Corp, owned by Rupert Murdoch, to stave off an Australian government law to compel them to. Facebook refused, for a time blanking access to news content from its site in Australia. The stand-off only ended after international condemnation of the firm, and some concessions from the Australian government.

While it did bring the companies to the negotiating table, Australia's attempts to make tech platforms pay for access to news was "tremendously misguided", says John Bergmayer, legal director at Public Knowledge, a US-based organisation campaigning for an open internet. Some critics claimed the move was more about the Australian government protecting powerful allies in traditional media.

Others, however, are applauding an assertion of democratic rights. "The Australian case shows that when politicians decide to legislate and stick by that, the companies have to respond, even if they don't like it," says Collins. "I think it's an early taste of what we're going to see elsewhere."

And there is much more in the pipeline. In the UK, an Online Safety Bill has been drawn up for debate this year. As currently worded, it will make UK communications regulator Ofcom responsible for ensuring digital platforms protect their users from harm – defined as anything from enabling child sexual exploitation to allowing the distribution of damaging content about eating disorders – with fines of up to 10 per cent of a company's annual global turnover for failings.

The European Union's General Data Protection Regulation (GDPR), in force since 2018, has already restricted how tech platforms can handle user data, and the EU is planning a Digital Services Act similar in purpose to the UK legislation. "It will protect users and their

Others agree. "The idea of disruption that's embedded in the Silicon Valley ethos has created amazing new opportunities and tools and services that transform the world," says Beverton-Palmer. "But when you reach a certain size with a company, there's inertia in the system and you're either trying to hold on to that power or you're trying to battle against other power sources."

Jennifer Cobbe, a member of the Trust &



RICK CROFT/AP/SHUTTERSTOCK

The Australia vs Facebook case highlighted big tech's fraught relationship with other media

Bergmayer favours a more direct approach, breaking up big tech where necessary. “You don’t just have one big, global telephone company for Earth, but that’s kind of where we are with Facebook,” he says. Gorman, meanwhile, thinks that at least some of the initiative for change has to come from within. “I’d love to see more initiatives at companies, whether big or small, to build a democracy by design framework into their product development, so the emphasis isn’t only on scale, scale, scale and grow, grow, grow, but also doing that in a civically minded way,” she says. That would ensure businesses have the time to think through changes to their products and the impact they could have on society, rather than letting algorithms focused on driving attention pollute the discourse, she says.

But decisions need to be made, and made quickly. “We’re at an inflection point, where either we leave things as they are so they become entrenched so deeply that it would be difficult to remove, or we intervene more strongly,” says Cobbe.

“The gold standard should be a cross-border cooperation on these ideas to set up principles and standards that will work everywhere,” says Beverton-Palmer. He also suggests that governments should bring big tech into the discussion. “We should create regulatory structures and global geopolitical agreements that incentivise things like the Facebook Oversight Board, but shore it up to make sure it is truly independent and can hold companies to account,” he says. Encouraging good behaviours alongside explicitly punishing bad ones – and creating a cohesive set of rules of the road for tech companies to follow – is likely to get us closer to rebalancing things, but we may have to accept there is no perfect solution, says Beverton-Palmer. “We’re never going to get over the problem of who watches the watchmen.” ■



Chris Stokel-Walker is a freelance technology journalist based in Newcastle, UK

fundamental rights, rebalancing the responsibilities of users, platforms and public authorities according to European values, placing citizens at the centre,” a European Commission spokesperson told *New Scientist*. Individual EU countries can go further. Germany, whose history gives it a low tolerance of hate speech, recently beefed up its Network Enforcement Act, requiring digital platforms not just to remove offensive content fast or face punitive fines, but also to proactively report the worst cases to police.

Meanwhile, under a planned EU Digital Markets Act, companies found to be engaging in monopolistic behaviours will be fined up to 10 per cent of their global turnover, with the aim of levelling the playing field for smaller, nimbler start-ups. In the US, there is increasing talk across the political spectrum about breaking up the tech titans, with executives such as Facebook’s Mark Zuckerberg called to congressional hearings to explain why their companies should be spared. In India and Pakistan, governments have become more interventionist against content they feel is inappropriate being shared on social media

Holistic approach

The diversity of these different approaches has some people worrying. “It’s not helpful to have too diverse a hodgepodge because you end up having to comply with the

“We may have to accept there’s no perfect way to rebalance the relationship with big tech”

bottom line anyway,” says Gorman. She points to unintended consequences of the GDPR: following its introduction in Europe, some US news websites refused to allow European visitors to access their sites for fear of falling foul of the regulation.

Yet there is little agreement on the best way forward. Beverton-Palmer favours something like the UK’s planned online safety legislation: it is a worthy attempt to build something coherent from first principles to minimise digital harms, he says. Collins agrees, saying the proposals will target how the tech giants make money, forcing action. Cobbe is less sure. “There’s very little in the way of targeting their business models and root problems,” she says. “Some of it could be very useful, but it’s not the holistic, multipronged approach we need.”

An old-growth conifer
forest in British
Columbia, Canada



R. TYLERGROSS/GETTY IMAGES/CAVAN IMAGES

The wisdom of the woods

When **Suzanne Simard** discovered the wood wide web, people were sceptical. Now she has found that trees are caring, sentient and wise, she tells Rowan Hooper

FEW scientists make much impact with their PhD thesis, but, in 1997, Suzanne Simard did just that. She had discovered that forest trees share and trade food via fungal networks that connect their roots. Her research on “the wood wide web” made the cover of *Nature*. What was then a challenge to orthodox ideas is today widely accepted.

But Simard and her colleagues continue to challenge our preconceptions of how plants interact. Among other things, their research shows that the wood wide web is like a brain and can communicate information throughout the entire forest, that trees recognise their offspring and nurture them and that lessons learned from past experiences can be transmitted from old trees to young ones.

Simard calls herself a “forest detective”. Her childhood was spent in the woods of British Columbia, Canada, where her family had made a living as foresters for generations. As a young woman, she joined the family profession, but soon realised that modern forestry practices were threatening the survival of the ecosystem she loved. She knew that, when logged with a lighter touch, forests can heal themselves, and she set out to discover how they are so naturally resilient. Along the way, her concern for the future of forests sparked an intense curiosity about what makes them tick.

Simard is now a professor in the faculty of forestry at the University of British Columbia. Her new book, *Finding the Mother Tree: Uncovering the wisdom and intelligence of the forest*, tells how – like trees in a forest – her life and research are intricately intertwined.

Rowan Hooper: How did your discovery of the wood wide web change the received wisdom about forests?

Suzanne Simard: The key finding is that trees are in a connected society, and that it’s a physical network and that they trade and collaborate and interact in really sophisticated ways as a cohesive, holistic society. From my training, and from the way we viewed forests or any plant community prior to that – at least in Western thinking – we didn’t see plants as collaborative and linking. We thought that plants are solitary and compete to acquire



Suzanne Simard was raised in the Monashee mountains in British Columbia, Canada. Her research, beginning with the discovery of the wood wide web, has transformed our understanding of forests. She is now a professor of forest ecology at the University of British Columbia.

as many resources as they can to increase their fitness. That idea isn’t necessarily wrong. It’s just that the way plants grow isn’t simply by competition. They also collaborate, and there are synergies.

The wood wide web consists of fungi as well as tree roots. What are fungi in these mycorrhizal networks like?

There are many different species of fungi, and they have niches and different physical and physiological structures. Some are really big pipelines. Some are little – tiny, fine threads. They all have different roles in extracting resources and moving things around. If you change the composition of that fungal community, you actually change how nutrients and carbon and water are moved around.

At first, some biologists were sceptical about the wood wide web. How did you convince them?

