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WEEKLY July 18–24, 2020






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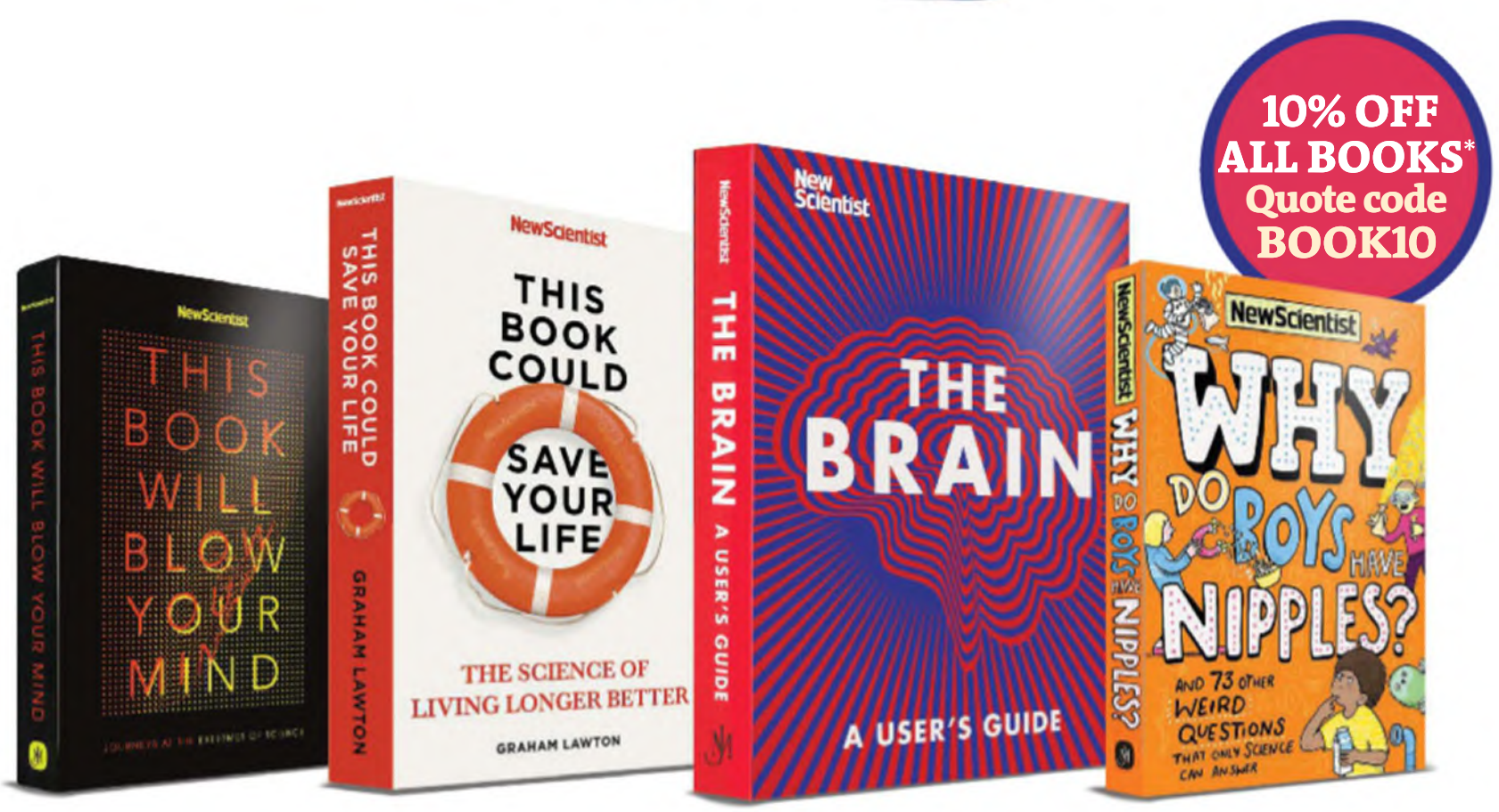

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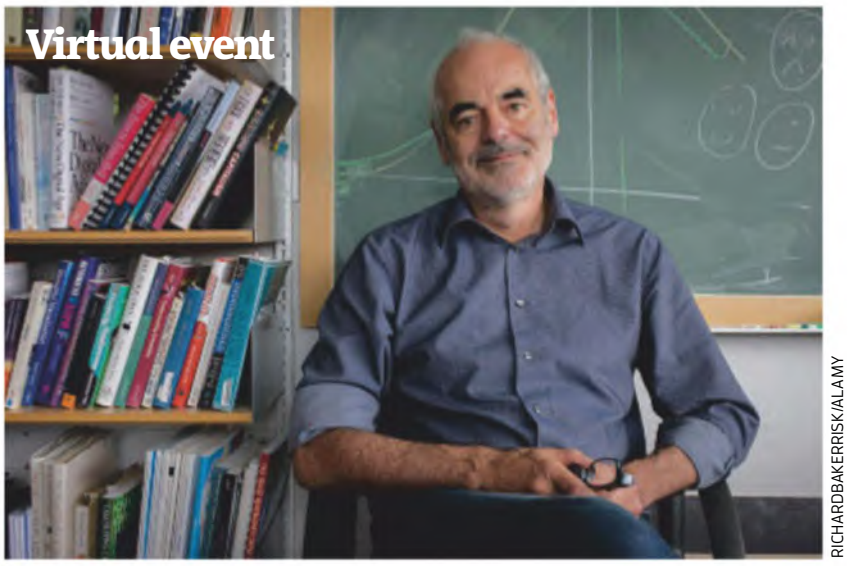

RICHARDBAKERRISK/ALAMY

Number crunching David Spiegelhalter on the dark art of statistics

Virtual events

The art of statistics

Statistician David Spiegelhalter asks if we can communicate uncertainty about facts, numbers and hypotheses without losing credibility. Thursday 23 July at 6pm BST and on demand.

newscientist.com/events

Podcasts

Weekly

Half a year in a world of covid-19, meat production breaking Earth's nitrogen limits and figuring out the weight of gravity. Plus: two debut missions to Mars from the United Arab Emirates and China.

newscientist.com/podcasts

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newscientist.com/sign-up/launchpad

Online

Covid-19 daily update

The day's coronavirus coverage updated at 6pm BST with news, features and interviews.

newscientist.com/coronavirus-latest

A note from our news editor

I am pleased to share with you that *New Scientist* is now seeking applications for the second iteration of our Diversity Internship Programme, a positive action scheme for aspiring journalists from black, Asian and minority ethnic backgrounds.

At *New Scientist,* we believe very strongly that science is for everyone and that its power to enrich and inform our lives is universal. But science journalism – as with all journalism – remains largely the preserve of the privileged few, with many barriers preventing a diverse range of voices from entering the newsroom.

The goal of our internship is to remove some of these barriers. Money is one of those, so we pay the London Living Wage. We also don't ask that applicants have had any formal journalistic training, as this is a personal expense that many can't afford. The only requirements for applicants are that they have a science, technology or computing degree and a demonstrable interest in writing or journalism.

"At *New Scientist*, we believe science is for everyone and its power to enrich our lives is universal"

Our selection process is carefully designed to remove bias and choose on the basis of merit alone. That is why we don't ask applicants to submit a CV, which can be a source of unconscious bias during the hiring process. Instead, we ask for a short statement explaining an applicant's suitability for the programme, and for a writing sample in the style of a *New Scientist* article. To further eliminate bias, these are both marked blind – with no names attached – by two different people and according to a rigid scoring system, allowing little room for personal judgement. Further selection rounds involve an anonymised reporting test, which is also marked blind according to standard criteria.

It is a process that worked well last year. Our first three interns enjoyed an intensive six-month programme of on-the-job training based on our news desk, with placements across the company as a whole. From covering our live events on social media and assisting in video shoots to writing for all sections of the magazine, they participated in every aspect of *New Scientist*. Each intern left with a portfolio of published work, and you will still see their names – Gege Li, Layal Liverpool and Jason Arunn Murugesu – regularly on our pages.

The deadline for applications for this second roll-out of the scheme is 31 July, and more details can be found online at **newscientist.com/intern**.

Penny Sarchet
News editor

New Scientist Podcast

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Press Gazette

The New Scientist Weekly podcast

Episode 25 out Friday 17 July

Our weekly podcast has become the must-listen science show, bringing you the most important, surprising or just plain weird events and discoveries of the week. If you missed the earlier episodes you can still listen in to hear about:

Episode 24
Half a year in a world of covid-19, meat production breaking Earth's nitrogen limits and what does gravity weigh?

Episode 23
Coronavirus immunity and vaccine implications, evolutionary reasons for the types of world leader and treating people with CRISPR gene editing

Episode 22
Consciousness from the body as well as the brain, record temperatures in the Arctic and long-term symptoms of covid-19

Episode 21
How to prevent future pandemics, how our brains might trigger a hibernation-like state, plus black lives matter and racism in science

Hosted by *New Scientist*'s Rowan Hooper and Valerie Jamieson, new episodes are out each Friday. Follow us on Twitter **@newscientistpod**

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The benefit of foresight

Emerging technologies such as AI bring risks – so let's regulate them now

DONE wisely, artificial intelligence "can be the best thing ever for humanity", says the fundamental physicist turned AI researcher Max Tegmark in our interview this week (see page 34). We subscribe wholeheartedly to his assessment. Seldom has there been a technology with such an obvious power to improve our lot – or one with such obvious dangers.

The risks are potentially existential. The excerpt from our recently published *Essential Guide*: *Artificial Intelligence* (see page 46), a classic article from strategy researcher Kenneth Payne on AI warbots, provides a case in point. Yet they are also insidious: in amplifying biases, for instance against women and minority groups, that exist in the data AI feeds on; in undermining democracy and the rule of law via the automated propagation of information designed to play to prejudices; in entrenching the economic power of companies that control this technology, at the expense of those whose jobs it takes.

The answers to these issues are simply stated: more research, more regulation and more agreement on where AI's boundaries should lie. The work on ways to balance AI accuracy and fairness we report on in this issue (see page 12) is a good example of how basic research can help. There are encouraging signs that big tech is finally, albeit reluctantly, waking up to the idea that with the great power AI grants comes great responsibility.

"The coronavirus crisis found many governments asleep at the wheel. We can't afford the same mistakes with AI"

Yet the scale of the challenges involved means that, ultimately, governments and international organisations must step up to the plate. The Council of Europe, which exists to uphold democracy, human rights and the rule of law across the EU, the UK, Russia and other European countries, has already made a start on exploring what sensible regulatory frameworks for AI look like.

More action and urgency are needed, however unfashionable global cooperation might be right now. The coronavirus crisis found many governments asleep at the wheel, faced with a pandemic that researchers had warned for years was a matter of if not when. We can't afford the same mistakes with AI. It could well be the best thing for humanity – but we must think carefully about what we want it to be now. ▮

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New Scientist
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Fix the Planet

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Join *New Scientist* chief reporter Adam Vaughan as he brings you scientific reasons to be optimistic that catastrophic climate change isn't inevitable.

Adam Vaughan

Get a monthly dose of climate optimism, delivered straight to your inbox. Sign up at **newscientist.com/fix**

URBANIMAGES/ALAMY

A sign outside a doctor's surgery in the UK. Flu injections could be vital this winter

Prepare now for winter

The UK has just three months to get ready for a covid-19 second wave that could be deadlier than the first, reports **Jessica Hamzelou**

A PARTICULARLY challenging winter in the UK could bring a second wave of coronavirus infections that results in around 120,000 hospital deaths – twice as many as the first wave – according to an estimate of a reasonable worst-case scenario.

Assuming lockdown restrictions continue to ease, the average number of people one person with the virus goes on to infect, known as the R number, could rise in the UK from the current estimate of between 0.7 and 0.9 to 1.7 by September, say the scientists behind a report. This would lead to a second wave peaking in January and February next year.

"A peak of coronavirus infection in the winter could be more serious than the one we've just been through," report chair Stephen Holgate at the University of Southampton, UK, told a press briefing. "We're anticipating the worst, which is the best we can do."

The report, requested by the UK government's chief scientific officer, was by the UK Academy of Medical Sciences. It considered what might happen if people went back to a typical way of life and didn't factor in the use of new medicines or a vaccine.

The team considered the known impact of covid-19 on healthcare resources, combined with that of flu and other seasonal infections.

In any given year, deaths in the UK rise in winter, due to the effects of cold weather and the impact of seasonal viruses like the one that causes flu. People tend to stay indoors with their windows closed, providing ideal conditions for infections to spread.

A worst-case scenario would involve an unusually cold winter and a flu epidemic, on top of the backlog of routine care and elective surgery that has already been postponed as a result of the coronavirus outbreak.

If it were to happen, around 119,900 hospital deaths related to covid-19 could be recorded in the UK over the winter – more than double the number seen in the spring, according to the report. The figure is an estimate, and could lie somewhere between 24,500 and 251,000, according to the authors. It also doesn't include deaths outside hospitals, such as in care homes.

The figure isn't a prediction and the UK has a crucial three-month window to avoid this scenario, the authors say.

One important approach will be limiting the impact of seasonal flu. "We don't know how covid-19 will interact with flu," says report co-author Anne Johnson at University College London. An adequate supply of the flu vaccine will be vital in the autumn, she says. Those who are vulnerable to flu, people working in healthcare and schoolchildren should all have the vaccine, she says.

"A peak of coronavirus infection in the winter could be more serious than the one we've just had"

Test, trace and isolate schemes will need to be scaled up, according to the report, which also recommends widespread flu testing, so people know which virus they have.

With this in place, the UK might be able to treat many flu infections with antiviral drugs. This hasn't previously been possible due to a lack of testing, says Johnson.

The authors also advise using facilities set up to deal with the coronavirus outbreak, such as the Nightingale hospitals, to help clear the backlog of hospital procedures that have accumulated since the spring.

Any attempts to limit the impact of coronavirus should prioritise those at the greatest risk of severe illness and death, including people who are from black, Asian and minority ethnic groups, and those living in crowded housing, the authors say.

If measures successfully limited the R number to 1.1, the outcome would be very different. "There's a lot to do and we don't have a lot of time to do it," says Johnson. "The window for action is now." ▮

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

Infectious diseases

Covid-19 could have disastrous impacts on HIV, TB and malaria

Adam Vaughan

THE impact of the coronavirus pandemic on healthcare for tuberculosis (TB), malaria and HIV might be so severe that it could lead to deaths on a similar scale to those from covid-19 itself in some parts of the world, a new analysis finds.

In a worst-case scenario, malaria deaths are projected to rise by 36 per cent over the next five years as malaria net campaigns are affected in the sub-Saharan countries where the disease is most prevalent. Over the same period, deaths from TB could rise by a fifth as new cases go undetected while deaths from HIV could rise by a tenth as access to life-saving drugs is hit. Such disruption would lead to hundreds of thousands of extra lives lost each year.

For countries with high HIV, TB and malaria rates and weak healthcare systems, "this is right up there in terms of a major priority for how we're going to combat and minimise the entire risk that the covid-19 pandemic brings", says Timothy Hallett at Imperial College London, who led the study. "It's not piddly in comparison to covid-19, it's absolutely a priority."

The analysis came up with four hypothetical scenarios, based on different interventions in low and middle-income countries. Hallett points out that these scenarios may not come to pass and it is hard to predict how the covid-19 pandemic will unfold (*The Lancet Global Health*, doi.org/d3qt).

However, recent history holds precedent for possible knock-on effects. The research was inspired by what was seen during the Ebola outbreak in West Africa between 2014 and 2016, where around half of deaths were from other diseases as healthcare suffered.

Hallett tells of one NGO chartering a plane from India to bring in drugs to Nigeria for HIV treatment, and of drugs stuck in ports globally because customs officials were in lockdown.

Initial surveys of health services add weight to such anecdotes. The Global Fund, a crucial financier of programmes to tackle these three illnesses, found in June that 85 per cent of the HIV programmes it funds had seen disruption to delivering their services. For TB programmes, it was 78 per cent, and 73 per cent for malaria.

Meg Doherty at the World Health Organization (WHO) says that the impact on HIV services has been "profound", largely due to disruption of antiretroviral drugs for people with the virus. Twenty-four nations around the globe have less than three months of the medicines left, she says.

For TB, which already kills around 4000 people daily, a reduction in diagnosis and treatment is the biggest concern. A recent study found that without mitigation, there could be more than 200,000 extra deaths from TB between 2020 and 2024 across China, India and South Africa.

A common thread across these three epidemics is that people aren't going to healthcare facilities because they fear catching covid-19 or overwhelming the system.

Campaigns encouraging people to overcome those fears will be one way to mitigate the impact. The WHO has also called for healthcare providers to issue multi-month prescriptions of antiretroviral drugs. ▮

An HIV testing clinic in Mombasa, Kenya

GINA RODGERS/ALAMY

Narcotics

How cartels get around lockdowns to ship drugs

THE illegal drug trade has been affected by the covid-19 pandemic, but that hasn't stopped cartels finding ways to ship narcotics.