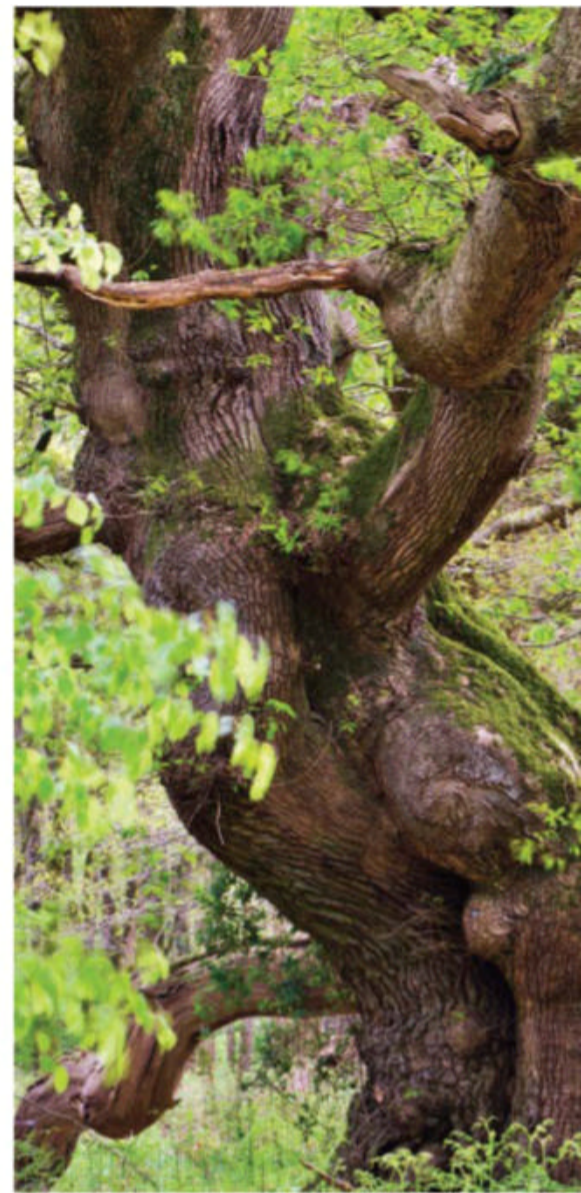
It was so tiring. I had to keep showing that these networks exist, and that plants are obligate mutualists with fungi; this means

they need them to gather nutrients and water from the soil, especially in a stressful environment. That is what all seeds encounter when they are trying to germinate. The environment is a stressful place because seeds are small, there are predators, competitors – there’s all sorts going on. And this little boost, the boost provided by the fungi, even though it’s hard to measure, can make the difference between survival or death.

This doesn’t challenge natural selection at all. Darwin wrote about the importance of collaboration in communities. It’s just that it didn’t gain traction like the idea of competition did. Natural selection results from more than competition. It involves a lot of different interactions and relationships between species and with the environment.

Richard Powers fictionalised your struggle in his arboreal novel *The Overstory*. Did his account ring true?

Powers did such a great job. He was able to construct this character, and I thought that he really captured it well. Even though





ADAM BURTON/NATUREPL.COM

“Mother trees are the hubs of information, and nurture their own offspring”

Patricia Westerford studied above-ground communication and I was studying below ground, that didn't really matter. All the personal things about the difficulties in advancing her ideas and getting her work out there, I encountered something in parallel.

The pushback against your work reminds me of the reaction James Lovelock's Gaia hypothesis received. Do you agree?

I think it comes back to the fact that there had been this separation of humanity from nature, mind from body, spirit from intellect, and that we had moved away from this more holistic, spiritual way of seeing the world. Lovelock's idea of the biosphere as a self-regulating system was antithetical to the view that we could dissect the world and understand all the parts in a deterministic way. It was similar with Lynn Margulis and her endosymbiotic theory, showing how eukaryotic cells evolved from the engulfment and collaboration between different prokaryotic cells. She was ridiculed and her papers were rejected – but now her ideas are mainstream.

Mature trees, such as this oak, hold information accrued over centuries

You have continued to make remarkable discoveries. How did you find out that trees recognise their family members?

I was working on mycorrhizal networks, seeing if the networks were improving regeneration of seedlings around trees. And it seemed like the next logical question was: well, would the networks be able to favour seedlings that were coming from the mother trees, the parent trees? I worked with Susan Dudley at McMaster University [in Canada] and we have found that kin recognition occurs in conifers. It's happening through mycorrhizal networks, and it's an important phenomenon in structuring these forest communities.

We were able to trace the carbon transferred between trees. We would label a mother or a sibling plant [by feeding it with carbon dioxide that contained a radioactive form of carbon] and then we would see that the carbon would transmit to a kin seedling, but not to a stranger planted nearby. I don't know how they recognise their kin, but I assume it's by chemicals because when we allow seedlings to connect with the mother trees or with their siblings, through these mycorrhizal networks, we get responses much more dramatically than if they connect with non-kin. It changes the rooting behaviour. It changes their chemistry, the nutrition of the plants and the response to disease.

All this reminds me of the “mother tree” in *Avatar*, a film featuring an alien species that can tap into something like a forest-wide natural network. Were you involved with that?

It's funny, when the movie came out, I got a call from someone who said that [director] James Cameron based his idea of the film's “hometree” and the Na'vi people connecting to the network on my work. I was like: “Oh, really? That's cool. I'm glad somebody picked it up.” And then when I went to see the movie, I'm just like: “Oh my god, of course he read my papers.” Interestingly enough, James Cameron is making sequels to *Avatar* right now, and they're making a documentary on the science behind *Avatar*. And now they've contacted me.

Your latest findings are even more mind-blowing. Tell us what you discovered when ➤

The Mother Tree Project

you mapped the nodes and connections in mycorrhizal networks.

The architecture of those networks follows a biological neural network. In your brain, neurotransmitters have got to move from different lobes in order for your thought patterns to emerge. So they have evolved to do that efficiently.

It turns out, the underground network in the forest is designed the same way. I think it's for efficient transfer of information and resources for the health of the full community. Not only that, but the chemicals that are moving in those networks include glutamate, which is one of the dominant neurotransmitters in brains.

Is it too much to suggest that, like in a brain, there is intelligence in this network, even wisdom?

From a purely biological, physical analysis, it looked like it had the hallmarks of intelligence. Not just the communication of information and changes in behaviour as a result, but just the pure, evolved, biological chemistry and the shape of the networks themselves spoke to the idea that they were wired and designed for wisdom.

If you look at the sophisticated interactions between plants – and some of that happens through the networks – their ability to respond and change their behaviours according to this information all speaks of wisdom to me.

What about awareness? Are trees aware of us?

Plants are attuned to any kind of disturbance or injury, and we can measure their biochemical responses to that. We know that certain biochemical pathways are triggered to develop these cascades of chemicals that are responses to stresses and disturbances, like chewing by herbivores. And if they are so attuned to small injuries like that, why wouldn't they be attuned to us? We're the dominant disturbance agent in forests. We cut down trees. We girdle them. We tap them.

If I injure trees so much that they start to die, they start sending their carbon through their roots to their neighbours. They are responsive to us. We've proven it by doing our experiments. People go: "Oh, that's kind of scary". But why

Every forest has its share of mature, majestic trees. Forest ecologist Suzanne Simard at the University of British Columbia, Canada, calls these "mother trees". She and her colleagues have found that they are crucial to the well-being of the entire forest community. They are the hubs of communication, protection and sentience, they nurture their own offspring and they provide information to help generations of trees survive. This has crucial implications for the way we manage forests, which is why, in 2016, Simard launched The Mother Tree Project to explore the role that mother trees play in forest regeneration.

"It's the biggest project I've ever done," says Simard. It involves 24 Douglas fir forests stretching across nine climate regions in British Columbia. Each forest is logged using five different harvesting treatments, ranging from felling all the trees in an area to keeping large patches of trees with mother trees present. The team

monitors and measures how the forest responds and regenerates by collecting information before and after logging about things like carbon storage, biodiversity and productivity.

Research is ongoing, but there have already been some compelling results. "We've found that the more mother trees we leave, the more diverse and abundant the natural regeneration is," says Simard. Her team also has good evidence that mother trees protect seedlings, especially when conditions get tough, such as when there is a frost or a particularly hot, dry day. By comparing results in different climate regions, the researchers aim to identify more sustainable ways to manage forests in the face of climate change.

"I wanted to create a project that would show people that you can do things in a different way and design forest practices around the idea that the forest is a connected, nurturing, healing place," says Simard.



The roots of trees like this red cedar form an underground network with fungi to create a kind of forest-wide brain

CHERYL-SAMANTHA.OWEN/NATUREPL.COM

“Trees are aware of everything around them. Why wouldn’t they be aware of people?”