On 1 July, Colombian and US naval forces seized 7.5 tonnes of cocaine with a street value of £226 million – one of Colombia's largest drug busts in recent years. The cocaine had been chemically mixed with kaolinite, a clay mineral, and was only found after lab tests.

"These modus operandi are indeed advanced and sophisticated, since you need a chemical procedure to extract the cocaine at destination," says Bob Van den Berghe at the United Nations Office on Drugs and Crime (UNODC) Container Control Programme.

To separate the cocaine from the clay, the traffickers would probably have used gas chromatography, a way to analyse and separate substances, says Colombia's anti-narcotics investigation unit.

Lockdowns have frustrated South American drug cartels. Less traffic on roads and a reduction in shipping cargoes have made it harder to conceal drugs. Chemical shortages have complicated drug production.

In Europe, drug dealers have masqueraded as delivery drivers or health staff to sell drugs under the guise of "essential workers".

£226m

The value of cocaine seized by US and Colombian officials on 1 July

The cartels are also using basic chemistry to dupe police. Powder cocaine is sometimes dissolved into petrol or acetone and the resulting liquid can be soaked into materials. In June, Bogotá's Anti-Narcotics Police Unit found nearly 5 tonnes of cocaine inside granulated rubber. In Spain, it has been found impregnated into cardboard in fruit shipments from Colombia. The cocaine is later reverted to powder form with heat or chemicals. ▮

Luke Taylor

Death rates

Is coronavirus becoming less deadly?

The virus appears to be getting less lethal in the UK and US, but the reasons are far from clear

Michael Le Page

CORONAVIRUS deaths are falling in the US even as cases skyrocket. In the UK, a lower proportion of people hospitalised with covid-19 are dying. This has led to suggestions that the risk of dying if you are infected with the virus is falling, but the truth may be more complicated.

"At this point, I don't think we have conclusive evidence that the death rate is going down," says Tessa Bold at Stockholm University in Sweden.

Having plateaued at around 20,000 in May, the number of daily confirmed cases in the US began rising in June and has now exceeded 60,000. However, the number of deaths in the US reported as being due to covid-19 has fallen from more than 3000 a day in mid-April to well under 1000 (see graphs, below right).

"It's encouraging. We are either getting better at treating covid-19 or it's becoming less severe"

There are several possible explanations for this. For starters, it could be a result of better treatments, including use of the steroid dexamethasone.

Another reason why deaths aren't tracking case numbers in the US could be the lag between people testing positive for the coronavirus and dying. Those who die usually do so around two weeks after developing symptoms and their deaths typically aren't reported for another week. More widespread testing, no longer limited to those with serious symptoms, could mean that cases of coronavirus are being detected even earlier, increasing this lag.

It could also be that most new cases are in younger people, whose risk of dying from the virus is far lower. The median age of those testing positive in the US is falling, suggesting that while older people continue to shelter and avoid infection, younger people are being infected as they return to work and socialising.

"As this group begins to mingle with older relatives, we may see a spike in cases for the older," says Richard Grewelle at Stanford University in California.

Plenty of mingling will have occurred over the Independence Day weekend, which could lead to a spike in deaths in late July, he says. "We'll see if my prediction holds true."

The situation in England points to a similar trend in the UK. An analysis of government data by Jason Oke at the University of Oxford and his colleagues suggests there has been a steady and steep decline in the proportion of people hospitalised with covid-19 dying. "It's encouraging," says Oke. "We are either getting better at treating this or it's becoming less severe."

But there might be other explanations, he cautions. It could just be an artefact of the data due to survivors staying in hospital longer. Another possibility is that hospitals are admitting less severe cases now they have the resources.

To know for sure if the odds of dying are falling, we really need to know how many of those who are infected succumb and if this is changing – that is, if the infection fatality rate (IFR) is declining.

Early estimates put the IFR across populations at between 0.6 and 1 per cent. Some thought this would turn out to be an overestimate, but recent estimates are similar. A statistical analysis by Grewelle and his colleague Giulio De Leo, for instance, suggests that the global IFR so far is 1 per cent.

JEENAH MOON/REUTERS

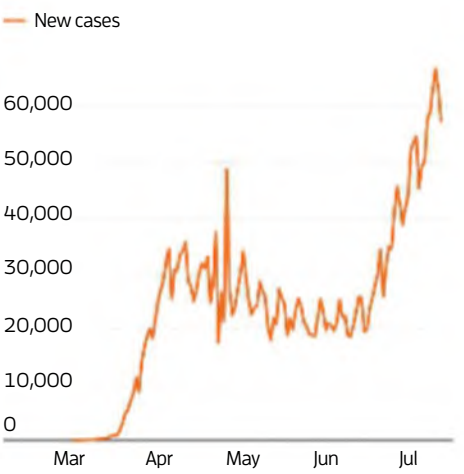
People enjoy a meal outside as restrictions ease in New York

Bold's team has estimated IFRs for different countries around the world based on death rates in France, and also came up with relatively high numbers. For instance, Brazil, one of the world's hardest-hit countries, should have an IFR of around 0.4 per cent given the ages of its inhabitants and their general health. Adjusting for the quality of healthcare, however, pushes the predicted IFR up to 0.8 per cent.

This matches research by Fernando Barros at the Catholic University of Pelotas in Brazil. He has tried to directly measure the nation's IFR by doing antibody tests on more than 25,000 people. His team puts it at 1 per cent.

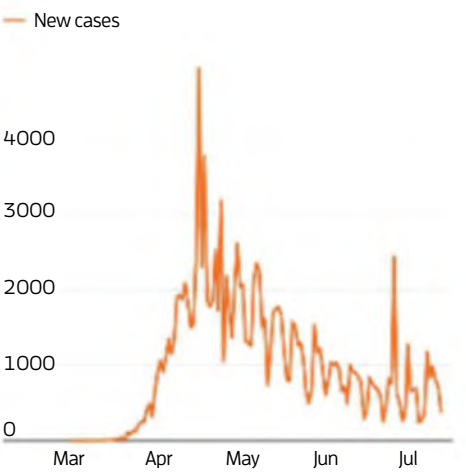
So far, though, there are no estimates of how IFRs are changing over time. "We have only one estimate, and not two or more points in time, so we are not in the position of studying trends," says Barros.

US daily coronavirus cases



Source: Our World in Data, 13 July 2020. Created with Datawrapper

US daily coronavirus deaths



Source: Our World in Data, 13 July 2020. Created with Datawrapper

Interview: Cathy Creswell

How kids are coping with lockdown

Families in the UK report that some children are more emotional or disobedient, while others have lower anxiety without the pressures of school, finds **Catherine de Lange**

SINCE lockdown began in the UK, Cathy Creswell at the University of Oxford and her colleagues have been surveying thousands of families to find out how they are affected by the covid-19 pandemic. The Co-SPACE Study has now published its first findings from a longitudinal study that questioned people over several months.

IMAGE COURTESY OF CRESWELL

Profile
Cathy Creswell is a psychologist at the University of Oxford who studies anxiety disorders in children and young people.

What has your survey of families during lockdown shown?
More than 10,000 people have now taken part. Our first report was at the beginning of April, looking at the first 1500 people. What we saw then has remained pretty consistent all the way through, which was that families were certainly feeling under a great deal of stress. Parents were particularly struggling with balancing work and childcare, and the most common concern they were reporting was about their children's emotional wellbeing. We could see that very early on, but we couldn't obviously see the direct impact that lockdown had.

Now you have data over a longer period, how have young people changed during the lockdown?
From our longitudinal data in June, that was from about 3000 people, so far we are seeing significant increases in behavioural problems, emotional symptoms and attention and impulsivity problems in primary school age children [age 4 to 10].

In secondary school age students [age 11 to 16], based on parent reports, we actually saw a reduction in emotional symptoms over time and no change in behavioural problems. We only have a small subset of teenagers who are self-reporting, but again they weren't reporting an increase in difficulties either.

We need to keep looking at it carefully, but it does fit with what many families have told us, which is that, for many young people of secondary school age, not having the pressures of school does seem to have brought some benefits in terms of their mental health.

How do you explain the differences you have seen between primary and secondary school children?
Younger children will require more adult input. The majority of adults in our sample are trying to work and look after children, and we know that they are struggling with that. In our early report, two-thirds of parents said they didn't feel that they were adequately meeting the needs of both their children and their work.

One hypothesis at this point is that it is easier for adolescents to connect with peers electronically, without seeing them face-to-face. Through lockdown, it's been much easier for older young people to be able to keep their social contacts going. For younger children, doing chats on Zoom, that's not how they would normally interact. And it would need adult organisation, and in many cases adults are quite stretched.

What does anxiety about this situation look like in younger kids?
The emotional symptoms are: being tearful, being clingy, being sad or worried. The behavioural stuff is disobedience or tantrums.

Everyone I speak to about their experience during lockdown says this sounds very familiar. If these findings do nothing else but help normalise people's experiences, hopefully that is helpful. Just so parents don't feel they are doing a terrible job, or their children are a nightmare, but see that actually it's just a really hard situation.

What can parents do? Are there any strategies that are known to work?
For managing behaviour in primary school aged children, there are good evidence-based approaches that involve parents developing strategies, skills and confidence to manage their children's behaviour. We need to kind of up our game, and put a bit more focus on managing behaviour than we might have in other situations.

"For those in secondary school, not having the pressures of school has mental health benefits"

For anxiety-related problems, we have good evidence that cognitive behavioural approaches are effective. In our studies, we have found that you can get really good outcomes for children by working directly with parents, where you are giving them skills to manage their children's anxiety in their day-to-day lives, rather than children having to go to appointments (for practical tips, see "Helping children cope", left).

How representative of the population is your sample?
There is quite a lot of bias in the sample, so we are quite cautious to not make claims about the wider population. In our sample, the numbers of children and young people with pre-existing mental health problems is pretty much what you would expect in the population. We have probably got a slightly higher number of

Helping children cope

Cathy Creswell is the principal investigator for Emerging Minds, a research network looking at mental health in children. The group offers the following tips for parents of school-aged children who have worries or anxieties about coronavirus:

- **Be curious about their worries. For instance, ask: "What is worrying you about this?", "What are people at school talking about?", "What have you heard about the virus?"**
- **Empathise and help them to feel that their worries are normal. For example: "That is a worrying thought, I can see why you feel that way."**
- **Gently correct any misunderstandings they have, using reliable, age-appropriate language. For resources grouped by age, visit the Emerging Minds website: bit.ly/30cuzb5.**
- **Help your children find ways to feel in control.**
- **Highlight the good things people are doing for each other, whether that is at a national level or in your own neighbourhood.**

JAMES VEYSEY/SHUTTERSTOCK

Understanding how people are helping others can ease children's anxiety

children or young people with special educational needs. These are obviously groups that we are concerned about at the moment and we were keen to track them.

What have you found in groups with special educational needs and pre-existing mental health issues?
Amongst these groups, we have seen a reduction in reported mental health symptoms over time. Again, this is consistent with what we are hearing from lots of families, which is that being able to do things at their own pace and not having the same pressures of school means many young people have been doing well.

The important thing to say is that their mental health symptoms are still elevated, they are still higher than the groups who don't have those difficulties. There is also a lot of variability, but overall there has been a bit of an improvement over time. Many families have told us that they are really concerned about how this may change as things start to get back to normal.

Could the easing of restrictions make things more difficult?
Absolutely. For young children, this has been quite a big chunk of their lives and there has been this message that interacting with other people is potentially dangerous, so it will be really important for us to be thinking about how we support children to overcome that, in a way that still fits with whatever the guidance is at the time.

Another thing that we are hearing from quite a lot of families at the moment, those with younger children, but also children who might have particular issues, for example those with autism, is that ambiguity in the rules is more challenging. These things can then cause frustration, which can lead to other difficulties.

"Parents shouldn't feel they are doing a terrible job or their children are a nightmare. It's just hard"

What have you learned about the pressures of school and how that plays into anxiety in young people?
This situation has certainly raised a lot of questions about schools and how we approach schooling as a culture. It will be important to see what happens as children start going back to school.

We know that mental health problems in teenagers in the UK are high, particularly among girls and particularly as they move into the later school years. And we know that levels of school stress are extremely high among UK school students. So I think it does give us a good opportunity to understand that a bit more and be able to think about whether it has to be like that, or whether there are different approaches to education.

How long term or serious are these anxiety problems in children?
So far, when looking at change over time, we have just been looking at anxiety symptoms. For most people, they are within the normal range. But the measures that we use allow us to look at the probability of someone meeting a diagnostic criteria.

Studies with adults during lockdown suggest increases in cases of anxiety disorders. This has been particularly the case among adults who are married or in civil partnerships, according to data from the Office for National Statistics. This may be due to juggling work with home schooling. This is quite striking and fits with stress levels reported in our study. We are going to look at whether these criteria are increasingly being met by school children in our next report. ▮

The Co-SPACE study is still recruiting families of school-aged children living in the UK. Visit bit.ly/co-space-study for more information

Technology

We can tackle bias in AIs without making them less intelligent

Edd Gent

MAKING an artificial intelligence less biased makes it less accurate, according to conventional wisdom, but that may not be true. A new way of testing AIs could help us build algorithms that are both fairer and more effective.

The data sets we gather from society are infused with historical prejudice and AIs trained on them absorb this bias. This is worrying, as the technology is creeping into areas like job recruitment and the criminal justice system. New techniques can make AIs fairer, such as by preprocessing training data to remove bias, but in practice these lead to less precise results.

Or do they? "The trade-off that we see is kind of an illusion," says Sanghamitra Dutta at Carnegie Mellon University, Pennsylvania.

For example, a firm may employ more men as its predominantly male management has hired fewer women due to unconscious bias. If that company uses its employment data to train an AI to assess job applicants and hire staff, the dearth of information on women makes it harder for the system to judge their aptitude, putting them at a disadvantage.

The company could use existing fairer training techniques to create a new AI, but if it is tested on the original, biased data it will appear to be less accurate than the original AI, says Dutta.

That doesn't mean the fairer AI is no good though, says Dutta. Biased hiring practices have made the firm's data unrepresentative of the entire pool of job candidates. Instead, AIs should be tested using an ideal data set, says Dutta. When you do this, the trade-off between accuracy and fairness disappears.

Dutta, who carried out the work with colleagues while at IBM, has developed a way to create this ideal data set. The technique draws on a field of mathematics called information theory to equalise the amount of information on each group, providing a statistical guarantee of fairness. In the case of the hiring company, that might mean using the existing data to

"The data sets we gather are infused with historical prejudice and AIs trained on them absorb this"

invent some fictional women to balance the amount of information on each group, though Dutta says the approach works with multiple categories and more complex data than just numbers of employees.

In work presented at the virtual International Conference on Machine Learning on 16 July, the team shows that by using these techniques, it is possible for an AI to improve in accuracy and fairness simultaneously.

The approach can help evaluate AI, says Dutta. If two AIs perform similarly on biased data, but one performs better on the ideal data set, it has greater potential for both fairness and accuracy. If fair algorithms perform much better when using ideal data sets, this could also alert companies to serious bias in their data.

Fairness tests are important, says Sandra Wachter at the University of Oxford, but she cautions that they only reveal the problem of bias in society. "That's the first step, but the actual hard work is how are we going to fix that problem." To do so, computer scientists can't rely on automated fixes and will need to engage more with social scientists, she says. ▮

Biodiversity

European bison will be introduced to the UK in 2022

CONSERVATIONISTS want to bring European bison to the UK for the first time outside a zoo, hoping to regenerate ecosystems and help other animals and plants thrive.

Europe's largest land mammal was reduced to just 54 individuals in the early 20th century, but reintroductions across continental Europe from the Netherlands to Romania have seen numbers swell to more than 5000. The UK will follow suit in early 2022 with an initial four *Bison bonasus* set for release in a controlled area of a nature reserve outside Canterbury.

European bison bones have previously been found on Dogger Bank, a sand bank beneath the North Sea that was once part of a fertile plain connecting the UK to mainland Europe. DNA analysis suggests the species also has genetic roots in the UK.

WILDMEDIA/ALAMY

A herd of European bison in Slovakia. There are more than 5000 animals across Europe

"This is a trial to see: can we do this, can we replicate what we've seen work successfully in Europe?" says Laura Gardner at the Wildwood Trust in the UK, which was awarded £1.15 million from the People's Postcode Lottery for the project.

Working with Kent Wildlife Trust and several universities, the team at the Wildwood Trust hopes to monitor how the grazers break up soil and open spaces in woods to bring back complexity to ecosystems. "It's not just about how the bison interact directly with the landscape, but the impact of that: what does it mean for soil quality, invertebrate abundance, the number of plant species," says Gardner.

The animals will be fenced in a 500-hectare area away from footpaths. The project team hopes to assuage any potential concerns from dog walkers and ramblers by engaging with local people.