JAAP ARRENS/NURPHOTO VIA GETTY IMAGES

wouldn’t plants be aware of people? They are aware of everything else.

That might surprise some people in the West, but not the Indigenous communities in North America with which you collaborate. How do they see the forest?

The work I do about trees being connected and nurturing each other represents a world view that has been known for thousands of years by the Aboriginal people of North America. But there’s been this long history of ignoring them and ridiculing them and destroying them. Maybe we won’t listen to Aboriginal people because we think it’s mystical and airy-fairy and spiritual, and that we really only want science, but I’ve been able to demonstrate some of these holistic connections with science. We’re doing the same things. We have the same findings and world views. So let’s work as a team.

How has your upbringing shaped your own views?

I grew up in the forest, seeing how it was this diverse, entwined, very complex place where all these creatures live together. The trees, the roots overlapping, the many species growing together, the lush, structured forest – that was what I knew. My family are foresters, and when I started getting involved as a forester, there was a big shift going on in industrial practices,

with clear-cutting [felling all the trees in an area]. Intuitively, it didn’t make sense to me.

Have things got better now that we know about the connections in forests?

We know a ton about how to make it better, and there are definitely people who want to make it better. There’s a lot of pressure to improve practices, and we even have certification of our forests to show that we do sustainable forestry practices. But look at the big picture in British Columbia. We’ve turned, in my short lifetime, from a province of old-growth forest to a province full of clear cuts. Even the iconic old-growth forests with the big cedars and hemlocks and spruces on the west coast, those towering forests, only about 3 per cent are left. We’ve cut everything down, and it’s not stopping.

So, no, it hasn’t improved. In some ways, it’s got a lot worse. And I think that this is manifested in these big indicators, which are climate change and loss of biodiversity. A lot of that comes from forestry practices.

Should there be some sort of charter for trees, akin to animal rights or human rights?

That’s a great idea, yes. We have the United Nations Convention on Conservation of Biodiversity and we’ve got the Paris Agreement on climate change. Conservation of forests is

Science points to ways in which we can improve forestry management

crucial to both of those things. So we have treaties and yet we don’t honour them. The iconic old-growth forests are hugely diverse and store megatons of carbon. Those forests aren’t very well protected and they aren’t protected far into the future. When we push the system to collapse – which is what we’re doing if we lose those old-growth forests – what are we going to do? They are the places where that genetic diversity lives, that we are going to depend on in order to get us through climate change.

What would you like people to do after hearing about your work or reading your book?

I want them to want to go to the forest. That’s the most simple, basic thing. Just go and be with it and love it and care for it and talk to it and show your respect for it. I think that is the foundation of changing our behaviours. Ultimately, this will translate into action. Not everybody will act, of course, and not everybody has to act. But we need that change to happen, and it starts with connecting back with nature. ■



Rowan Hooper is podcast editor at *New Scientist*. His latest book is *How to Spend a Trillion Dollars*



Making malaria history

The battle to eradicate this killer disease is entering a crucial phase.

Will it succeed? **Jacob Kushner** reports from Kenya.

Photographs by **Lena Mucha**



We longed for it to come,” Janet Mula told me, recalling her reaction to hearing that scientists were developing a vaccine against malaria. Mula, a nurse I met while travelling in rural Kenya, has seen the devastation caused by this disease first-hand. Each year, it sickens more than 200 million people globally, killing at least 400,000. The vast majority of cases are in sub-Saharan Africa, with the biggest burden falling on younger people. “Malaria causes many complications for children – anaemia, organ failure, jaundice, liver complication,” says Mula.

That could soon change, however. While most of the world is focusing on new vaccines for the coronavirus, thousands of Kenyan children are finally receiving a longed-for malaria vaccine, 37 years after its development started. Since 2019, Kenya, Ghana and Malawi have been taking part in a pilot

programme coordinated by the World Health Organization (WHO). If it is successful, the vaccine will be rolled out to infants across Africa. As this went to press, results of trials of another vaccine, developed by the University of Oxford, suggested it was 77 per cent effective.

Some hope these vaccines will eventually help to eradicate malaria entirely. Every year on 25 April, World Malaria Day, the WHO assesses the progress made in combating the disease – and it has been considerable. But eradication would be a massive achievement: it has only ever happened with one human disease, smallpox. “Eradicating smallpox – it’s a wonderful story,” says global public health consultant Desmond Chavasse. “But we so nearly failed. The world nearly lost its determination to do it.” When it comes to malaria, even with a new vaccine, if action isn’t fast, we may miss our chance.

The parasites that cause malaria have

Left: Eight-year-old Trizah Makungu sits on the bed she shares with her parents, protected by a mosquito net. These nets, which cost about \$5 in the local market, have helped save millions of lives

Top: Two girls cut grass in a watery field in Kakamega County, Kenya. Malaria is spread by female *Anopheles* mosquitos, which breed in stagnant water and proliferate during the rainy season

been around for at least 30 million years. They probably started infecting humans tens of thousands of years ago in Africa and, by 10,000 years ago, were decimating nomadic societies as far away as Asia. Today, malaria is caused by five species of *Plasmodium* parasites – *Plasmodium falciparum* being



Above: Baby Prince Jackson has so far received two of the four doses of malaria vaccine

Right: At Kenya Medical Research Institute, scientists study mosquitoes' resistance to insecticides

Far right: Children, like these two girls in Kakamega, are more susceptible to malaria because they lack immunity



the most deadly – all of which are spread to humans via mosquitoes. Although malaria is endemic in 87 countries, 95 per cent of cases occur in just 29 countries in Africa. Nigeria seems to be worst hit, accounting for 27 per cent of known infections and 23 per cent of deaths overall. In 2007, the World Bank estimated that malaria costs Africa \$12 billion a year in treatment and lost productivity – that figure is probably higher now.

Nevertheless, in the past half-century, we have made big strides against the disease. Between 1955 and 1987, 22 countries were declared malaria free, and five others joined them between 2007 and 2014. Progress has been particularly rapid this century. Malaria cases have dropped from 80 per 100,000 people in at-risk populations in 2000 to 57 per 100,000 in 2019. In the same period, deaths have fallen from 25 to 10 per 100,000. In its *World Malaria Report 2020*, the

WHO describes this as “a period of unprecedented success in malaria control that saw 1.5 billion cases averted and 7.6 million lives saved”.

Mosquito nets sprayed with insecticides have proved the most effective measure for saving lives and reducing sickness, according to the WHO. Bed nets aren't just effective, they are also cheap, at about \$4.50 a pop. But they are no cure-all. “Prevention measures that require daily behaviours – such as the use of a bed net – can be harder to adhere to,” says Eliane Furrer, who works for the WHO on malaria vaccine implementation. Especially in hot climates and places that bustle after dark, not everyone wants to spend their whole night under a net. And nets won't stop the mosquitoes that transmit malaria by day.

The second pillar in the fight against malaria is a drug called artemisinin. Discovered in 1972, it is generally given

as part of a cocktail of drugs known as artemisinin-based combination therapies (ACTs). ACTs are credited with saving millions of lives, but some people believe they could have a bigger impact if a novel application is more widely adopted. It entails giving ACTs preventively to an entire community at once, reducing the levels of the malaria parasite in the blood of anyone who may be infected, so that it isn't passed back to mosquitoes that bite them. Starting in 2007, use of this approach dramatically reduced the spread of malaria in the Comoros islands, a small volcanic archipelago in the Indian Ocean.

Despite such success stories, progress against malaria has stalled. In 2016, the WHO identified 21 countries with the potential to eradicate the disease by 2020. But by 2019, only 10 of them had done so. “We've reached this plateau,” says Kate O'Brien, an epidemiologist at the



Malaria and covid-19

Nets treated with insecticide have been the most effective measure to reduce the incidence of malaria. They are frequently distributed at community gatherings, but because of the spread of covid-19, such gatherings are now often deemed dangerous. A study published in August warned that if routine anti-malarial campaigns such as bed-net distributions continued to be neglected, “the malaria burden in 2020 could be more than double that of 2019”.

By late November, less than half of the 222 million long-lasting insecticidal nets planned for distribution in 2020 had been distributed, according to the World Health Organization. The WHO has also said that 409,000 people died of malaria in 2019. It didn’t yet have a figure for 2020, but said covid-19 would have an impact. “Despite commendable global and national efforts to maintain essential malaria services,” it noted, “it is likely to lead to higher than expected malaria morbidity and mortality.”

WHO. The challenge is “getting at the hardest to reach children, the hardest to reach communities”. Global health professionals call this the “last mile” problem. They warn that the hardest part of any intervention is to bring it to the most remote places, or to reach every last individual in a dense urban environment.

My own experience suggests the problem is bigger than that. In western Kenya, where Mula works, malaria prevalence can reach 40 per cent, one of the highest incidences in the world. Yet, when I travelled in the region in March 2019, mosquito nets were absent even in inpatient wards inside government healthcare facilities. And the previous year, on a visit to Kenya’s malaria-endemic Indian Ocean coast, people told me they were unable to get ACTs to treat malaria because hospitals that are supposed to administer them for free were out of stock. When it comes to the distribution of bed nets

and anti-malarial medication, there seem to be enough “last miles” left to make it a marathon.

Even with these challenges, if past interventions are anything to go by, an effective vaccine could be a game changer. “This has been arguably the most successful health intervention programme in history,” says O’Brien of the 21st-century campaign to provide vaccines against a suite of infectious diseases in the developing world. “Every country in the world now has an immunisation programme that’s for every kid in that country.”

That has brought huge health improvements in just two decades. “Close to 10 million children were dying every year due to preventable causes, and 95 per cent were in poor countries,” says Anuradha Gupta, deputy CEO at the GAVI vaccine alliance. Now those deaths have been reduced to about 1.5 million a year.

This helps explain why there is

so much hope riding on the malaria vaccine, known as RTS,S. But the road to roll-out has been far from smooth. In development since 1984, it is one of the longest awaited vaccines in history. The challenge lies in the fact that, unlike a virus, such as the one that causes covid-19, the parasites that cause malaria transform themselves through several different stages of life.

Before creating a malaria vaccine, scientists had to work out which stage would be best to target, and how. Following a bite from an infected mosquito, the parasite enters the bloodstream. It then moves to the liver, where it matures into the next phase of its life cycle. RTS,S works by triggering an immune response to fight off the parasite at an early stage, just after infection.

Some critics worry that, although it has already been decades in the making, the vaccine is being rolled out too soon. They argue that it

Right: In the pilot programme currently taking place in Kenya, Ghana and Malawi, all children under 2 years of age are offered the malaria vaccine for free

Below left: So far, the vaccine has taken 37 years and billions of dollars to develop. It is only 40 per cent effective, at best

Below right: Silas Agumba, a research assistant at the Kenya Medical Research Institute, holds a box full of female mosquitoes

Far right: In Kenya, private clinics such as the Cheldeb Medical Center in Kakamega, administer the majority of anti-malaria treatments



isn't sufficiently effective, or cost effective. In phase III trials to assess effectiveness, it cut infections by only about 40 per cent – and by less than 30 per cent for severe malaria, the type most likely to kill. To reach even these levels of protection, a child needs four doses. “This has not been a standard vaccine on the level of efficacy,” admits An Vermeersch, head of global health vaccines at GSK, the company that manufactures RTS,S.

Then there is the cost. It has been estimated that implementing the vaccine will take an average of \$87 per DALY that it averts. DALY stands for disability adjusted life year, typically thought of as one lost year of healthy life. That makes it far cheaper than some medical interventions for infectious diseases: antiretroviral drugs for HIV costs an average of \$11,900 per DALY averted, for example. However, distributing more mosquito nets would cost much less, an average

of just \$27 to achieve the same effect.

Added to that, the cost of implementing the RTS,S vaccine doesn't include research and development, which may come to billions of dollars. GSK hasn't disclosed how much it has spent. However, a report published in 2009 revealed the vaccine was costing \$200 million a year to develop. And the Bill & Melinda Gates Foundation, which has invested more to stop malaria than any other organisation, has spent hundreds of millions of dollars on the vaccine. To those who say the cost is too high, Vermeersch counters that the investment signals confidence in the vaccine's potential. “The fact that everyone is committed to it after more than 30 years shows that there is a willingness to bring this vaccine to market,” she says.

Furrer points out that although the vaccine is more expensive than bed nets, it has some big advantages. “The

vaccine is targeted at young African children, who suffer the highest malaria burden,” she says. “Once a child is vaccinated, they carry this protection with them throughout the day and night.”

Besides, RTS,S doesn't have to be viewed as a replacement for bed nets and artemisinin. It is an addition to the armoury. “[We must] bring new tools to bear in the fight against malaria,” says Scott Filler, at The Global Fund, which aims to end the AIDS, tuberculosis and malaria epidemics. “We will leave no tool on the table.” The reason for that can be summed up in one word: resistance.

Parasites that are resistant to the drug artemisinin have long been observed in Asia, but last year they were found in Africa for the first time. The team that discovered them said the mutation found in *P. falciparum* in Rwanda could “pose a major public health threat” to people living in



Africa. In addition, some scientists fear that drug resistance will rise if ACTs are used preventively in entire communities to try to eradicate malaria, as they were in the Comoros islands. Meanwhile, mosquitoes are becoming increasingly resistant to the insecticides used to spray bed nets. By 2019, 73 countries had reported resistance to at least one of these chemicals, according to the WHO.

But there is some good news. Recently, bed nets sprayed with a chemical called piperonyl butoxide have been found to repel malaria-laden mosquitoes more effectively than those treated with the insecticides currently favoured. Another ray of hope comes from the part of Kenya where the RTS,S vaccine is being rolled out. On the shores of Lake Victoria, mosquitoes carrying a naturally occurring microbe don't contract the malaria parasite. According to a study published in 2019,

of the 5 per cent of mosquitoes that carried this microbe, *Microsporidia MB*, not one tested positive for the malaria parasite. If we can figure out how to spread the microbe further – or to restrict reproduction among mosquitoes that don't carry it – it will give us another way to fight malaria.

Unfortunately, as covid-19 spreads across Africa, even existing anti-malarial interventions are being threatened (see “Malaria and covid-19”, page 47). And coronavirus-related restrictions have also delayed plans to roll out the vaccine beyond Kenya, Ghana and Malawi, which health officials had hoped to do this year. Nevertheless, some still believe that a healthier future is in sight. Vaccines aside, huge efforts are being made to develop new drugs and insecticides.

Whether we can totally eradicate malaria is another matter. Successes like the vaccine that eventually put an end to smallpox in 1980 may be a thing

of the past. In today's globalised world, we are constantly on the move, carrying parasites and viruses along with us. And with climate change, mosquitoes are moving too, from equatorial regions to northern latitudes where most of the world's population resides. If we hope to beat this disease, it is crucial that we act fast, before the malaria parasite develops resistance to any new measures employed against it. “If you don't innovate, resistance goes up, so malaria does too,” says Chavasse. ■



Jacob Kushner reports on global health and foreign aid from East Africa, Germany and the Caribbean. Reporting for this story was made possible by a grant from the European Journalism Centre



GOVERNMENT OF INDIA

**Ministry of Education
Department of Higher Education
Technical Section - I**

Invitation of Applications for the post of Director, IIT Madras

Applications are invited for appointment to the post of Director of Indian Institute of Technology (IIT) Madras. The Director of an IIT is the academic and administrative head of the Institution. He/she is expected to have a minimum of 5 years' administrative experience and leadership qualities to head an Institute of National importance. The candidate/person should be a Ph.D. with first class or equivalent at the preceding degree, preferably in a branch of Engineering. In exceptional cases, candidates with Science, Mathematics or Management degrees may be considered. He/she should have an outstanding academic record throughout and a minimum of 10 years teaching experience as a Professor in a reputed Engineering or Technology Institute or University and should have guided Ph.D. students. The applicant should preferably be less than 60 years of age on the last date of receipt of the applications. The post carries a fixed pay of Rs. 2,25,000/- (Revised) per month, with allowances as per rules.