Rebecca Wrigley at the UK charity Rewilding Britain, which isn't involved in the scheme, says the plans "could be good news for Britain's battered biodiversity". ▮

Adam Vaughan

Introducing ATEM Mini

The compact television studio that lets you create training videos and live streams!

Blackmagic Design is a leader in video for the medical industry, and now you can create your own streaming videos with ATEM Mini. Simply connect up to 4 HDMI cameras, computers or even technical equipment. Then push the buttons on the panel to switch video sources just like a professional broadcaster! You can even add titles, picture in picture overlays and mix audio! Then live stream to Zoom, Skype or YouTube!

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ATEM Mini's includes everything you need. All the buttons are positioned on the front panel so it's very easy to learn. There are 4 HDMI video inputs for connecting cameras and computers, plus a USB output that looks like a webcam so you can connect to Zoom or Skype. ATEM Software Control for Mac and PC is also included, which allows access to more advanced "broadcast" features!

Use Professional Video Effects

ATEM Mini is really a professional broadcast switcher used by television stations. This means it has professional effects such as a DVE for picture in picture effects commonly used for commentating over a computer slide show. There are titles for presenter names, wipe effects for transitioning between sources and a green screen keyer for replacing backgrounds with graphics!

Live Stream Training and Conferences

The ATEM Mini Pro model has a built in hardware streaming engine for live streaming via its ethernet connection. This means you can live stream to YouTube, Facebook and Twitch in much better quality and with perfectly smooth motion. You can even connect a hard disk or flash storage to the USB connection and record your stream for upload later!

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Blackmagicdesign

Technology

Light-activated microscopic pliers built on optical fibres

Donna Lu

MINUSCULE pliers made of soft filaments added to the ends of optical fibres can be controlled with visible light, and could be used to grip objects tens of micrometres in size, such as some individual cells.

Piotr Wasylczyk at the University of Warsaw in Poland and his colleagues made the pliers from liquid-crystal elastomer, a soft polymer material. They bend when visible light shines through attached optical fibres (*Advanced Materials*, doi.org/d3mw).

The texture of the pliers is similar to a very soft rubber, and becomes even softer when the pliers bend, says Wasylczyk. Despite the softness of the material, the pliers can grip with a force equivalent to 100 times their weight.

The researchers created the pliers by dipping the ends of optical fibres – transparent glass fibres about the thickness of a human hair – in a liquid-crystal elastomer.

They then used ultraviolet light to set the elastomer: the UV light triggers a reaction that makes the material harden. This created cone-shaped tips on the ends of the optical fibres.

Shining visible light through the optical fibres causes the tips to reversibly bend, a process that Wasylczyk estimates can be repeated several thousand times before the material eventually breaks. In principle, the tiny pliers could be controlled from kilometres away.

"There are [other] technologies to 3D print different structures in the micrometre scale, but all of them are very complex," says Wasylczyk. Many need large workstations and expensive equipment, and the advantage of these tiny pliers is their ease of fabrication, he says.

The team wants to scale down the pliers so they could grip objects as small as 1 micrometre in size, such as a bacterium. ▮

Medicine

Damaged lungs restored by connection to a pig

Jessica Hamzelou

DONATED lungs that are too damaged to be used in transplants have been revived after being connected to the blood supply of a live pig. The technique might triple the number of lungs available for transplant, say the researchers behind the work.

As soon as someone dies, their lungs begin to deteriorate. "The lung is very delicate," says James Fildes at the University

"The lung is very delicate. It is one of the most difficult organs to preserve"

of Manchester, UK, who wasn't involved in the work. "It is one of the most difficult organs to preserve."

Most donated lungs are outside the body for only a matter of hours. But despite this, few can safely be used. Just 28 per cent or so of donated lungs meet the criteria for transplantation in the US, according to the American Lung Association.

Doctors can attempt to "recondition" damaged lungs using ex vivo lung perfusion (EVLP) devices that pump oxygenated air and fluid through the lungs, but even then, many fail, says Gordana Vunjak-Novakovic at Columbia University in New York.

Vunjak-Novakovic and her colleagues wondered whether the lungs might do better if they were connected to a living body, with other working organs able to deliver nutrients and remove harmful substances.

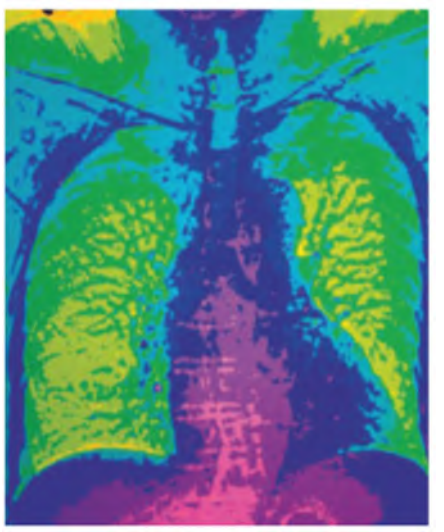
To find out, the team obtained lungs from six human donors that had been rejected for transplant, both single lungs and pairs. One lung had failed even after 5 hours on an EVLP device, and had been outside the body for a day before the team received it.

The team connected each lung to the circulatory system of an anaesthetised pig for 24 hours, with tubes feeding the blood vessels of the human lung running from those in the pig's neck. At the same time, the lung was pumped with air using a ventilator. Immunosuppressant drugs, which prevent "foreign" tissues from being rejected by the immune system, were introduced to both the pig and the lung.

Vunjak-Novakovic's previous research has shown that the procedure doesn't seem to have any lasting effects on the pigs. In one earlier experiment, they were able to move around, play with toys and feed while connected to a device used to support lungs taken from other pigs, she says.

Before the new treatment, all the lungs had a lot of white areas, suggesting tissue was dying, and weren't considered capable of getting enough oxygen into a person's blood.

A CT scan of a healthy chest and lungs



MIRA/ALAMY

But after 24 hours of being connected to the pigs, the lungs looked transformed. A range of tests showed that their cells, tissue structure and capacity to deliver oxygen had significantly improved (*Nature Medicine*, DOI: 10.1038/s41591-020-0971-8).

Even the lung that had been outside the body for almost two days appeared to have recovered. "That's remarkable," says Fildes. "My expectation would be that that lung would be destroyed, but actually it doesn't look like it is at all."

"They aren't 100 per cent normal, but they're close enough," says Vunjak-Novakovic. The lungs looked healthy enough to be acceptable for transplant, but she wants to repeat the experiment with lots more of them before implanting treated lungs in people.

Vunjak-Novakovic also plans to use medical-grade pigs, which researchers can be sure won't harbour potentially harmful pathogens that could be transmitted to people.

The lungs may not be entirely free of pig cells, however. The lungs in the current study were found to contain white blood cells from the pigs – cells that could trigger an immune reaction in a lung recipient, warns Fildes.

Eventually, Vunjak-Novakovic hopes that a potential lung recipient could use their own blood supply to revive donated lungs that they will receive. It is unlikely that the approach will rescue the most severely damaged lungs, but "if you can salvage two out of every four that are rejected, you can increase the number of lungs available to patients by three times", she says. ▮

Animals

World's lemurs threatened

Nearly all lemur species are now officially at risk of extinction

Adam Vaughan

THE lemurs pictured here were once common in southern Madagascar, but the species is now listed as critically endangered, one step from extinction. The plight of Verreaux's sifaka (*Propithecus verreauxi*) is sadly shared by many of its cousins, says the International Union for the Conservation of Nature (IUCN).

Due to rampant deforestation and hunting in their heartland of Madagascar, 103 of the world's 107 lemur species are now threatened by extinction. A growing lemur pet trade in the country has also emerged as a new pressure.

"Everything seems to be stacked up against lemurs," says Russ Mittermeier at the IUCN. Local taboos about hunting Verreaux's sifaka had previously helped this species, but with new people moving to the forests they occupy, that protection has evaporated. "It's a wonderful, beautiful animal," says Mittermeier. ▮

CYRIL RUOSO/NATUREPL

Space

Migrating stars could be sign of alien tech

ADVANCED alien civilisations could build a machine capable of moving a star – and we might be able to catch one in action.

The Star Tug, thought up by Alexander Svoronos at Yale University, would allow extraterrestrial civilisations to avoid cosmic disasters.

"It's a megastructure that can be used to move an entire star system," says Svoronos. "If their star system is going to be in proximity of a supernova, they might want to try to avoid it."

The idea of moving stars isn't new. In 1987, Russian physicist Leonid Shkadov first described his Shkadov thruster. This giant mirror would reflect a star's light back on its surface to produce thrust, enabling modest speeds over a long period of time.

Svoronos's concept is somewhat different. Assuming that the star to be moved is the same mass as the sun, it would involve placing a structure at least a fifth the mass of our moon as close as 10,000 kilometres from the star. The gravitational pull of the object, although small, would accelerate the star towards it.

The Star Tug would have thrusters, allowing it to move and drag the star along with it. Svoronos estimates that it could accelerate the star to 0.1 per cent of the speed of light in 5300 years and 10 per cent of this speed in 38 million years – up to a million times faster than a Shkadov thruster (*Acta Astronautica*, doi.org/d3hg).

One complication is that the Star Tug would need to extract material from the star to power its engines via nuclear fusion. This could be done with giant space elevators, but they might struggle to survive so close to a star. "You need ridiculously strong materials," says Anders Sandberg at the University of Oxford's Future of Humanity Institute.

38m

Years it would take a Star Tug to reach a tenth the speed of light

But if all this were possible, the Star Tug could enable an advanced alien civilisation to move its solar system to another part of its galaxy, colonising other systems along the way, or even to relocate to a different galaxy altogether. "You can actually expand to another galaxy over hundreds of millions of years," says Svoronos.

Although beyond humanity's ability for now, we could in theory look for alien Star Tugs. Most stars rotate around the galaxy in the same direction, but some don't. "We think they're natural," says Sandberg. "But if you see a lot of them, that might be a hint that something weird is going on." ▮

Jonathan O'Callaghan

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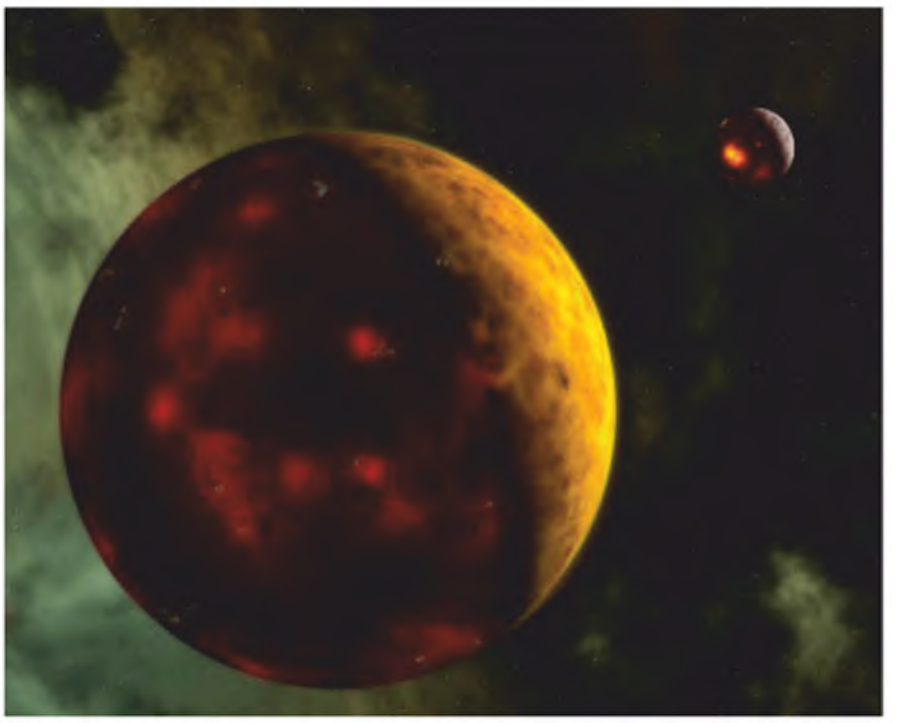
Solar system

Earth dodged snowball fate thanks to the moon

Jonathan O'Callaghan

THE sun is thought to have once been far fainter than it is today, which should have left Earth frozen as a global snowball. That it wasn't, a discrepancy known as the faint young sun paradox, has plagued astronomers, but now we might have an answer: the moon kept Earth warm.

Earth and the moon formed about 4.4 billion years ago. Models suggest the sun was up to 70 per cent dimmer until about 3.5 billion years ago. "Earth should have been frozen for at least a billion or even 2 billion years," says René Heller at the Max Planck Institute for Solar System Research in Göttingen, Germany.



WALTER MYERS/SCIENCE PHOTO LIBRARY

The moon formed when a large object struck Earth

Geological evidence, as well as the evolution of life, shows this didn't happen. We know Earth had water back then thanks to a mineral called zircon, some crystals of which have survived for 4.3 billion years and retain evidence of water from that time.

When the moon and Earth formed, our satellite was as little as 20,000 kilometres away, compared with an average of 380,000 km now. Earth was also rotating much faster, as quickly as once every 3 hours.

Heller and his colleagues have calculated that these two factors mean the gravitational interaction between the two bodies would have been much stronger – enough to produce tidal heating from the gravitational squeeze. This would have slightly warmed Earth and could have triggered the eruption of volcanoes, giving our planet a thicker atmosphere that could trap more heat (arxiv.org/abs/2007.03423).

"The classic example in our solar system is [Jupiter's moon] Io, which is spectacularly volcanic because of the tidal heating from Jupiter," says Rory Barnes at the University of Washington. "The moon could have turned early Earth into something like Io for tens of millions of years."

Finding out how Earth was able to hold liquid water back then could be crucial in our search for life on other worlds, says Ludmila Carone at the Max Planck Institute for Astronomy in Heidelberg, Germany. "We are not entirely sure why Earth was habitable," she says. "We have the possibility to go back in time and think about the early Earth as a kind of exoplanet."

4.4bn
The age in years of Earth and the moon

Other solutions for the faint young sun paradox include Earth having a thicker carbon dioxide atmosphere at the time, as a result of the planet being molten following the giant impact that formed the moon, trapping more heat. Another is that the planet's orbit brought it closer to the sun at times, warming it up, or that the sun had more mass at the time and was brighter than we think.

All these ideas have many unknowns, says Barnes, but while tidal heating is a good fit, it isn't perfect. The amount of energy produced directly by the moon's gravity would have been small, requiring it to cause other processes like volcanic eruptions, which we don't have any direct evidence for.

"The amount of tidal heating required to have a climatological effect is very great," says Kevin Zahnle at the NASA Ames Research Center in Mountain View, California. The moon moved away from Earth quickly, limiting the duration of the tidal heating to just 10 to 20 million years, he says – not enough to warm Earth sufficiently. Further modelling of the early Earth could help better understand the different factors at play, says Heller. ▮

Fertility

Sperm with lazy tail can swim faster

Jason Arunn Murugesu

A HUMAN sperm can move up to 70 per cent faster if it has a lazy tail, a finding that could pave the way for new fertility diagnostic tests.

Sperm cells use their tails to swim, though some don't use the whole tail, leaving a piece at the end inactive. This part only comprises about 3 to 5 per cent of a normal sperm tail, which is usually between 50 and 55 micrometres long, and doesn't actively bend like the rest of the tail. But it may be key to gaining speed.

The tail makes a shape a bit like a sine wave to propel the sperm, says Meurig Gallagher at the University of Birmingham in the UK. "The tail moves left and right, but when you get to the end, that part is also trying to move this way in the fluid," he says. "We found that when the end piece instead relaxes with the tail, it generates a shape that allows the tail to swim more efficiently."

Gallagher and his colleagues, led by Cara Neal at the University of Birmingham, devised mathematical models for how sperm swim. Unlike previous models, the team included the end section of a sperm's tail that had been historically overlooked. "Nobody has looked at the end piece because it's effectively at the limit of light microscopy," says Neal.

The researchers modelled sperm swimming in a range of environments, including in semen and in the female reproductive tract, including in cervical mucus. They found that sperm with an inactive end piece swam more efficiently and faster than sperm with tails that were completely active.

Depending on the environment, a less active tail was found to propel sperm 20 to 70 per cent faster and was between 1.5 and 4.5 times more energy efficient when swimming (*Physical Review Liquids*, doi.org/d3h3). ▮

Biotech

Mitochondria edited for the first time

THE cell structures that turn food into energy have been genetically edited for the first time.

Mitochondria have their own genomes, and mutations in this DNA can lead to muscle disorders or even prove fatal in childhood.

Standard gene-editing techniques don't work with mitochondria, however, hindering efforts to develop treatments. For instance, most gene editors cut DNA, but mitochondrial genomes break down if sliced.

Now David Liu at the Broad Institute in Massachusetts and his team have collaborated with two other groups to create a new kind of editor. In tests in human cells growing in a dish, this made the desired change in up to 50 per cent of mitochondrial genomes (*Nature*, doi.org/d3gd).