2. Interested individuals may apply giving their detailed resume in the prescribed format clearly bringing out research, teaching, industry-academia collaborations and administrative achievements, alongwith a two-page justification in support of their candidature, a two-page vision statement for the institution and contact details of at least two distinguished individuals well acquainted with their work. The application typed in the prescribed format along with enclosures may be sent by Registered/Speed Post to **The Under Secretary (TS.1), Department of Higher Education, Ministry of Education, Room No. 428 "C" Wing, Shastri Bhawan, New Delhi -110 001** so as to reach the Ministry on or before **31st May, 2021**. The detailed advertisement and the format of application is available on the website (www.education.gov.in).



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Feedback

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Twisteddoodles for *New Scientist*

Picturing the lighter side of life **p56**

Citizen science

Sniffing out allergies

Seasonal reactions to pollen and the like are on the rise. You can help researchers find out why, writes **Loyal Liverpool**



Loyal Liverpool is a digital journalist at *New Scientist*. She believes everyone can be a scientist, including you. @layallivs

What you need

A smartphone with the #BritainBreathing app downloaded

APRIL showers bring May flowers, or so the saying goes. But those beautiful spring blooms – and their plentiful pollen – mean sneezing, runny noses and itchy eyes for many people.

If this is you, and if you live in the UK, you can become a citizen sensor this spring by downloading the #BritainBreathing app and using it to record any allergy symptoms you develop. Doing so will help researchers learn more about when allergy symptoms are occurring at a population level and what the precise triggers are. Even if you don't live in the UK, you can still download the app and use it for personal symptom tracking.

About one in four people in the UK experience seasonal allergies, such as hay fever and asthma, and the incidence seems to be on the rise. The main culprit behind these ailments is pollen, with different types in the air at different times of year, but other factors such as the weather or levels of air pollution may also play a role.

The #BritainBreathing app matches anonymised symptom information with a rough geographical location, so that researchers can get an idea of where allergy symptom reports are clustered across the UK.

“That might start to tell us a little bit more about what's in the environment that's causing the huge increase in allergies and asthma that we're seeing – because it's going up and up,” says Sheena Cruickshank at the University of Manchester, UK, who is part of the #BritainBreathing team.



SCIENCE PHOTO LIBRARY/LAMY

Thousands of people have joined the project so far and a 2017 study found that symptom reports collected via the app mapped well onto areas with high levels of prescriptions for allergy treatments by doctors.

Using data from the app and from other studies, Cruickshank and others are currently looking at how the interaction of pollens with pollutants in the air might be contributing to the rise in seasonal allergies.

Allergies occur when the immune system mistakes something harmless for something threatening, says Cruickshank. This happens when a substance triggers a signal of infection or damage in the body. “That's what kind of gets your immune system going,” she says.

“It's very likely that some of the pollutants are providing both of those signals, alongside the pollen,” says Cruickshank. Pollutants in the air may also be changing the structure of pollen in a way that makes it more stimulating to the immune system, she says.

It has been projected that climate change will increase the severity of the pollen season in Europe, and there are already signs its impact on plants has made the hay fever season in North America longer and more intense.

To find out more about the project and how to get involved, visit britainbreathing.org. ■

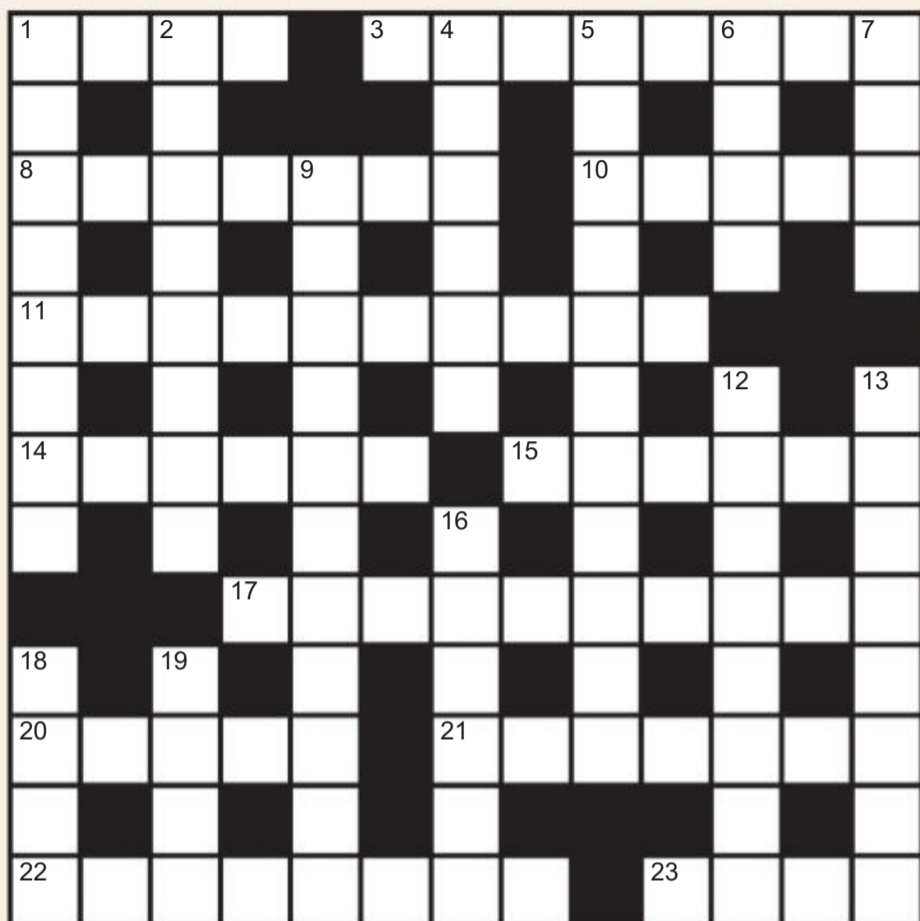
Citizen science appears every four weeks

Next week

Science of cooking

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

Cryptic crossword #56 Set by Rasa



Scribble zone

Answers and the next quick crossword next week

ACROSS

- 1** Uh-oh, earrings scratching face (4)
- 3** Admitting error, chem lab reconstituted white mixture (8)
- 8** Shine like a Scottish stream? (7)
- 10** Almost pay for each report (5)
- 11** The first-rate *T. rex* interrupted by couple of boors with private seating (7,3)
- 14** Character turned brown by river in Yorkshire (6)
- 15** Multicoloured cat appears in musical I commissioned (6)
- 17** L.A. gripped by weird personal rooftop device (5,5)
- 20** Wildlife enthusiast gaining entrance to unspoiled area (5)
- 21** More disorganised astronomer (7)
- 22** Note elk's unusual bones (8)
- 23** Secret plan: power and fortune (4)

DOWN

- 1** Going around Oregon with acid (8)
- 2** Completely fill meat-eating French father (8)
- 4** Mimicked tech, essentially, then did groundbreaking work? (6)
- 5** Cool opportunity arises at place to study part of the brain (11)
- 6** Cleaning tool at end of vestibule: look down! (4)
- 7** Instrument fabricator overheard (4)
- 9** Possibly use a graph to estimate crime-fighting group at start of event (11)
- 12** I brought in Ben and rested up every two years (8)
- 13** Cultivated mould from pulverised Toblerone (one piece short) (5,3)
- 16** Become more interested in fighting male cat, tail first (4,2)
- 18** Buffoons oddly ignored sci-fi vehicles (4)
- 19** Sign incorporates black eight, for example (4)

Quick quiz #99

- 1** A doughnut-shaped device that uses a powerful magnetic field to confine plasma is known as what?
- 2** Where in the body would you usually find the zona pellucida?
- 3** The deepest known bird call is produced by which species?
- 4** A Schwarzschild black hole has mass, but lacks spin and what other attribute?
- 5** In what year was the IUCN Red List of Threatened Species established?

Answers on page 55

Puzzle

set by Brian Hobbs
#111 Eclair-voyance

Tom and Amy are colleagues who are both excellent logicians; they speak honestly and accurately, and no bit of good deduction slips past them. Another thing they won't let slip past is the last éclair on the tray at the annual puzzlers' party. Since neither is willing to back down, they propose a solution. They will take the spades out of a deck of playing cards and remove the ace, king, queen and jack, leaving them with the 2, 3, 4, 5, 6, 7, 8, 9 and 10 of spades. They will shuffle the remaining cards and each draw one. Whoever has the higher card gets the éclair.