Michael Le Page

JAVIER BLANCO

Climate change

Sprinkle rock dust to limit global warming

SPREADING rock dust on cropland globally could absorb about a tenth of our "carbon budget", the amount of carbon dioxide humans can emit without triggering catastrophic climate change.

Rocks naturally absorb CO_2. This can be accelerated by grinding them up to increase their surface area, a process called enhanced rock weathering.

David Beerling at the University of Sheffield in the UK and his team modelled its potential. They found that rock dust could remove between 0.5 and 2 gigatonnes of CO_2 a year by 2050. Humanity's fossil fuel use emits about 35 gigatonnes of CO_2 a year.

If 2 gigatonnes of CO_2 were removed annually over half a century, it would be equivalent to 12 per cent of the world's carbon budget (*Nature*, doi.org/d3gh).

Adam Vaughan

Anthropology

Americans and Pacific islanders met 800 years ago

POLYNESIANS and Native Americans met and had children together about AD 1200, modern genomes show. But the encounter didn't take place on Easter Island (Rapa Nui), the Polynesian island closest to South America.

Beginning about 5000 years ago, people sailed from South-East Asia into the Pacific and discovered hundreds of islands. Easter Island, the easternmost of the group, was the last to be settled.

This story is backed by genetic, archaeological and linguistic evidence, but there were clues that Polynesians might also have some Native American ancestry.

"There is the sweet potato in Polynesia, even though it was domesticated in, and is native to, the Americas," says Alexander Ioannidis at Stanford University in California. Some have argued that the Easter Island statues (pictured) resemble ancient Peruvian ones.

Geneticists have found evidence of Native American genes in Polynesian people, but the results are disputed. Now, Ioannidis and his colleagues have sequenced the full genomes of 354 Polynesian people from 17 islands, and 453 Native Americans belonging to 15 groups from the Pacific coast. Small amounts of Native American DNA were found in Polynesians from the eastern islands, including Easter Island (*Nature*, doi.org/d3f6).

The islanders who were the point of contact were almost certainly from one of the more westerly of these islands, the team says. The genes were later carried east.

But did Polynesians sail east to South America and back or did Native Americans stray west? Either scenario fits the data, says Ioannidis. Michael Marshall

Really brief

LESLEY WOOD PHOTOGRAPHY

Climate change may widen range of Zika

Climate change may help spread the mosquito-borne Zika virus to cooler regions. In the most drastic model of global warming, the risk of transmission will increase in southern and eastern Europe, the northern US, northern China and southern Japan by 2080 (*Proceedings of the Royal Society B*, doi.org/d3fk).

Windows that cut noise but let in air

Small speakers fixed to the outside of a window can halve the noisiness of urban traffic, reducing the sound coming through an open window by up to 10 decibels. A sensor allows the speakers to emit sound at the same frequency as the noise outside, cancelling it out (*Scientific Reports*, doi.org/d3fm).

Quick swimming traits evolved twice

A 24-million-year-old fossil of a giant tusked dolphin lacks vertebrae and pectoral bones that help modern dolphins and baleen whales swim faster. This suggests that whales and dolphins separately evolved these adaptations for more efficient swimming (*Current Biology*, doi.org/d3fn).

New Scientist
Newsletter

Launchpad

Voyage across the galaxy and beyond with our monthly space newsletter

A new era of space travel has officially begun. Let our resident space expert Leah Crane fill you in on all the very latest news on our exploration of the solar system – and beyond.

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Leah Crane

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newscientist.com/launchpad

Signal Boost

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

Grow a greener future

For communities in the African drylands, the climate crisis is not a future threat but a daily reality. The effects of deforestation, desertification and a changing climate are widespread. There is clear evidence that temperatures are rising. A shorter rainy season is now a reality, and droughts and floods are becoming more frequent and severe. Forest resources are depleting faster in the drylands of Africa than elsewhere in the world.

Our strategy lays out ambitious plans to grow over 8 million trees in 5 years and to support 2.5 million people through poverty-alleviating initiatives.

These initiatives are rooted in the power of trees. The trees we grow enhance soil quality, improve harvests, protect from wind and flooding, support ecosystems and increase biodiversity. We provide people with essential training on Farmer Managed Natural Regeneration. They can utilise this training to encourage tree growth from degraded land and shrub vegetation. Additionally, we train communities in soil and water conservation techniques. This means that families can increase their land's resilience to drought and climatic stresses. In one project in Ghana last year, we worked with local communities to plant 898,368 trees along the Daka River.

Local small business enterprise has a vital role to play in combating climate poverty. We support people to form Village Tree Enterprises (VTEs). The members of these VTEs protect trees and work together to turn the tree products into nutritious food and goods, such as shea butter and moringa powder. By providing training, processing equipment and access to new markets, we can empower families and communities to grow their way out of poverty. These groups are particularly important to women, who often have limited access to resources.

Since 1987, TREE AID has planted more than 18.5 million trees. But there are significant challenges facing the people we work with, and we need your support to fight the climate crisis and poverty together.

Want to help?

Your support will help to build resilience to a changing climate, reverse the growing desert and empower communities to reclaim the land for themselves and their future generations. Visit **treeaid.org.uk/support-us/donate**

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
Stuart Hall's essays about cultural studies are challenging to read but very enriching.

What I'm watching
Probably a few too many horror films!

What I'm working on
I'm about to roll out a new academic paper on the timescales involved in the condensation of axion dark matter into a unique state called a Bose-Einstein condensate.

This column appears monthly. Up next week: Graham Lawton

Columnist

Our ever-changing star

The sun may seem timeless, but it is constantly evolving and is already halfway through its life, says **Chanda Prescod-Weinstein**

YOU should never stare directly at the sun. This isn't a euphemism of some kind – you really shouldn't because it will damage your eyes.

Of course, some among us may have stared at it anyway, perhaps in what we irresponsibly perceived to be a show of daring. But maybe you have been good and have never stared at it or only used special glasses to look, if you have ever witnessed a solar eclipse.

Either way, you have probably never noticed that the sun seemed different. Sure, clouds, fog or even the moon might get in the way, but, in general, it is just this extremely bright yellowish circle in the sky that we are either longing for, annoyed with or contented by. It is, by all other measures, timeless.

But the sun is more fantastical than it appears to be to us in everyday life. It is easy to forget that, like many of the pinpoints we see in the sky at night, it is just an average so-called main sequence star – and that means it is changing all the time.

To start with, the sun hasn't always existed. In fact, it isn't a first-generation star. If it were, we wouldn't be here on Earth. The first generation of stars, counter-intuitively called population III stars, were made entirely of primordial hydrogen and helium, the by-products of big bang processes. These stars formed when clumps of gas collapsed under their own gravitational pull, leading to the ignition of nuclear fusion.

Fusion in stars is the universe's primary source of elements that are more massive than hydrogen and lighter than iron. The process changes with time. At the start of its life, a star has a lot of hydrogen. By the end, there will be less because some will have fused into helium and other more massive elements like oxygen and carbon. One quirk of the astronomy community is that everything heavier than hydrogen or helium is called a "metal". So, in our lingua franca, you are mainly metal.

> **"We are carbon-based life forms, requiring heavy elements that didn't exist in the era of the first stars"**

At the end of their lives, population III stars either underwent supernova explosions or slowly blew off their outer layers. Both scenarios left behind a lot of hydrogen, helium and some metal-rich gases. In the case of supernovae, elements heavier than iron might have fused during the explosion.

The evaporated remains, mixed with other hydrogen and helium gas, eventually repeated the gravitational collapse and nuclear ignition process, birthing second generation population II stars. These stars have a different composition to their ancestors because metals were available in their nursery.

It is from the mix of population III and population II remains that stars like our sun were born. These generational stages are vital for our existence: those metals are what make up the planets orbiting the sun, including our own, and we are carbon-based life forms, requiring heavy elements that didn't exist in the population III era.

Our sun, like its forebears, has a finite lifetime. Our calculations, and dating of elements on Earth, suggest it is about 4.5 billion years old, halfway through its life. With each passing day, the sun has less hydrogen and more helium.

It also has an outer magnetic field whose behaviour and effects on Earth remain somewhat unpredictable. Several of my colleagues at the University of New Hampshire's Space Science Center work in the area of heliophysics, trying to figure out the exact dynamics of the magnetosphere and other parts of the sun that are constantly in flux. This work, sometimes known as space weather, points to how dynamical and constantly evolving our sun actually is.

It might look the same to you from the park, but the sun is changing every day in ways that are noticeable with missions like NASA's Parker Solar Probe. In about 4.5 billion years, when it begins its transition into a planetary nebula, the sun will look different by anyone's standards. ▮

Editor's pick

Maybe a second wave won't be as bad as feared

20 June, p 10

From Christine Duffill, Southampton, UK

You ask how many people have caught the coronavirus. This is relevant to possible levels of immunity to infection. A suggestion is emerging that only those who have had severe covid-19 develop lasting antibodies, while detectable antibodies are fleeting in mild or asymptomatic cases.

Together with evidence that the virus came to Europe on many separate occasions and the fact it was found in Italian waste water as far back as December 2019, this picture of antibody duration may mean that antibody studies tell us little about the true extent of infection in the first wave. This could mean that swathes of the population fought off the virus and are likely to do so again, should there be a second wave.

This may mean that in places with poorly controlled outbreaks, such as the UK or the US, a significant proportion of those at risk of serious disease became ill and produced antibodies first time round. We may not actually need the approximately 70 per cent level of infection said to be required for herd immunity to avoid a second peak as devastating as the first. Only time will tell, of course, but I remain hopeful.

Keep watching for covid-19's full effects

27 June, p 34

From Santosh Bhaskaran, Mumbai, India

If there are other potential long-term effects of covid-19, they may only come to light when much more time has elapsed. We should watch for any impact on fertility, the number of miscarriages and stillbirths and any health conditions in the next generation. We may therefore need to follow up with those who have had covid-19 and their families for decades.

Dietary change may help us avert future pandemics

20 June, p 30

From Bruce Friedrich, The Good Food Institute, Washington DC, US

Among the many steps we could take to lower the risk of the next pandemic, perhaps the most effective would be to stop farming animals for meat. By removing that viral vector, we would make humanity's future much safer.

This isn't another call for universal veganism. Rather, we need to work to modernise meat production and remove animals from the supply chain. By making "meat" from plants or cultivating it from cells, we will create a food system that is safe, secure and sustainable.

Yet just as we can't depend on a private lab to come up with a vaccine for the coronavirus, we can't count on a private company to shift global meat production on its own. As has been the case with just about every transformative advancement, public funding of fundamental research will be key.

We have seen this in communications, aviation, microprocessors, clean energy, the internet and many other fields. Shifting the agricultural research dollars of governments towards developing and deploying plant-based "meat" and cultivated meat will have countless pay offs, but the benefit of fewer devastating pandemics alone makes it a vital and compelling public investment.

Are we really the sum of our parts?

27 June, p 28

From Josh Schwieso , Spaxton, Somerset, UK

Laura Spinney's interesting article on the role of the wider body in consciousness is a reminder of the degree to which Cartesian ideas of the mind as separate from the body still haunt cognitive psychology.

Seeing, hearing, smelling, feeling, sensing and being conscious are all attributes of the whole person embodied in an actually existing world, not of an isolated brain. Medieval thinkers, especially those in the tradition of Thomas Aquinas, took this as their starting point.

Then the Renaissance, with Descartes, muddied the water and sent the psychological sciences off on a centuries-long wild goose chase from which they have only recently begun to return.

From Brian Horton, West Launceston, Tasmania, Australia

You show that consciousness depends on feedback from the body's organs, and that this is an essential part of our sense of who we are. The article finishes by suggesting that a robot with no way of integrating signals from its body will never be truly conscious – but robots already have feedback from their bodies.

Any robot that can move its arms or legs must have sensors that tell it where its arms and legs actually are. If they relied only on sending signals to move their legs without feedback, they would fall over as soon as they encountered any immoveable object.

Robots must monitor their battery life in the same way that a phone does and automatically alter some functions to conserve energy when the battery level is low. Any robots with arms capable of picking up an egg must rely on feedback about the pressure of their fingers.

If the brain integrating signals from the body is an essential part of being conscious, then a lot of robots are probably capable of this already.

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

You emphasise the connection between body and consciousness. But what about consciousness when the body is clinically dead, as in near-death events? This was discussed in an interview that *New Scientist* ran a while ago (9 March 2013).

For instance, there was a case in Spokane, Washington, in which a clinically dead man, later revived, could see and hear what was going on in the operating room (see *Journal of Near-Death Studies*, vol 31(3), p 179).

From Keith Bremner, Brisbane, Australia

Your article certainly explains why I have long conversations with my stomach about what to order from the menu.

Neanderthals may have inspired folk tales

6 June, p 12

From Sophie Grillet, Ann Arbor, Michigan, US

I'm happy to see that Neanderthals seem to be in vogue at *New Scientist* this year. I would like to add a little speculation. All around Europe (and, for all I know, the world), there are folk tales of "the little people": leprechauns, fairies, trolls, the green man, mountain dwarves and the like, beings that are near-human, but not quite.

Is it possible that such stories relate to Neanderthals suffering from catastrophic habitat loss and population decline? Could they have been around long enough while people were also in northern Europe that perhaps they were at the root of tales like these?

For the record

Congratulations to the many readers who pointed out that the "Planning" puzzle reproduced in our extract from *The Brain: A user's guide* (20 June, p 47) can in fact be done in five moves.

Want to get in touch?

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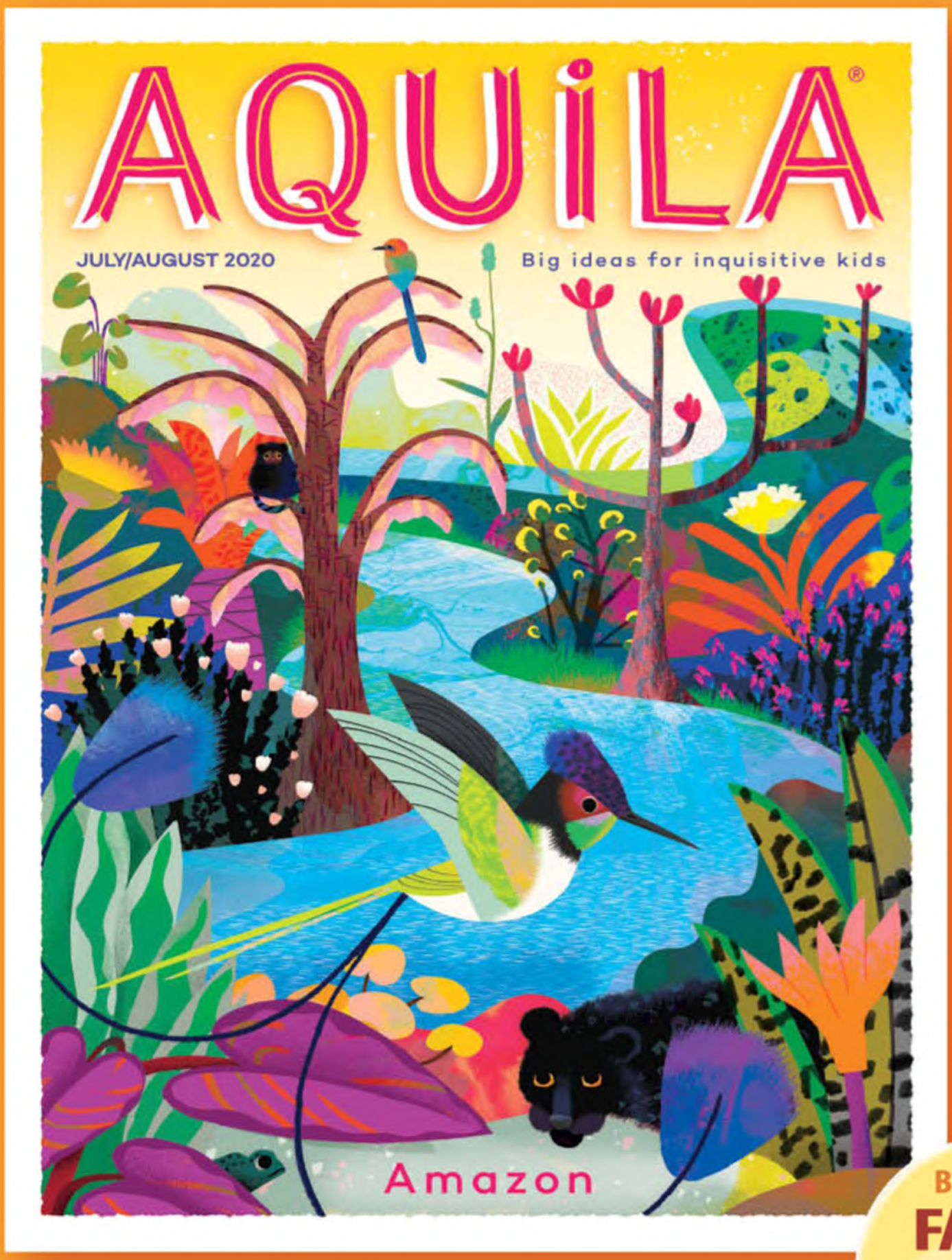

In the fabulous Summer Double Issue, children can take an imaginative journey to the heart of the Amazon Jungle, make a herbarium and a rainforest mask; read about biobanks and the science of rubber plus try some Ant maths! PLUS: pink river dolphins and the well-travelled Bear from Darkest Peru as created by author Michael Bond!

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Richard Robinson, Brighton Science Festival

Incredible treatment

Alice Ball pioneered leprosy drug development, but she is relatively unknown. A scientist who claimed her work as his own is partly to blame, finds **Gege Li**

HAYE YUKIO

Film

The Ball Method

Dagmawi Abebe

Amazon Video Direct from August

IN 2000, the World Health Organization declared that leprosy had been eliminated as a global public health problem, due to effective multi-drug treatments. It is a disease that has long been stigmatised due to disfiguration it can cause. The story of one unsung hero in the development of a treatment for leprosy is told in the short film *The Ball Method*.

The story starts with archive footage of the Hawaiian island of Moloka'i, where thousands of people with leprosy were quarantined from 1866 by the Hawaiian government. Back then, little was known about the disease and people feared it was highly contagious, though we now know it doesn't spread very easily.

Countries such as the UK, the US and India exiled people with leprosy to remote locations, where they were left to die. One of the film's clips shows a child covered in sores on his face and hands.

By 1915, when the film is set, one remedy was beginning to show promise. We are introduced to Alice Ball (played by Kiersey Clemons), a chemistry professor at the University of Hawaii, as she visits Kalihi Hospital in Honolulu. Ball has been enlisted to help develop a treatment for leprosy by Dr Harry Hollmann (Kyle Secor) using the oil from the seeds of the chaulmoogra tree. Chaulmoogra oil seemed to work in treating some cases of leprosy and had already been used for centuries in China and India for skin ailments.

Taking the oil orally caused nausea, so it was administered by injection. But this method was flawed. In its unpurified form, chaulmoogra oil isn't water soluble and doesn't react well with the body; oil oozes painfully out of the forearm of one patient with leprosy as he is given a shot.

In between teaching students at her university, Ball tries to purify the oil into chemical compounds

> **"Ball was the first woman and first black American at the University of Hawaii to teach chemistry"**

called ethyl esters so it can be successfully injected. To do this, the oil first needs to be converted into fatty acids. Ball has a eureka moment. She realises the acid needs to be frozen overnight to give enough time for the esters to separate, as well as to stop them degrading at room temperature.

Her discovery, the Ball method, led to the most effective treatment for leprosy at the time, one that was used until the 1940s, when a full cure was found. Why, then, is Alice Ball not more famous?

One reason is that credit wasn't given to her at the time. Ball's colleague Arthur Dean (played by Wallace Langham), who was president of the University of Hawaii, took her findings as his own, naming the technique the Dean method. There was no mention of Ball in his papers. She didn't get credit until 1922 when Hollmann published a paper detailing her work.

Director Dagmawi Abebe says this is why he felt it was so important to make the film. "When I came across Alice's story and saw all the amazing accomplishments she's done, and how not a lot of people even knew about her, I really wanted to make that known."

There are few historical records about Ball. She didn't keep a diary that we know of and died in 1916 aged 24, possibly after inhaling chlorine gas in a lab accident.

Kiersey Clemons plays chemist Alice Ball, known for "the Ball method"

So Abebe had to make a lot of choices in how to portray her. He says he wanted to depict her as strong and ambitious given the barriers she is likely to have faced.

Looking at the facts, that doesn't seem like much of a stretch. At only 23, Ball was the first woman and first black American to teach chemistry and obtain a master's degree at the University of Hawaii. But being a black woman in this environment wasn't easy. In one scene, as Ball takes a class, students (all male and white) snigger as they pass around a picture of a crudely-drawn monkey.

For Abebe, who is originally from Ethiopia, it was important to highlight this aspect of Ball's experience. "I'm interested in telling a story where I feel like a lot of minority stories went untold or hidden," he says. This narrative is at last finding a wider audience. ▮

Bright spots in the dark

Zombies are taking over the world, yet there are still glimmers of hope in *The Last of Us Part II*, writes **Jacob Aron**

Game

The Last of Us Part II
Naughty Dog
PlayStation 4

THE end of the world is utterly miserable, but there are bright spots if you look closely enough. That was the message I took away from *The Last of Us Part II*, although it is perhaps not the one developer Naughty Dog was looking to convey.

The first game, released in 2013, introduced us to Joel and Ellie, two survivors in a world ravaged by a parasitic fungus that turns people into zombies or worse. Teenage Ellie is immune to the fungus, and Joel/the player is tasked with escorting her across the ruined US to doctors working on a vaccine.

The growing bond between Joel and Ellie as you fight off zombie hordes and hostile survivors is a big part of the appeal of the game, and sets up an explosive ending (big spoilers next, if you haven't played it) when Joel learns that developing the vaccine would mean removing part of Ellie's brain, killing her.

Unable to let her go, he shoots the doctors as they prepare to operate on an unconscious Ellie, and he squirrels her away, later telling her it proved impossible to make a cure.

Playing the game when it was released, I struggled with Joel's decision – sure, I'd grown fond of Ellie, but was saving her really worth dooming the whole of humanity?

It is a question that has grown ever more relevant in a world in which scientists are considering deliberately infecting healthy people with the coronavirus in an attempt to develop a vaccine, so it is apt that *Part II* is devoted to exploring the consequences of his choice.

Picking up four years later, Joel and Ellie are living in a settlement in Jackson, Wyoming. Life is far from ideal – people in the village are sent out on regular zombie patrols – but as post-apocalypses go, it isn't bad.

Unfortunately, a visit from outsiders disrupts everything and sends Ellie on her own cross-country mission in an effort to seek revenge.

What follows is a bloody and overly long tale in which the characters make one bad choice after another. A mid-game twist attempts to reframe everything that came before, but the execution is off. Naughty Dog seems to want to rub the player's nose in the violence.

"Why are you killing people? Don't you know killing people is bad? Maybe revenge isn't a good idea?" it seems to ask. To which the answer can only be "well, you made the game that way". I am unable to stop Ellie's mistakes, only able to be complicit in them.

The game is both gorgeous – an early level sees you exploring a ruined Seattle, now covered in luscious greenery as "nature is healing" – and grim, with far too many brutal injuries rendered in high definition.

If you read my recent review of *Doom Eternal*, in which I espoused the joy to be found in gory virtual death, that might sound hypocritical. But there is a big difference between playing as a space marine cutting down demon hordes and having desperate people smashing each other's heads in.

The absolute highlight of the game for me was nothing to do with death and destruction. Instead, it was a flashback (mild spoiler coming up) that sees Joel and a young Ellie exploring a ruined museum on her birthday, taking in dinosaur skeletons and a replica space capsule.

Joel gives Ellie something that must have been almost impossible to find in this devastated world, and her moment of happiness will stay with me for a good while. ▮

SONY PLAYSTATION

Ellie's guitar-playing creates peaceful moments in *The Last of Us Part II*

Don't miss

Watch

Japan Sinks: 2020, streaming now on Netflix, brings Sakyo Komatsu's hit 1973 science-fiction novel up to the present day. An ordinary family is put to the test as Japan is demolished in a series of massive earthquakes.

Read

X+Y: A mathematician's manifesto for rethinking gender sees Eugenia Cheng apply maths to gender bias and inequality. Never mind identity politics, she says: thinking using mathematics can gift us a fairer world.

Visit

Fons Americanus is artist Kara Walker's 13-metre-tall classically inspired fountain, whose stay in London's Tate Modern has now been extended. It didn't cost the earth: it is made from an innovative carveable, acrylic composite.

TOP: NETFLIX; BOTTOM: BEN FISHER

Silver linings

Photographer Ollie Taylor

THESE ghostly clouds add an ethereal edge to Knowlton church, a 12th-century ruin in Dorset, UK. Taken in the early hours by astrophotographer Ollie Taylor, the shot features silvery blue wisps known as noctilucent or night shining clouds. This rare phenomenon is only visible during twilight and is typically seen between May and August in the northern hemisphere and November and February in the southern hemisphere.

When the lower parts of the atmosphere heat up in the warmer months, air is pushed upwards to a colder layer of the atmosphere called the mesosphere. The water vapour in this air first condenses and then freezes into ice crystals around fine particles of dust that are thought to come from meteors. Volcanic dust and pollutants from the lower atmosphere may also play a role in the clouds' formation.

Floating up to 85 kilometres above us, noctilucent clouds are the highest clouds in the atmosphere. Taylor used space weather updates, webcam observations and help from social media to track these unique and other-worldly streaks, which he says are the best he has seen in this region of England.

Sightings of noctilucent clouds have become more common in recent years, in line with the increase in greenhouse gas emissions, particularly of methane. As more methane enters the atmosphere, more of it is converted to water vapour that can then fuel the formation of these clouds.

Gege Li

How to sit

Far from being a fast track to ill-health, sitting can be good for us, find **Herman Pontzer** and **David Raichlen.** The trick is how you do it









ANOTHER blistering afternoon in northern Tanzania, another high-stakes game of musical chairs. Stumbling back into camp to escape the sun, desperate for a seat, we glanced at each other and then at the single unoccupied camp chair. In the other, grinning, sat Onawasi, a respected elder with a mischievous bent. He seemed to be enjoying this.

We were spending our summer with the Hadza community, one of the last populations of hunter-gatherers on the planet. Hadza men and women manage to avoid heart disease and other diseases of the more industrialised world, and we wanted to understand why. Our small research team had come in two Land Cruisers loaded with tech to measure every movement made and calorie burned as Hadza men and women scoured the landscape every day for wild game, honey, tubers and berries.

After a long morning, we felt drained by the inescapable heat and humidity. All we wanted to do was sit. Onawasi seemed to feel the same way. He had spent the morning hunting, and certainly deserved the chair more than we did. But this was getting out of hand. Our precious camp chairs that we took into the bush despite their weight were Hadza magnets. Every visitor to our little research area seemed drawn to them like moths to a porch light.

We knew we had a lot to learn from the Hadza about staying physically active. It turns out they also had something important to teach us about resting. Together, over the next 10 years, we would come to understand why chairs are so irresistible, and why they seem to make us ill.

In a simpler time, before Brexit, Donald Trump was US president or covid-19, way back in 2012, the world was alerted to a new and insidious danger, an invisible pandemic. I-Min Lee, an epidemiologist at Harvard University, analysed mortality data from heart disease, diabetes and cancer and found a common culprit: sitting. In a landmark paper in *The Lancet*, Lee and her colleagues concluded that prolonged periods of inactivity killed more than 5 million people every year globally, making the health risks "similar to... smoking and obesity". In the media, sitting became the new smoking. Even more alarming for those of us who spend our lives in front of a screen, exercise doesn't fully undo the dangers of sitting. Long hours spent in a chair or on the sofa steal years from our lives, even if we hit the gym religiously. Sitting is different, and maybe worse, than just a lack of exercise.

Priests and public health workers have warned us against the sin of sloth for millennia. But the familiarity of the public health advice to get moving obscures a curious evolutionary puzzle. Why is inactivity bad for us even if we exercise? How could evolution produce an organism that responds so poorly to rest? As Charles Darwin articulated so clearly more than 150 years ago, natural selection favours strategies that direct an organism's resources towards survival and reproduction. Any effort that doesn't ultimately pay off in reproductive success is wasted. Natural selection, the amoral accountant, pays attention only to the number of offspring produced. It would seem to follow that our bodies should be well-adapted to rest whenever possible, sparing resources for future use.

"How could evolution produce an organism that responds so poorly to rest?"

Countless other species seem to be on board with this philosophy. In the ocean, some predators will rest for more than a day waiting for prey to float by. Numerous reptiles and amphibians slip into dormancy to wait out periods of tough weather or limited food. Bears, bats and a handful of other mammals spend their winters in hibernation, showing no ill effects when they wake up in the spring. Even our evolutionary cousins, the great apes, spend hours every day sitting and lying about like hungover spring breakers on the beach.

The perils of inactivity

And despite people's assumption that hunter-gatherers are more active than people in more industrialised societies, we also know from our own experiences with the Hadza community and scientific accounts of other populations that they spend lots of time sitting and resting, too. There aren't a lot of standing desks in Hadzaland. In the heat of the day, when they are back at camp after a foray, men and women invariably find a shady place to sit while they tend the fire, prepare food and socialise. But unlike with people in the more industrialised world, sitting doesn't make them sick. What was their secret? How had we managed to screw up something as simple as sitting?

The first clues that sitting for long stretches caused disease in the industrialised world came from a ground-breaking study of London transport workers published in 1953. Epidemiologist Jerry Morris noticed that bus drivers sat for most of the day while conductors stood and climbed the stairs of the iconic double-deckers. Morris and his colleagues followed about 31,000 men in ›

JASON RAISH

KARL-JOSEF HILDENBRAND/DPA/COVER IMAGES

Kneeling engages the muscles much more than sitting

these roles over two years and found that drivers were about 30 per cent more likely than conductors to develop coronary heart disease, and to do so at a younger age and with worse outcomes. Later research comparing postal workers who delivered the mail with their sedentary office mates showed similar results.

Summarising the findings, Morris focused on the importance of physical activity in preventing heart disease, helping to kick off the modern exercise movement. But beginning in the 1990s, researchers started to wonder whether sitting itself could be leading to problems. Indeed, studies began to show that people had an elevated risk of heart disease and of dying at an earlier age when they reported sitting for long periods while, for example, watching television.

This line of thinking was bolstered by data from attempts to mimic the effects of space travel on the body. As the space race heated up in the 1950s, NASA became concerned with how a lack of gravity might affect astronaut health. The agency began a series of bed-rest studies, where volunteers would lie down for long periods, sometimes more than two months. Their bones thinned and muscles weakened, but there were other, unexpected effects, too. Subjects had higher levels of fats called triglycerides in their blood and other risk factors for cardiovascular disease.

“Chairs and beds allow us to turn our muscles off and sag into the cushions”

As the evidence for the dangers of inactivity grew, a hypothesis began to develop for why it was so harmful. When we stand and walk, we engage the muscles of our legs and core to hold us upright. Chairs and beds allow us to turn those muscles off, sagging like wet dishcloths into the contours of the cushions. Perhaps muscle activity was the key.

Normally, medical researchers like to test their ideas in rodents, but convincing a rat to sit in a chair and watch television didn’t seem a viable option. Undaunted, Marc Hamilton at the University of Missouri and his colleagues suspended rats’ hind limbs off the floor by tying their tails to a swivel on the roof of the cage. With no need to support the body, the rats’ hind limb muscles switched off and stopped burning fuel. This in turn led to reduced levels of an enzyme needed to provide fuel to working muscles: lipoprotein lipase. This enzyme acts like a triglyceride vacuum cleaner, breaking the molecules into fatty acids that can be burned in the muscles, and thus removing them from the bloodstream.

In Hamilton’s rats, triglycerides built up in the blood because the muscles didn’t need them and didn’t produce the lipoprotein lipase to break them apart. The translation to humans seemed obvious: prolonged sitting allows us to switch our muscles off and causes triglycerides to climb.

Studies in humans have provided support for this mechanism. In several controlled trials, people forced to sit for long periods developed elevated triglyceride levels. Importantly, if the sitting time is broken up with light activity, even a bit of slow walking, triglyceride levels are greatly reduced. In fact, people asked to reduce sitting by spending more time walking and standing over a four-day period saw a 32 per cent drop in triglyceride levels. Sitting for long, uninterrupted periods also alters the walls of blood vessels in ways that make them stiffer and more prone to coronary heart disease, but breaking up sitting with light activity restores vessel function.

Perhaps societies like the Hadza avoided the dangers of inactivity by resting less each

day, or perhaps they broke up their sitting time with more frequent bouts of standing or walking. That idea certainly had intuitive appeal: it was hard to imagine a Hadza man or woman logging as many hours on their butt each day as a typical US citizen. But our experiences with Onawasi and the irresistible attraction of a nice chair hinted at another, deeper explanation. Perhaps chairs, those sirens calling out to us, were the problem.