They each take a card and look at it, being careful not to show it to the other.

**"Well I don't know whether I'll win," says Tom, "but I hope I do."
"Same goes for me," replies Amy.
"Do you know who won yet?"
"No," says Tom.
"Me neither," says Amy.**

At that, Tom sighs and tosses his card back into the deck, admitting defeat.

What cards did Tom and Amy have?

Solution next week



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Rowdy roads

Why is the noise from traffic on roads louder when it is raining or the road is wet than it is on a dry day?

Elisabete Freitas

*University of Minho,
Guimarães, Portugal*

Road traffic noise is mainly caused by tyre vibrations due to the friction between the tyre and the road surface. This noise is amplified by the horn-like shape in front of and behind where each tyre touches the road – known as the “horn effect”.

When it is raining, there is an obvious increase in the traffic noise due to the impact of the rain on the vehicles and the spray caused by the movement of the wheels. As well as this, the water on the surface interferes with the generation of noise caused by the contact between road and tyre, and how this noise is propagated.

Our studies on a Portuguese motorway found that the presence of water increases the overall traffic noise by 4 decibels. This increase is mainly at frequencies greater than 1000 hertz (which is at the middle of the frequency

“When disturbed, the spider dropped like a stone. A minute later, it did the reverse, ascending at exactly the same speed”

range for human hearing), where it can reach 15 decibels.

This noise increase depends on the type of tyre, the material the road is made from, the type of vehicle and the speed at which it is travelling. Porous road surfaces (such as special asphalt) are often less noisy than non-porous ones, but when these surfaces are wet, the traffic noise increases by similar amounts on both.

The difference between dry and wet traffic noise is smaller for vehicles travelling at higher speeds and for heavier vehicles.



ADRIAN SHERRATT/LAMAY

This week's new questions

Big wheels Bicycle frames come in different sizes to match the height of the cyclist, but the wheels stay the same size. **Would there be any benefit in a taller rider having bigger wheels?** *Andrew Whiting, Bournemouth, Dorset, UK*

Global benefits Do humans provide any benefit to planet Earth other than for ourselves? *Andy Moffat, Strathpeffer, Highland, UK*

Spider abseil

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

Jane Lambert

Penzance, Cornwall, UK

Watching a spider on a window, I saw it immediately drop like a stone to a ledge when the window was nudged, apparently under the influence of gravity.

A minute later, the spider did the whole thing in reverse, ascending to its original position at exactly the same speed at which it had descended. So it seemed

that the speed of descent wasn't dictated by gravity after all.

Todd Blackledge

University of Akron, US

When a spider falls or jumps from a height, it already has a built-in safety line attached. Most spiders continuously spin a dragline of silk as they move around and periodically secure that line with small attachment discs of adhesive silk to catch any fall – just like a rock climber's karabiner.

The dragline rapidly pays out from one of many silk glands on the spider's spinneret and is produced from a pre-made stockpile of liquid silk “dope” stored inside the gland.

This liquid passes through an S-shaped duct that processes it

What are the benefits of having bigger wheels on a bicycle?

into solid silk fibre in milliseconds through a combination of shearing of the liquid silk, removal of water and a drop in pH. You can think of the silk as “liking” to exist in two different states: as a liquid solution in the gland and as a solid fibre in any other chemical environment – but nothing in between. The “spinning” of the fibre simply involves the silk being nudged from one physical state to the other.

Many spiders have a muscular valve at the end of the spinning duct that can clamp down on the dragline to slow, or even stop, the spider's descent. Thus, the spider can stop almost on a dime in mid-air, then continue to descend.

After reaching the ground or some other perch, the spider rapidly secures its dragline with another attachment disc, in case of another fall, and continues trailing its safety line.

Spiders do sometimes cut silk threads, but usually only as part of the process of building or utilising webs. Draglines are almost never cut. That is why you can often see hundreds of silk threads criss-crossing your bushes or lawn in the early morning light – evidence of the nightly wanderings of many spiders.

Fritz Vollrath

University of Oxford, UK

Spiders produce their silk “on the hoof” by spinning stored liquid silk into a thread at speeds of up to a metre a second. Jumping spiders can do it even faster.

Limb renewal

Why can't humans regrow limbs like an axolotl or a lizard?

Mike Follows

Sutton Coldfield, West Midlands, UK

Salamanders, such as axolotls, hatch in ponds alongside hungry siblings that nibble on them. This may explain why they evolved the



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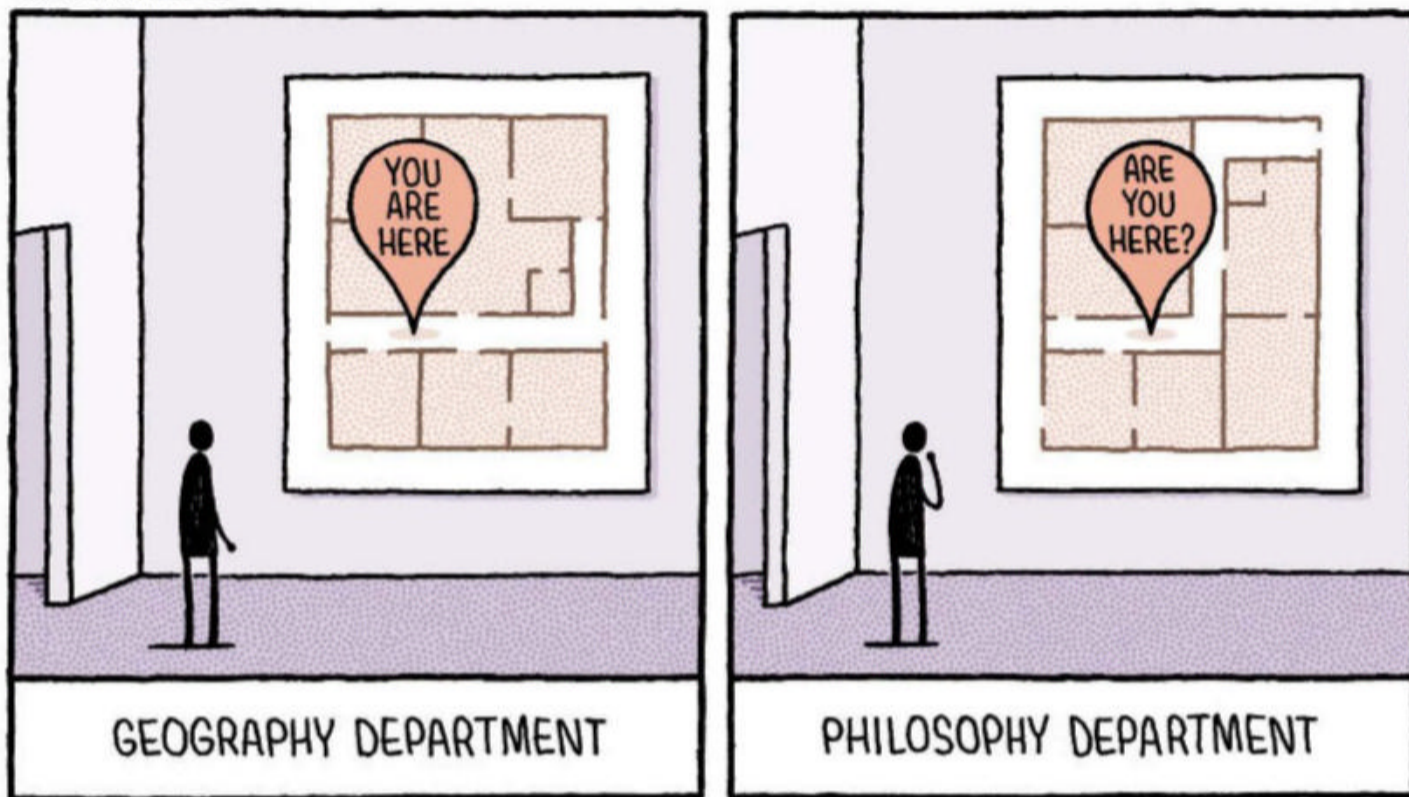
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Tom Gauld
for *New Scientist*

SIGNAGE



ability to regenerate missing limbs and gills. In contrast, humans have a rolling programme of replacing about 10 billion cells per day.