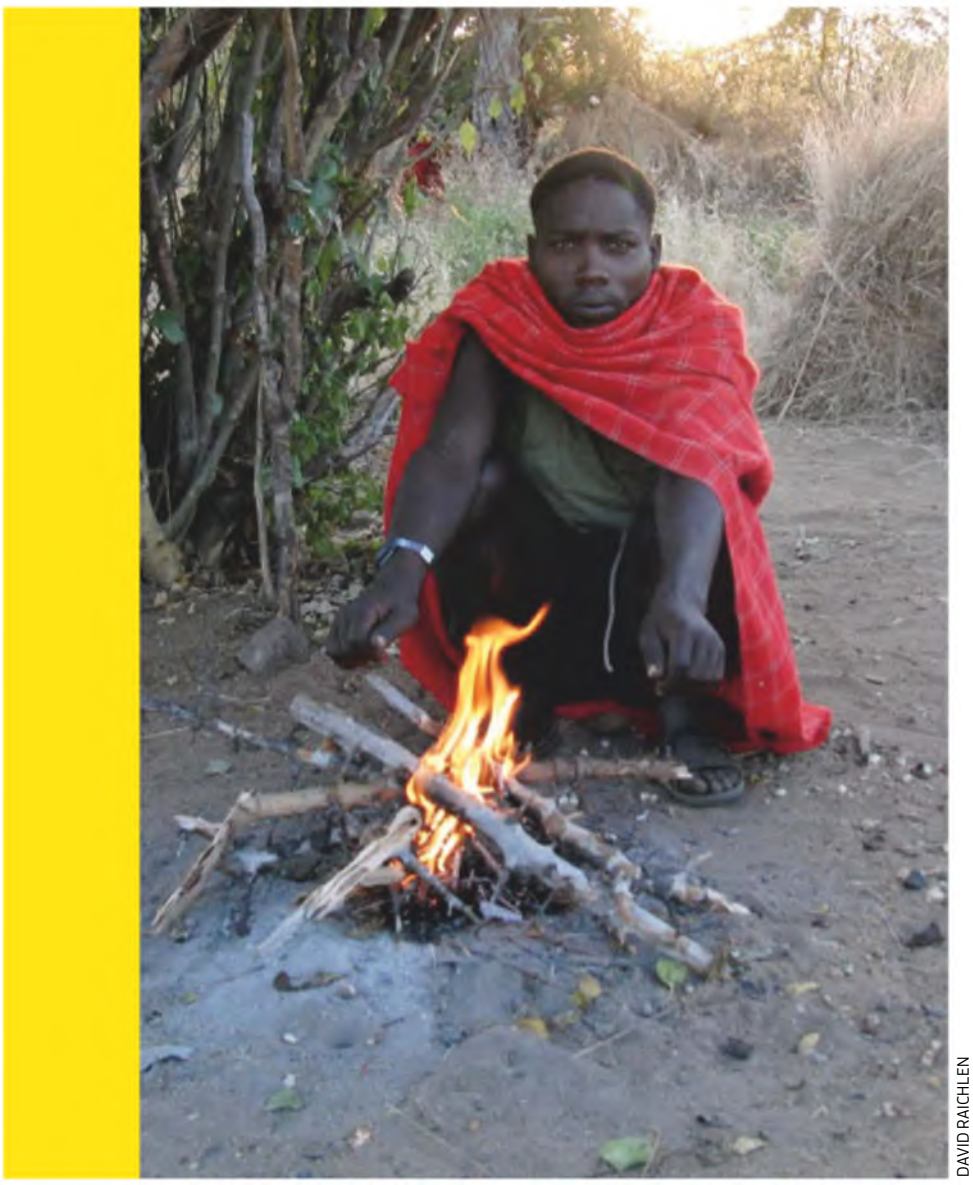
Material evolution is a curious phenomenon. Innovations tend to build on one another, as simple solutions give way to more sophisticated designs. Nonetheless, simple and elegant ideas often stay undiscovered for millennia. The ancient Britons who built Stonehenge were wise enough to track the sun and clever enough to move 20-tonne boulders, but never imagined the wheel. Chairs are another surprisingly recent invention. They first appear in the archaeological record less than 5000 years ago, well after the emergence of farming, towns and metallurgy. Our Palaeolithic hunter-gatherer ancestors never had them.

"We have found evidence of squatting dating back nearly 2 million years"

Even today, the Hadza don't use chairs. A Hadza man or woman can manufacture an impressive array of things, from powerful bows and arrows to breezy, weatherproof houses, and summon fire on demand. But they don't make furniture. The closest thing you will find in a typical Hadza household are animal skins for sleeping on the ground.

Without chairs or other furniture, how do we rest? Anthropologist Gordon Hewes was interested in this topic, having spent time teaching in Tokyo in the mid-1950s where seiza-style kneeling was often used as a rest posture in formal settings. Hewes amassed a worldwide compendium of nearly 1000 human postures. In societies with little furniture, Hewes found that resting often involved squatting or kneeling on the ground.

These postures are an ancient part of the human repertoire. Deep squatting flexes the foot upward, pressing the talus, a small bone in the ankle, into the end of the shin bone, or tibia. If it is done often enough, these postures leave a mark on the tibia, called a squatting facet. Palaeoanthropologists have found these facets on fossils of human ancestors going back to *Homo erectus*, nearly 2 million years ago.



DAVID RAICHLEN

People in the Hadza community often rest by squatting, like this man in the Lake Eyasi region of northern Tanzania

Resting squats

In the Hadza community, we noticed that people of all ages spent much of their resting time in a deep squat, heels on the ground, bottoms resting on the back of the ankles. If you don't grow up doing it, you have probably lost the flexibility to squat that deeply (go on, give it a try). Even if it is second nature, as it is for the Hadza, the posture would seem to require more muscle activity than lolling about in a chair. Here, then, was a third hypothesis for how the Hadza avoid the perils of inactivity: rather than sitting less ›

10'000 HOURS/GETTY IMAGES

Chairs and sofas mess with the way we evolved to sit when we relax

or breaking up their sitting into shorter bouts, perhaps the secret was in the way they sit.

Armed with these insights, we headed back to Hadzaland a few years later with an array of small, wearable sensors to record muscle activity and body position. We used the sensors to track the resting behaviours of 28 Hadza men and women for a week, calculating both the average number of hours spent inactive each day and the frequency with which they broke up long periods of sitting to stand up or walk around. We also conducted a set of controlled studies to measure muscle activity in various resting postures, including squatting and sitting in a chair.

The results surprised us. Hadza men and women spent nearly 10 hours every day resting, almost identical to the numbers for people in the US, Netherlands and Australia. The number of breaks was similar across populations as well. Hadza adults switched from resting to active postures like standing or walking roughly 50 times per day, on par with data from Europeans.

Still, Hadza blood profiles and blood pressures showed they were remarkably healthy, with low levels of triglycerides and other markers of heart disease. The Hadza were much healthier than their desk-bound counterparts in industrialised countries, but not because they rested less or got up to stretch their legs more often.

"Hunter-gatherers rest for 10 hours a day, identical to people in the US"

Instead, the big difference we found was in muscle activity during rest. Squatting forces you to keep the body balanced over the feet, requiring between five and 10 times as much muscle activity in the legs as sitting in a chair or on the ground, and sometimes even more muscle activity than we would expect from light activity. Sure enough, when we tallied the resting postures used around camp, we found that Hadza men and women were squatting and kneeling nearly one-third of this time. Putting the evidence together, we think that the use of "active resting" postures, like squatting and kneeling, might maintain enough muscle activity to prevent triglyceride build up and avoid disease. If our ancestors also used these more active rest postures, then the negative health effects of sitting make perfect sense: our physiology never experienced long periods of quiet muscles, so our bodies never evolved a protective response.

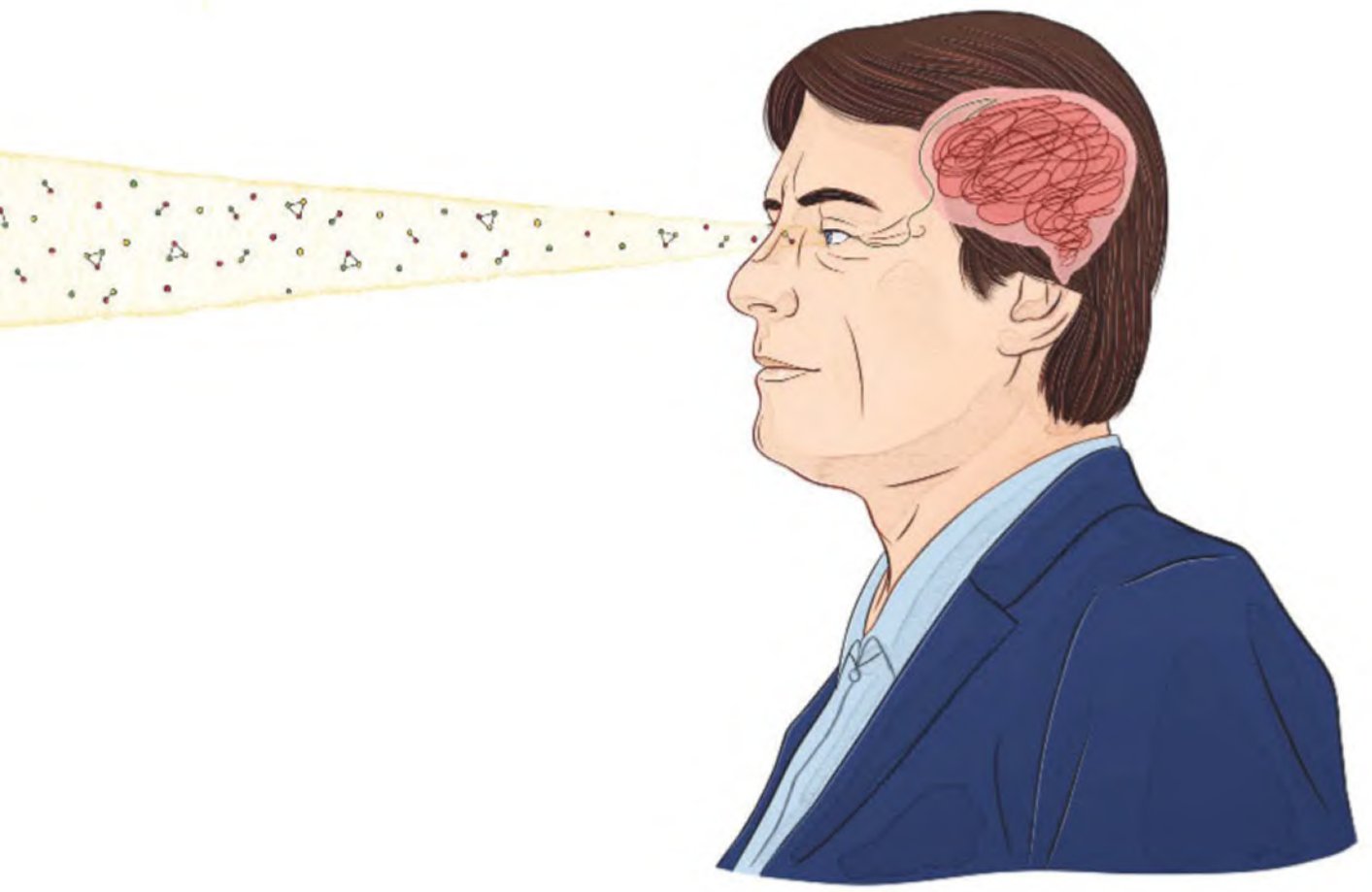
In the end, how could we blame Onawasi, or anyone, for wanting to sit in our camp chairs? We wanted them for the same reasons: chairs are an indulgence, allowing us to rest our tired muscles. The allure of a good chair has held our collective attention ever since they sprang into our material world. But chairs, once invented, let us rest in ways that are comparatively new to the human body. That novelty is both the draw and the danger.

Should we abandon our chairs? Unless you have been squatting since childhood, forcing yourself to do it may cause pain and discomfort. And Hadza men and women also spend much of their rest time in postures like sitting and lying down that entail low muscle activity, so maybe we don't have to avoid sitting altogether. But, our work suggests that you can improve your cardiovascular health by sitting less, and by breaking up your sitting into shorter bouts to increase muscle activity throughout the day. As our Hadza friends showed us, it is likely that quiet muscles are the enemy. So, while we are sheltering in place, working from home or watching more TV than ever before, let's try to break up the couch time into smaller bits. Get up, move around and if you are limber and feeling adventurous when you turn on Netflix, trying squatting just like the Hadza, in an active resting posture. Your heart will thank you. ▮

Herman Pontzer is professor of evolutionary anthropology at Duke University in North Carolina. His book, *Burn: The new science of human metabolism*, will be published in January. David Raichlen is a professor of human and evolutionary biology at the University of Southern California

"If we do it wisely, AI can be the best thing ever for humanity"

Where once he sought to unmask the mysteries of the multiverse, **Max Tegmark** now has his sights on artificial intelligence. He talks to Richard Webb about cosmology, consciousness and how to make AI work for everyone



STEPHANIE SINGLETON

"ALL possible universes exist, even triangular ones". These were the words on the cover of *New Scientist* on 6 June 1998, when Max Tegmark made one of his first appearances in the magazine. Inside, the then 31-year-old expanded on his idea of a multiverse on steroids, in which all logically possible universes not only can but must exist.

Tegmark, now a professor at the Massachusetts Institute of Technology (MIT), is known for his provocative ideas. As he explains in the "Crazy" section of his website: "Every time I've written ten mainstream papers, I allow myself to indulge in writing one wacky one." But the outlandish elements shouldn't overshadow his serious track record in cosmology, quantum information science and the study of some of the very deepest questions about the nature of reality.

Recently, Tegmark has shifted his focus to intelligence, both human and artificial. He conducts front-line research in artificial intelligence (AI), most recently working with fellow MIT researcher Silviu-Marian Udrescu to create an AI that was able to rediscover some of the most fundamental equations of physics by studying patterns in data. In 2014, he co-founded the Future of Life Institute, which aims to understand and mitigate existential risks to humanity, particularly those associated with the rise of AI.

Richard Webb: What made you switch from cosmology to working on artificial intelligence?
Max Tegmark: I've always been fascinated by big questions, the bigger the better. That's why I loved studying the universe, because there were philosophically very big questions like where does everything come from, what's going to happen, what is our place in the grand scheme of things? We have made enormous progress in cosmology, but at the same time, really new data has started to become rarer and harder to obtain.

So it was very natural for me to gravitate to the biggest unsolved mystery that's sort of coming within range. We are able to see things with telescopes that our ancestors could never see, and the same thing is happening now with the mind. We have so much data now from neuroscience, and the ability to build artificial versions of the things that we are trying to study.

What are you working on right now?
My research is focused on what I would call machine learning for good. We have been ›

doing a lot of work recently on a project that applies machine learning to identifying news bias. I had gotten increasingly fed up with the quality of the news here in the US, and I made a New Year's resolution a while back that I was no longer allowed to whine and complain about something unless I actually spent some time working on making things better.

How can AI make the news less biased?
There are these projects aiming to improve the quality of the news by having humans go in and fact-check and flag problems. But if you look more closely, you will see that some fact-checking sites find 95 per cent of errors in media outlets on the left side of the political spectrum, and other ones will only find errors in the media outlets on the right. It's unclear exactly what criteria they use.

We decided to build something entirely automated. It's a work in progress, but we use machine learning to classify news articles on all sorts of different metrics: by the topic that they are about, whether they are left or right, pro- or anti-establishment, in-depth or quite breezy, more inflammatory or quite nuanced. The tool is a bit like Google News, but with a bunch of sliders underneath, so you can adjust for what you want to read.

Doesn't that risk reinforcing echo chambers, with people choosing to see only the news that conforms to their biases?
The status quo is already like this – if you go on Facebook, it's entirely reinforcing your echo chambers. The question is, if you get the opportunity to make slightly more deliberative choices, rather than it being just sort of impulse eating, does that make things better or worse?

There are some really nice experiments done by psychologist David Rand at MIT that find it's a bit of a myth that people only want to read things that they agree with. People are interested in hearing other points of view, as long as they are presented in a nuanced way. We can use machine learning to discover which articles are the nuanced ones and which are the ones that are just likely to piss people off. My hope is that a user won't just set their preferences once and for all, but exhibit some curiosity.

> "The space of possible artificial minds is much bigger than that of biological minds"

What is the broader agenda of "machine learning for good"?
I think the fundamental challenge we have with AI, and technology more broadly, is to win the wisdom race. We need to make sure that the power of technology doesn't grow faster than the wisdom with which we manage it.

Historically, we have stayed ahead by learning from mistakes. We invented fire, screwed up a bunch of times and then invented the fire extinguisher, the fire brigade and fire alarms; we invented the automobile and then invented the seatbelt, the airbag, the traffic light and laws against driving too fast.

The challenge is that when the power of the tech crosses a certain threshold, learning from mistakes stops being a good idea. We don't want to have an accidental nuclear war between the US and Russia starting in 20 minutes and then, thousands of mushroom clouds later, be like: "Oopsie, let's learn from this mistake." We see the same thing happening with synthetic biology and ultimately with artificial intelligence as it gets closer to human abilities. So this is the focus of my research. How do we make AI that we can actually trust?

Why is trusting AI so important?
The greatest breakthroughs in machine learning recently have come from artificial neural networks, which can do all sorts of wonderfully smart-looking things, like beat everybody on Earth at chess and Go. But we have very little clue how this AI works. We tend to treat it as a black box and then, every once in a while, it doesn't work as we thought it would. We have problems like Boeing really wishing that it understood better how its automated system on the 737 worked, or the trading company Knight Capital wishing it knew how its automatic trading system worked before it managed to lose the company $10 million a minute for 44 minutes straight.

Then we had courtrooms around the US using a piece of software to recommend who was going to get probation and who wasn't. People didn't really understand how it worked and didn't realise that it was racially biased. If you can use the sort of techniques that we are hoping to develop in my group to let people peek inside the black box and understand what AI is actually doing, things might look much better.

It certainly sounds like you are a tech optimist.
Are you the kind of person who thinks fire can kill people or the sort of person who thinks that fire can keep people warm in the winter? Both things are true, obviously.

The interesting question isn't to argue for or against fire, it is to figure out how you can


ZHENG PENG/IMAGINECHINA/SIPA USA/PA IMAGES

REUTERS/BOBBY YIP

A visitor to an AI-powered self-service shop in Nanjing (far left), and facial recognition software on display at a security expo in Shenzen, China (near left)

manage fire wisely. Technology isn't good or evil: it's a morally neutral tool that can let you do good or bad. Right now, AI is still pretty stupid, but it's already given enough influence in the world that it's caused a lot of problems, from biased court decisions to crashing aeroplanes.

I think it's possible to make very powerful AI and I think if we do that wisely, it can be the best thing ever for humanity, because everything that I love about civilisation is the product of human intelligence. If we can amplify that with AI, we can use it to solve the climate crisis, to lift everybody from poverty, to figure out how to cure the coronavirus and so on. What's so bad about that?

Is building this sort of advanced "general" AI realistic, given that we don't even understand how human intelligence works?

You could just as well ask, how could we possibly figure out how to build a flying machine before understanding how birds fly? Darwinian evolution gave us both flying birds and thinking animals, but it was very constrained: to only build solutions that could self-assemble, that could self-repair, that only used a handful of chemical elements, that were super-energy-efficient. When you remove all these biological constraints, you can often find much simpler solutions to the same problems.

I know some people think there's something magical about intelligence, making it possible for it to exist only in human bodies. I don't think so. I am a blob of electrons and quarks processing information in certain complex ways, and the key to intelligence is just the nature of that information processing. I would go so far as to predict that the way we are finally going to understand exactly how the human brain works is by building something simpler that is comparably smart.

Presumably we can't build an AI that thinks or feels exactly as a human does, that has things like agency and consciousness?

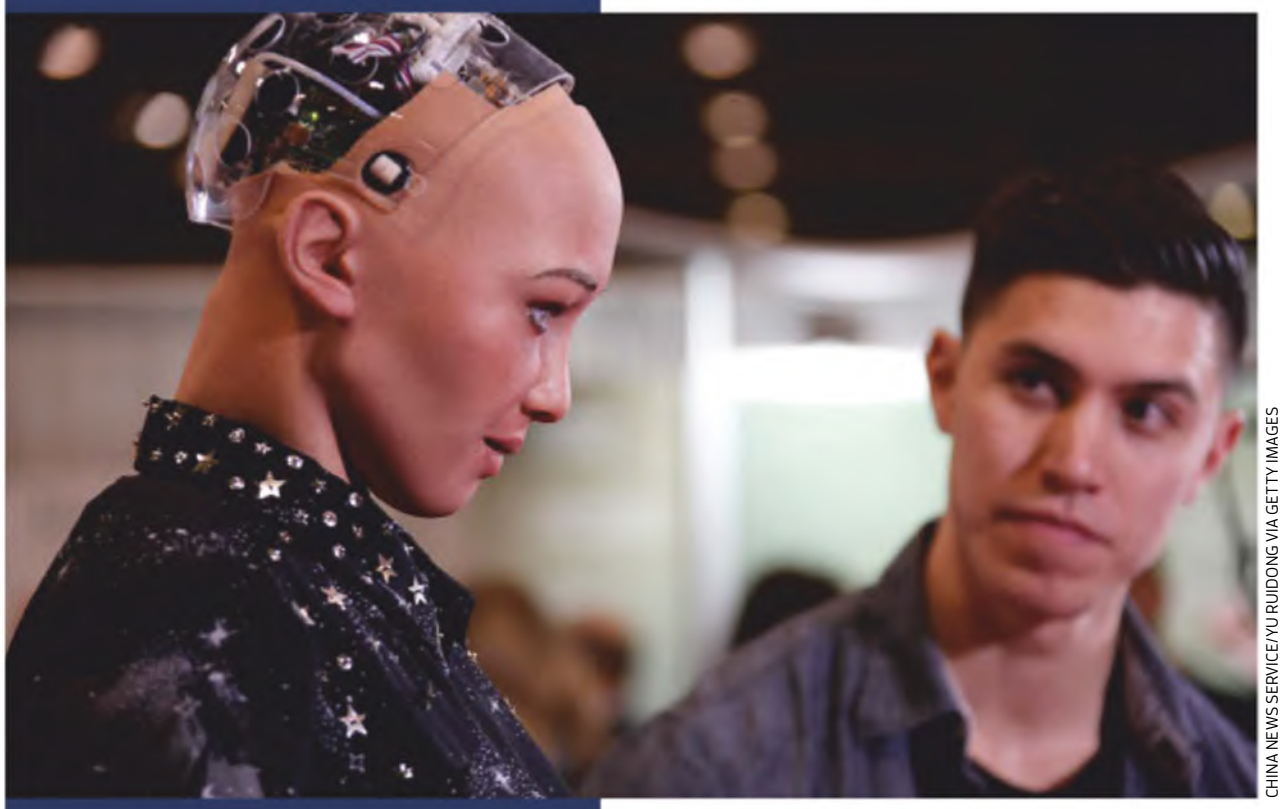
I wouldn't be so sure. I think the most interesting question isn't to ask what will happen, but what we want to happen. It might be that we have a lot of designer's choices. The space of possible artificial minds is much bigger than the space of biological minds, because all biological minds evolved – they tend to have a survival instinct first, then other things. When you are free of those constraints, there's so much more opportunity to choose.

It may be possible to build different AIs that perform equally well on tasks, but have a whole range of conscious experience, from nothing to a subjective experience that feels quite a lot like yours, where it experiences colours and sounds and vibrations and maybe even emotions.

Really? Surely you can't program something to have feelings?

I think we tend to be very arrogant about this. We have to be very careful with self-serving claims that we know when there is a subjective experience and when there isn't. We made that mistake with animals, and I think we are making it all over again with machines. Most of my colleagues just take it as an axiom that none of the machines they ever build will ever have any subjective experience, so they never have to worry about suffering and can just turn them off and on at will. I don't think that's so obvious at all.

My own guess is that consciousness is simply the way information feels when it's ›



CHINA NEWS SERVICE/YU RUIDONG VIA GETTY IMAGES

We can't assume that humanoid robots such as Sophia (left) will never have subjective experiences

being processed in certain complex ways. I think scientists owe it to the world to figure out what those complex ways are.

What do you mean by "the way information feels"?
Many people make the mistake of assuming that, when you look around you and you see different colours, that those experiences somehow have something to do with the outside world. For example, if you see an apple and it's red, and you think somehow that you only have redness because there's an apple. That's obviously wrong: you can dream about an apple and you will still experience it as being red, even though now there is no outside world at all. So there is something happening that's just purely inside your brain as the neurons fire. What is this thing? I want to figure that out.

Do you think we will ever arrive at a full description of how consciousness emerges from atoms and molecules?
This is the Wild West where we are very clueless and have to have very open minds, obviously. But in the big picture, I think about consciousness as the last bastion that has still refused to be captured by physics.

Now even intelligence is beginning, little by little, to yield to mathematical description, right? That's what artificial intelligence is all about, and there are already some theories out there trying to predict which information processing is conscious and which isn't. It's ripe for the scientific assault.

But the laws of physics are themselves the product of conscious deliberation. Isn't consciousness always going to fall down at describing itself?
Yeah, that's a very fun idea. Is it possible for a small part of something to be able to describe the whole thing that it is part of, including itself? Or do you get into some bizarre recursive loop? Of course, I can't know for sure that we will be able to describe consciousness with physics or machines. There are plenty of people who think that we will never be able to describe consciousness because it involves some sort of soul or something that's by definition impossible to study.

> "I think about consciousness as the last bastion that has refused to be captured by physics"

I'm more optimistic. My personal guess is that consciousness can be fully understood in terms of information processing done by particles moving around. But regardless of whether you think it's going to work out or not, one way to guarantee failure is if you start by convincing yourself that it's impossible. So let's try our best. If this all fails, it's also going to be very cool.

Where do you see all this going?
I think we shouldn't conflate intelligence with consciousness here. On the intelligence side, I have no doubt that we are going to keep making more progress, unless we self-destruct as a species by screwing up somehow. I just hope we won't end up saying that curiosity killed the cat, that our curiosity to figure out intelligence made us build things that we used to drive ourselves extinct. That's why I'm so big on also thinking through the wisdom part.

Are we wising up to AI's dangers?
I think there's been a big shift for sure. Now you can't go to an AI conference without coming across a bunch of talks about AI safety, transparency, interpretability and robustness. There is a lot of idealism in the community. This is where I get a lot of hope that we can use machine learning to empower the grassroots, push back against the powers that be and even sometimes use those tools to uncover sneaky stuff.

That sounds like tech optimism again.
The key to having a good future is to be able to formulate a vision that people around the world can really get on board with. This isn't a zero-sum game: you can easily envisage scenarios in which artificial intelligence multiplies the world's GDP by a factor of 100 or more. It's very easy to envisage a future in which everybody wins at the same time and becomes much better off. But we have failed epically so far to get humanity to collaborate to make it real. ▮

Richard Webb is executive editor at *New Scientist*

Coventry University

Navigating intelligent vehicle innovation through the coronavirus

The automotive sector has been impacted by the outbreak of COVID-19, obstructing the development of future vehicle technologies. However, a shift in the needs and behaviours of consumers caused by the pandemic has exposed opportunities for intelligent, low-carbon technology and accelerated the demand for research and development.

Coventry University's Institute for Future Transport and Cities is carrying out pioneering research focused on building and integrating resilient and secure systems into the production of new automotive technologies. This will be a key building block in the progression of smart transport innovations through the coronavirus pandemic.

Research Coventry | discover more online **www.coventry.ac.uk/research**

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Supercrops!

The secret photosynthesising powers of some unusual plants could be the key to feeding the planet sustainably, says **Larissa Fedunik**

MICHAEL HADDAD

CLOSE to the town of Ayr in Queensland, Australia, there is a field of unusual crops. The plants are a silvery shade of teal, with long fleshy leaves splaying out in all directions like thin, serrated knives. When Daniel Tan walks among them, the tallest stand two heads taller than him. There are thousands of these blue agaves here. Best known as the raw ingredient needed to make the fiery spirit tequila, they are more commonly found in Mexico than on Australia's Pacific coast. Yet for Tan, a researcher at the University of Sydney, they are part of an impending global revolution.

We certainly need one. Plants provide us with food, fuel, building materials and natural beauty, all while locking away untold volumes of carbon dioxide that would otherwise crank up the planet's thermostat. But as Earth's population and temperature continue to rise, we will need more from our green allies. Our food requirements alone will be eye-watering. In 30 years, we may need to produce about 50 per cent more food to feed nearly 10 billion people – just as global warming is predicted to slash the yield of many major grain crops.

Researchers like Tan are looking to a radical solution, involving plants' not-so-secret weapon: photosynthesis. We ultimately depend on this process, by which plants store energy from sunlight for everything that nourishes us. So it might seem odd to say it is scandalously inefficient. But it is – for most species. By understanding the secrets of plants such as agave with supercharged versions of photosynthesis, the hope is we can create a greener, cleaner, more secure future for us all.

Photosynthesis captures the power of sunlight to convert CO_2 and water into sugars, which plants then use to fuel their growth. It is a wondrous thing. Yet despite the fact that

"For most plants, photosynthesis is scandalously inefficient"

evolution has had at least 2 billion years to perfect it, we have to content ourselves with the wonder that it is done at all, not that it is done well. The maximum conversion efficiency of solar energy to biomass in most plants is a disappointing 4.6 per cent.

This is true for the C3 version of photosynthesis, the metabolic process used by almost 90 per cent of plants, including wheat, rice and soya beans. The inefficiency comes down to an enzyme called rubisco. This piece of biochemical machinery picks up CO_2 molecules and combines them with another compound to form a molecule containing three carbon atoms, as a first step in the production of sugar. The trouble is that 40 per cent of the time, rubisco slips and picks up oxygen instead, wasting energy. The problem gets worse when plants close their leaf pores, or stomata, to prevent water loss. Oxygen builds up inside the leaf and rubisco is even more likely to mistakenly grab it.

None of this mattered when rubisco evolved more than 3 billion years ago, when Earth's atmosphere was rich in CO_2 and almost free of oxygen. But as oxygen has ›

Tequila sunset?

The blue agave may be fancied as a plant to save the world because it uses the more efficient CAM form of photosynthesis (see main story). For most of us today, however, it is the raw ingredient for making the spirit tequila. In the US, sales of this drink have rocketed over the past few years, spurred by the introduction of smooth brands you sip rather than knock back. In 2018 came a shot of bad news: a tequila shortage.

The slow pace at which CAM photosynthesising plants such as blue agave generally grow means farmers guess at future levels of demand years in advance. If a lot of agave matures at once and floods the market, prices drop and farmers then lack the incentive to grow more. This can lead to cycles of over and undersupply.

Even more tricky, farmers try to harvest agave before they flower because flowering drains the plant's sugar content. Getting this right also involves guesswork because the timing of flowering is unpredictable.

"Other species respond to changes in temperature and light intensity, whereas agave ignores these stimuli for many years," says June Simpson at the National Polytechnic Institute in Irapuato, Mexico. Simpson and her team are working to pin down the triggers that initiate flowering by sequencing the agave genome. The hope is that this will help to take some of the unpredictability out of agave and tequila supplies. Here's to her success.

MICHAEL DEFREITAS CENTRAL AMERICA/ALAMY

The drought-hardy agave is finding favour beyond its traditional Mexican heartland

become more abundant – ironically largely as a result of plants photosynthesising – it has become a roadblock to better photosynthesis.

Over the past 100 million years, some plants have found a workaround, evolving a process known as C4 photosynthesis. This splits the metabolic pathway involved in normal photosynthesis between two parts of their anatomy. First, they capture CO_2 molecules in spongy cells called mesophylls beneath a leaf's waxy protective layer, where they produce a four-carbon molecule. This molecule is then transported through special channels to cells clustered around leaf veins, where it is broken down to release CO_2 again. Only here does rubisco come in, and with higher concentrations of CO_2 present, it has fewer chances to grab oxygen. C4 plants also have enlarged chloroplasts, the parts of the cell where photosynthesis is conducted, which gives them an extra boost.

The benefits of these adaptations are stark. Although only about 4 per cent of plant species use C4 photosynthesis, they are responsible for about 23 per cent of the biomass produced on land. C4 crops include major sources of food such as maize and sugar cane, and pasture grasses that feed many of the animals we consume.

The warming planet is adding fuel to the idea that we could make more of these potent photosynthesis machines , for example by using genetic engineering to prod C3 plants

into using the C4 pathway. Even if global warming is contained at 2°C this century, that could lower yields of C3 crops such as wheat, rice, maize and soya beans by between 6 and 15 per cent.

The C4 rice project is an international effort that kicked off in 2008 to transform the staple food of half the world's population into a C4 crop. Rice lacks the special leaf structure of C4 plants, so its anatomy requires resculpting through the insertion of 20 or 30 new genes. "This is the biggest project in synthetic biology and genome engineering that's around at the moment," says Robert Furbank at the Australian National University in Canberra.

Rice dreams

It initially took the team seven years to transplant six genes. But new techniques allowing multiple genes to be transferred at once moved the work along apace, and in 2017, the team announced it had created a proto-C4 rice species complete with those crucial intercellular channels and beefed-up chloroplasts.

Jane Langdale at the University of Oxford, coordinates the project. She expects C4 rice plants to be in field trials by 2030. "We may not get a perfect C4 rice, but we will get varieties that are better yielding," she says. Meanwhile the International Rice Research Institute, which helped initiate the project, has grown rice plants under atmospheres with a higher than usual CO_2 concentration in order to simulate what C4 rice would be like. Calculations based on these experiments suggest it would have a yield up to 50 per cent higher than the conventional crop.