This hints at a possibility that we have inherited the ability to regenerate limbs, yet the relevant bits of genetic code may be switched off or modified. Rapid cell division is associated with tissue regeneration, but it is also a feature of cancer. It is possible that evolution in humans has suppressed rapid cell division in order to combat cancer at the cost of losing our ability to regenerate tissue. Tantalisingly, salamanders regenerate tissue but hardly ever get cancer.

The axolotl is easy to breed in captivity, which has made it the focus of intensive research. When it loses a limb, cells migrate to the site of the wound, turning back their internal clocks on the way. The cells form a blastema, a mass of undifferentiated cells, like embryonic cells or stem cells. Immune cells called M2 macrophages reduce inflammation at the wound

“Salamanders hatch in ponds alongside hungry siblings that nibble on them, which may explain why they regenerate limbs”

site, while connective tissue cells called fibroblasts carry positional information that allows them to differentiate into the appropriate specialised cells specific to their location as the lost limb regrows.

Scientists have recently mapped the axolotl genome and this should speed up our genetic understanding of why some creatures can regenerate their limbs.

Feline fix

Is it possible, or desirable, to produce a genetically engineered cat that doesn't have an urge to kill wildlife? (continued)

Garry Trethewey
Cherryville, South Australia
Over the last 10,000 years, dogs,

cows and probably many other species have been engineered, through selective breeding, to reduce aggressive and homicidal urges, without any moral qualms.

Here in Australia, feral cats are a huge killer of native wildlife. I would love to see some of the new genetic tools launched into this population. The caveat would be that this modification shouldn't be able to be spread to cat populations elsewhere.

Some people might want a more aggressive guard cat, to protect grain silos from rodents for example. But just as with guard dogs, there could be more aggressive breeds of cat for this purpose, as long as appropriate fencing and microchipping was in place to ensure these breeds remain contained.

Bob Davis

Hilo, Hawaii, US
Maybe cats could be genetically reconfigured to have an aversion to attacking feathered animals and instead fixate only on animals with hairless tails? ■

Answers

Quick quiz #99

Answers

- 1 A tokamak
- 2 The ovaries – it is a membrane surrounding an egg cell
- 3 The dwarf cassowary (*Casuarius bennetti*). Its call can have frequencies as low as 23 Hz
- 4 Electric charge
- 5 1964

Quick crossword #81

Answers

ACROSS 1 Climate models, 8 True, 9 Clinometer, 10 Stitch, 11 Endgames, 12 Semi-fluid, 14 Hiss, 15 Pore, 16 Placental, 20 Coughing, 21 Orache, 23 Geologists, 24 Emit, 25 Nervous system

DOWN 1 Curette, 2 Inert, 3 Alcohol, 4 Epidemiologists, 5 Ovoids, 6 Elevation, 7 Siemens, 13 Irregular, 15 Protein, 17 Chomsky, 18 Atheism, 19 Pigao, 22 Agent

#110 Reflecting on time

Solution

It was 11:51 when I woke up. The only digits that reflect to make a valid digit are 0, 1, 2 and 5. Digit 8 would work for the second digit in the hours or minutes, but can't be transposed to another position on the clock and give a legitimate time. The hour must change, and if it changes by 1, then it could be 01 to 02, 20 to 21 etc. The smallest time advance (apart from zero) turns out to be 20 minutes. There are three times when this happens: 01:50 (reflection 02:10); 11:51 (12:11) and 21:55 (22:15). Only one of these is in daytime – which is why the darkness of the tunnel made the difference.

But is it art?

In a former life, Feedback's daily doings regularly took us across a windswept plaza on a university campus that, through no fault of its own, had been built in the 1960s. Adding to a general air of faded cold war chic was a huge, rusting iron sculpture on a concrete plinth, on which the words "Vorsicht! Kunst" had been graffitied in yellow paint.

This was in Germany, we perhaps should have said, but the warning to beware of art has stayed with us. We are reminded of it when we read that a Sotheby's auction of non-fungible tokens by the crypto-artist Pak has brought in \$16.8 million, including a single grey pixel that went for \$1.36 million worth of Ether.

If, to you, that sounds like just words with a few numbers thrown in, then we can only assume you are not au fait with the worlds of art collection or cryptocurrency, and certainly not the uniquely important new conjunction of the two.

The true value of art, of course, lies not in aesthetics, but in someone else not having it. This is problematic in the world of digital art, with pixels being so readily copy-and-pastable. Non-fungible tokens, digital widgets that can be added to an unfalsifiable blockchain to assert sole ownership of a digital asset, are the answer to this problem you didn't know you had yet.

Following the sale of a gif of a flying cat in February for some \$600,000, selling the rights to a single pixel represents some sort of progression, if only towards a logical singularity. "This single pixel is one of the most significant pieces of Art imo," wrote someone who had drunk the Kool-Aid on Twitter. "The future will be very kind to the value of this piece".

Others have been significantly less kind. Feedback is wary not only of art, but change and new things generally. We will stick for now with the stuff that looks like it will hurt if it falls on your foot – plus those couple of Rothko gouache-on-papers we have stashed behind the photocopier for a rainy day.

Twisteddoodles for New Scientist



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New Scientist, 25 Bedford Street, London WC2E 9ES

Consideration of items sent in the post will be delayed

Moral fibre

Colin Nicholson of Stockport, UK, doesn't say why he is receiving regular emails from a US provider of "alternative" views about health and healthcare. Mind you, seeing the unwanted emissions that fill our litter – apologies, "in-" – box, we aren't one to cast aspersions.

Colin expresses surprise at an item highlighting the very real problem of discarded protective face masks in the environment, "due to the size of the fibres used in their manufacture – between 1mm and 10mm thickness".

Polymer extrusion processes aren't our strong point, but we agree that something needs to happen with a centimetre-thick fibre before it is any use against nanosized viral particles. Then again, clicking through to the site that the email links to, so you

don't have to, it seems aimed at those who would prefer to reduce viral transmission probability via a paper bag secured by a tin-foil hat. On that basis, anything will do.

The real Sean Carroll

In our item last week on our theory that people with the same name are actually all the same person, we missed the example under our nose. We discovered this when a colleague wrote in agitation querying the publicity shot for a *New Scientist* pixelated happening on the origins of life with scientist Sean Carroll. "My god he's aged suddenly – and we're still using the more familiar clean shaven pic of him on the Big Ideas in Physics page," they wrote.

Indeed, we see that this younger version of Sean Carroll is speaking next week on "How time works", so we shall watch with interest for

clues. Alternatively, it might be that these aren't the same Sean Carroll. Then we recall that one, or perhaps both, of the Sean Carrolls is a noted proponent of the many worlds interpretation of quantum theory. Perhaps they can tell us which branch of the multiverse we are in, unless it's both at the same time.

DIY AI

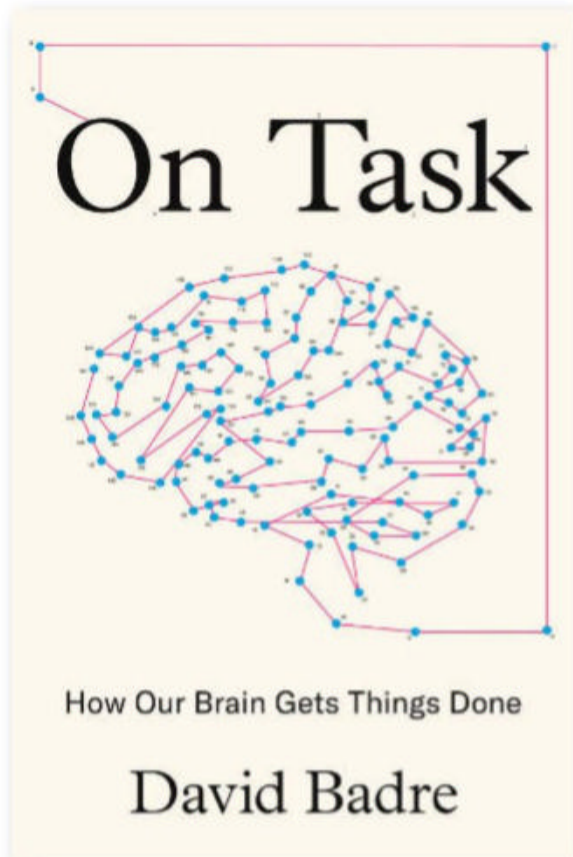
"Deep Learning-based Online Alternative Product Recommendations at Scale" is a preprint that was just posted on the arXiv server, with its authors based at the US's largest home improvement retailer. "We've reached the stage of AI ubiquity where I'm just like "cool, makes sense" when seeing a deep learning paper published by researchers at Home Depot", tweets Miles Brundage, head of policy research at OpenAI.

Nothing wrong with a do-it-yourself approach, after all. Pausing only to note the appearance of late writer and literary critic Rebecca West on the author list, Feedback congratulates the researchers on how their algorithm combines textual analysis of product data with historical customer behaviour patterns to improve purchase completion rates by 12 per cent. If you liked that product recommendation algorithm, you'll love this one.

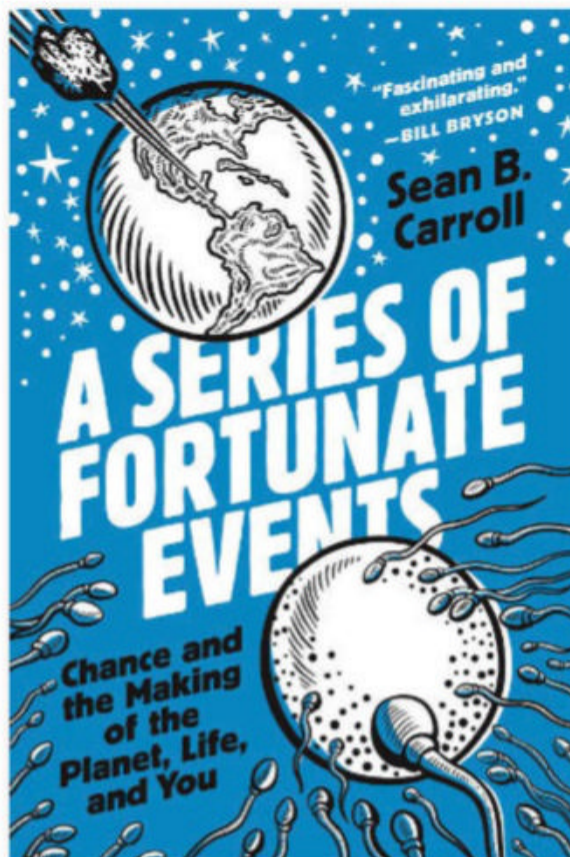
Solar intruders

A product we do like the look of is the Solar Animal Repeller pointed out to us by reader Chris Webster. With the sun's activity due to hit a periodic peak shortly, it is as well to be prepared for whatever heat-hardened critters coronal mass ejections may fling our way.

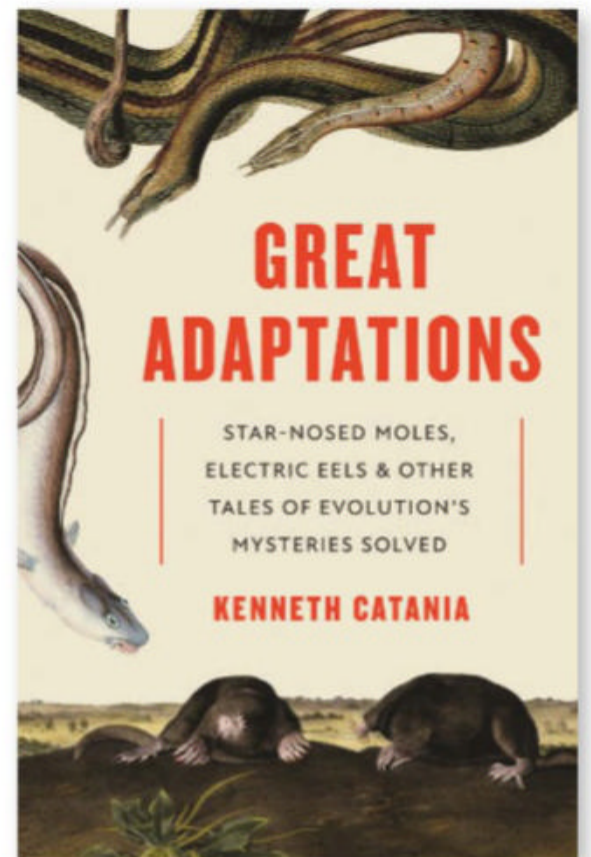
The Home Depot offers quite a few that are also effective against gophers, chipmunks and groundhogs. Just the thing to ward off intruders to Feedback's stationery cupboard, along with that supersized pack of snake glue traps. Or is that the product recommendation algorithm talking? ■



“A stimulating, enjoyable read for anyone interested in brain function.”
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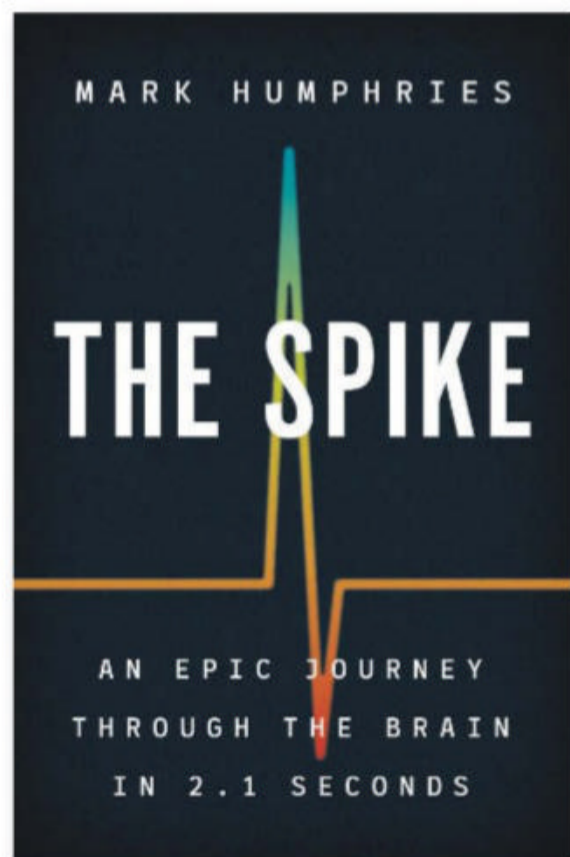
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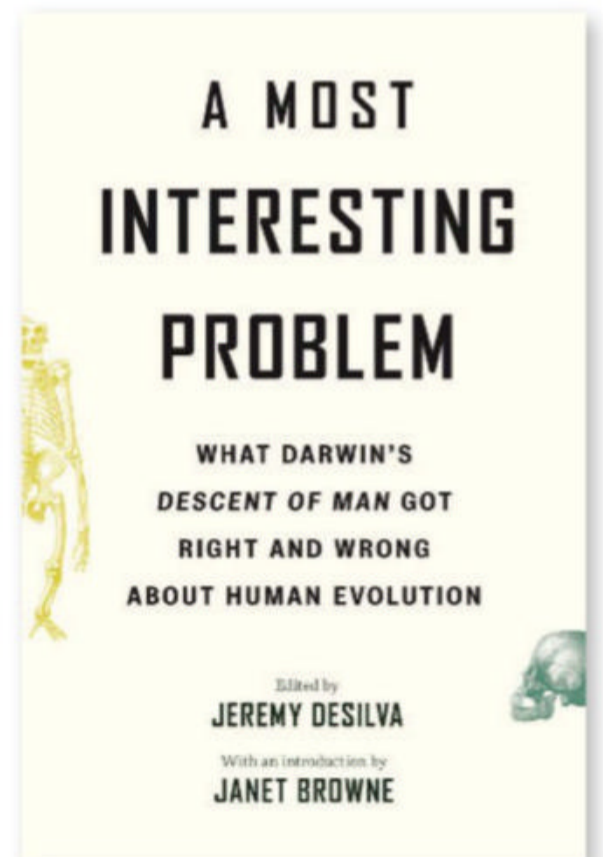
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