But ambitious though the C4 rice project is, it won't be enough. As the climate changes, we don't just need crops that produce food more efficiently, we need them to do it under more taxing conditions. "Water is going to be the rate-limiting factor for agriculture in the context of our global climate crisis," says John Cushman at the University of Nevada in the US. Drought is predicted to ravage many semi-arid regions over the coming century, with 45 per cent of land expected to have droughts that are more frequent, more intense and longer lasting. Turbocharged rice will be no use to anyone if it is simply too dry for it to grow.

There is, however, another trick up nature's sleeve. About 7 per cent of plant species use a third kind of photosynthesis called crassulacean acid metabolism (CAM). Those silvery agave with the serrated leaves in Queensland are one; others include pineapple, aloe vera and vanilla.

Like C4 photosynthesis, CAM pre-concentrates CO_2 to improve the performance of rubisco. But while C4 plants physically separate photosynthesis, CAM plants split it into time intervals. Unlike most vegetation, CAM plants open their stomata only in the cool of night to capture CO_2. When the sun comes up, the stomata close to prevent water loss and the plants use stored CO_2 to photosynthesise. Thanks to these adaptations, CAM plants only need about 20 per cent as much water as the least thirsty C3 and C4 crops.

Agave and its ilk have long been used for food (see "Sugar 'n' nice", page 44). But they are increasingly being grown in new places and for unusual purposes. The point of Tan's plantation is to test whether agave can be used to produce biofuel. Already used, for example, to supplement petrol in many parts of the world, biofuels are increasingly seen as a viable alternative to liquid fossil fuels, but are also controversial due to the land, water and other resources needed to grow them.

IMAGEBROKER/ALAMY

Vanilla is one of some 16,000 plant species that use CAM photosynthesis

> "Water is going to be the limiting factor for agriculture as the world warms"

Tan and his colleagues recently published the first comprehensive life cycle assessment of agave bioethanol, examining greenhouse gas emissions, water consumption and environmental pollution. They found that it has a 60 per cent lower impact on global warming compared with ethanol derived from maize, and 30 per cent lower than that from sugar cane. It requires neither irrigation nor pesticides, because agave has no native pests in Australia.

Agave isn't the only CAM crop with potential. Cushman leads a project growing the prickly pear cactus for food, animal feed, bioethanol and biogas. Native to the Americas, this cactus can thrive anywhere where the temperature remains mostly above freezing. This means a fifth of land that is unsuitable for other crops could be used to grow it. Field trials in Nevada have shown that a hectare of cactus produces as much as 44 tonnes of biomass each year, a similar productivity to maize and sugar cane.

Even if you don't use the CAM plants for anything in particular, they are worth having around. Brazil and Tunisia have both planted prickly pears across areas equivalent to that of the Grand Canyon. Originally grown to feed cattle, scientists at the International ›

B. TRAPP/COVER IMAGES

The prickly pear cactus could be a more sustainable source of biofuels

Center for Agricultural Research in the Dry Areas in Tunisia observed that hedges comprising the cactus prevent erosion and boost the soil's nitrogen content. In South Africa, which has seen extreme droughts over the past few years, some farmers are growing another CAM crop called spekboom to revive their parched land.

CAM plants are often thought to be slow to grow, but they don't necessarily deserve this reputation. Annual crops like maize and soya beans grow fast, but only for one season, typically four to six months. Most CAM plants are perennials that grow continuously for years. "If you take seasonality out of the equation, some cultivated CAM species are just as productive," says Cushman.

Pollination problems

That isn't the full story, however. Some CAM crops, including agave, flower and produce seeds only once towards the end of their lives. And their lives are long; one species of agave is known as the "century plant", though in truth it lives about 30 years. To be commercially successful, agave must be propagated not by germinating seeds, but by cloning.

This creates several problems, including a world shortage of tequila in 2018 (see "Tequila sunset?", page 42). A more serious issue is that the pollinators that feed on agave flower nectar – in Mexico this is largely bats – are threatened with extinction. The cloned crops, being so genetically similar, are also vulnerable to pests and disease. Prickly pears are at risk of infection by a stunting disease called "macho". We don't know its cause.

Cushman's team is sequencing the DNA of prickly pear plants afflicted by macho to investigate the disease and prevent it from spreading. And several sustainable tequila projects have been established that allow a portion of the agave plantation to go untouched, so that the plants flower and can be pollinated naturally. It is estimated that if 5 per cent of the agave planted on a hectare of land is allowed to flower, that will provide enough food for about 90 bats each night.

Some are wondering if we can go further, with an effort akin to the C4 rice project that aims to combine the traits of C3 and CAM crops into the ultimate supercrop. Over the past five years, scientists have sequenced the genomes of several CAM plants. But there is a long road ahead. While we broadly understand how the CAM photosynthesis pathway operates, important details such as how regulatory enzymes fluctuate over time remain unclear.

For the moment, Cushman and his team are piecing together an understanding of CAM genetics with a view to developing a prototype CAM soya bean. He thinks we could have one in about five years, so it may be a while before we see them in the fields. In the meantime, more and more of Earth's semi-arid land looks set to be planted with crops like agave. Its tall, teal leaves are going to become a lot more familiar. ▮

Larissa Fedunik is a science writer based in Canberra, Australia

Sugar 'n' nice

You may have heard of agave syrup, the trendy sweetener that is an alternative to sugar. But plants that, like agave, employ crassulacean acid metabolism (CAM) photosynthesis (see main story) can end up on your plate in other ways.

Take the prickly pear cactus, which is rich in carbohydrates, minerals and vitamins. Segments of its stem can be cooked like string beans and cactus pears are the sixth most popular fruit in Mexico. It also contains pectins, complex carbohydrates used as thickening agents in processed foods.

Agave itself provides more than just syrup, which, by the way, isn't necessarily a healthier option than sugar because it contains high levels of fructose, which can increase blood sugar levels. The stalks and hearts can be roasted and the seeds can be ground into gluten-free flour. Fermented agave sap can be used to make the spirits tequila and mezcal and pulque, a sour, beer-like drink.

Signal Boost

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

Practical ACTION

A world that works better for everyone is anything but normal

The worldwide coronavirus crisis has emphatically proven that the systems that underpin human society are at best fragile, or at worst fundamentally unfit for purpose.

Around the world, food supply chains have broken down, health services have been overwhelmed and millions of jobs have been lost. Increasingly, people are questioning whether a return to 'normal' will ever be possible, but maybe we should be asking: "can we do better than normal?"

The answer is 'yes', according to international development group Practical Action. Founded by radical economist and philosopher E.F. 'Fritz' Schumacher, author of 'Small is Beautiful', the group has challenged accepted thinking for more than 50 years. They have a remarkable track record of helping people reimagine normal and reshape the systems their lives are built on.

In drought stricken Sudan, it's not industrial agriculture or big business that's helping farmers secure the food supply chain and re-green the desert. It's Practical Action's clever combination of business and farming knowledge transfer, solar-powered irrigation, better seeds and a whole lot of shared effort. Farmers have been able to turn the tables on climate change and turn barren land into lush fields and forests – and quadruple their incomes.

In Bangladesh, it's not an increase in public spending that's cleaning up city slums for people. It's Practical Action, bringing low-income communities, local government, businesses and self-employed waste workers together to create the right plan. This approach has been adopted as national policy in Bangladesh and millions more will now have access to safe water and sanitation systems.

And in Zimbabwe, it's not an extension of the national grid that's transforming lives through the power of clean electricity. It's Practical Action's work to establish solar "mini-grids" for remote communities. These are now powering up homes, schools, health clinics, workplaces and crop irrigation systems. Almost every aspect of life has improved - and as people become more productive, they earn more and can pay for the electricity they use.

As we think about the sort of post-crisis world we want to shape, let's aim for anything but normal. Practical Action's work clearly shows us that with a little ingenuity and a lot of shared effort, we can build a world that works better for everyone. Let's do it.

Want to help?

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"ONLY the dead have seen the end of war," the philosopher George Santayana once bleakly observed. Humanity's martial instincts are deep-rooted. Over millennia, we have fought wars according to the same strategic principles based in our understanding of each other's minds.

But as strategy researcher Kenneth Payne writes in this classic feature extract, reproduced in our new *Essential Guide: Artificial Intelligence*, the advent of AI introduces another sort of military mind – with consequences we are only just beginning to understand.

SOCIAL intelligence gives humans a powerful advantage in conflict. In war, size matters. Victory generally goes to the big battalions, a logic described in a formula derived by the British engineer Frederick Lanchester from studies of aerial combat in the first world war. He found that wherever a battle devolves to a melee of all against all, with ranged weapons as well as close combat, a group's fighting power increases as the square of its size.

That creates a huge incentive to form ever-larger groups in violent times. Humans are good at this, because we are good at understanding others. We forge social bonds with unrelated humans, including with strangers, based on ideas, not kinship. Trust is aided by shared language and culture. We have an acute radar for deception, and a willingness to punish non-cooperating free-riders. All these traits have allowed us to assemble, organise and equip large and increasingly potent forces to successfully wage war.

Underlying this is theory of mind – the human ability to gauge what others are thinking and how they will react to a given situation, friend or foe. Theory of mind is essential to answer strategy's big questions. How much force is enough? What does the enemy want, and how hard will they fight for it?

Strategic decision-making is often instinctive and unconscious, but also can be shaped by deliberate reflection and an attempt at empathy. This has survived even into the nuclear era. Some strategic thinkers held that nuclear weapons changed everything because their destructive power threatened punishment against any attack. Rather than denying aggressors their goals, they deterred them from ever attacking.

That certainly did require new thinking, such as the need to hide nuclear weapons, for example on submarines, to ensure that no "first strike" could destroy all possibility for retaliation. Possessing nuclear weapons certainly strengthens the position of militarily weaker states; hence the desire of countries from Iran to North Korea to acquire them.

But even in the nuclear era, strategy remains human. It involves chance and can be emotional. There is scope for misperception and miscommunication, and a grasp of human psychology can be vital for success.

Artificial intelligence changes all this. First, it swings the logic of strategy decisively towards attack. AI's pattern recognition makes it easier to spot defensive vulnerabilities, and allows more precise targeting. Its distributed swarms of robots are hard to kill, but can concentrate rapidly on critical weaknesses before dispersing again. And it allows fewer soldiers to be risked than in warfare today.

This all creates a powerful spur for moving first in any crisis. Combined with more accurate nuclear weapons in development, this undermines the basis of cold-war nuclear deterrence, because a well-planned, well-coordinated first strike could defeat all a defender's retaliatory forces. Superior AI capabilities would increase the temptation to strike quickly and decisively at North Korea's small nuclear arsenal, for example.

Unexplored and unsettling

By making many forces such as crewed aircraft and tanks practically redundant, AI also increases uncertainty about the balance of power between states. States dare not risk having second-rate military AI, because a marginal advantage in AI decision-making accuracy and speed could be decisive in any conflict. AI espionage is already under way, and the scope for a new arms race is clear. It is difficult to tell who is winning, so safer to go all out for the best AI weapons.

Were that all, it would be tempting to say AI represents just another shift in strategic balance, as nuclear weapons did in their time. But the most unsettling, unexplored change is that AI will make ›

PAUL CAMPBELL/ISTOCK PHOTO

THE BOTS OF WAR

decisions about the application of force very differently to humans.

AI doesn't naturally experience emotion, or empathy, of the sort that guides human strategists. We might attempt to encode rules of engagement into an AI ahead of any conflict – a reward function that tells it what outcome it should strive towards and how. At the tactical level, say with air-to-air combat between two swarms of rival autonomous aircraft, matching our goals to the reward function that we set our AI might be doable: win the combat, survive, minimise civilian casualties. Such goals translate into code, even if there may be tensions between them.

But as single actions knit together into military campaigns, things become much more complex. Human preferences are fuzzy, sometimes contradictory and apt to change in the heat of battle. If we don't know exactly what we want, and how badly, ahead of time, machine fleets have little chance of delivering those goals. There is plenty of scope for our wishes and an AI's reward function to part company. Recalibrating the reward function takes time, and you can't just switch AI off mid-battle – hesitate for a moment, and you might lose. That is before we try to understand how the adversary may respond. Strategy is a two-player game, at least. If AI is to be competitive, it must anticipate what the enemy will do.

The most straightforward approach, which plays to AI's tremendous abilities in pattern recognition and recall, is to study an adversary's previous behaviour and look for regularities that might be probabilistically modelled. This method was used by AlphaGo, the DeepMind AI that beat the human champion Lee Sedol at the board game Go in 2016. With enough past behaviour to go on, this works even in a game such as poker where, unlike Go, not all information is freely available and a healthy dose of chance is involved.

This approach could work well at the tactical level – anticipating how an enemy pilot might respond to a manoeuvre, for example. But it falls down as we introduce high-level strategic decisions. There is too much unique about any military crisis for previous data to model it.

An alternative method is for an AI to attempt to model the internal deliberations of an adversary. But this only works where the thing being modelled is less sophisticated, as when an iPhone runs functional replicas of classic 1980s arcade games. Our strategic AI might be able to intuit the goals of an equally sophisticated AI, but not how the AI will seek to achieve them. The interior machinations of an AI that learns as it goes are something of a black box, even to those who have designed it.

Where the enemy is human, the problem becomes more complex still. AI could perhaps incorporate themes of human thinking, such as the way we systematically inflate low-risk outcomes. But that is AI looking for patterns again. It doesn't understand what things mean to us; it lacks the evolutionary logic that drives our social intelligence. When it comes to understanding what others intend – "I know that you know that she knows" – machines still have a long way to go.

Does that matter? Humans aren't infallible mind-readers, and in the history of international crises misperception abounds. In his sobering account of nuclear strategy, *The Doomsday Machine*, Daniel Ellsberg describes a time when the original US early warning system signalled an incoming Soviet strike. In fact, the system's powerful radar beams were echoing back from the surface of the moon. Would a machine have paused for thought to ascertain that error before launching a counterstrike, as the humans involved did?

THE MILITARY-AI COMPLEX

The military has always funded much AI research. Siri, for instance, is a by-product of an effort to provide an assistant for soldiers. The "Grand Challenge" races, sponsored by the US Defense Advanced Research Projects Agency (DARPA), stimulated development of the autonomous vehicles that others now hope to make ubiquitous.

When automation becomes autonomy becomes AI is a matter of debate, and in the military arena we are probably two decades away from fully autonomous, intelligent weapon systems. Meanwhile weapons are making increasing use of autonomy software that allows them to identify enemy targets and fire without intervention. Some governments such as the UK's have committed to always keeping a "human-in-the-loop", with firing decisions authorised by a human.

Other systems, notably South Korean guns along the border with North Korea, are classed as "human-on-the-loop": someone can intervene and stop firing once it has started. The Israeli Iron Dome missile defence system is fully automated. If it detects an incoming missile or artillery shell, it will fire a missile to intercept. No human is required.

An AI's own moves are often unexpected. AlphaGo's now notorious, game-winning "move 37" in its second game against Lee was down to probabilistic reasoning and a flawless memory of how hundreds of thousands of earlier games had played out. The last thing we need is a blindingly fast, offensively brilliant AI that makes startling and unanticipated moves in confrontation with other machines.

There won't necessarily be time for human judgement to intercede in a battle of automatons before things get out of hand. At the tactical level, keeping a human in the loop would ensure defeat by faster all-machine combatants. Despite the stated intentions of liberal Western governments, there will be ever-less scope for human oversight of blurringly fast tactical warfare.

The same may be true at more elevated strategic levels. Herman Kahn, a nuclear strategist on whom the character Dr Strangelove was partly based, conceived of carefully calibrated "ladders" of escalation. A conflict is won by dominating an adversary on one rung, and making it clear that you can suddenly escalate several more rungs of intensity, with incalculable risk to the enemy – what Kahn called "escalation dominance".

In the real world, the rungs of the ladder are rather imprecise. Imagine two competing AI systems, made of drones, sensors and hypersonic missiles, locked in an escalatory game of chicken. If your machine backs off first, or even pauses to defer to your decision, it loses. The intensity and speed of action pushes automation ever higher. But how does the machine decide what it will take to achieve escalation dominance over its rival? There is no enemy mind about which to theorise; no scope for compassion or empathy; no person to intimidate and coerce. Just cold, inhuman probabilities, decided in an instant.

That was move 37 of AlphaGo's second game against the world champion. Perhaps it is also early December 2041, and a vast swarm of drones skimming over the ocean at blistering speed, approaching the headquarters of the US Pacific Fleet. We can't bury our heads and say it won't happen, because the technology already exists to make it happen. We won't be able to agree a blanket ban, because the strategic advantage to anyone who develops it on the sly would be too great. The solution to stop it happening is dispiritingly familiar to scholars of strategic studies – to make sure you win the coming AI arms race. ▮

KENNETH PAYNE researches psychology, military strategy and international relations at King's College London, and is the author of *Strategy, Evolution, and War: From apes to artificial intelligence*

New Scientist events

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Will our universe collapse in upon itself, rip itself apart, or even succumb to an inescapable expanding bubble of doom, asks astrophysicist Katie Mack

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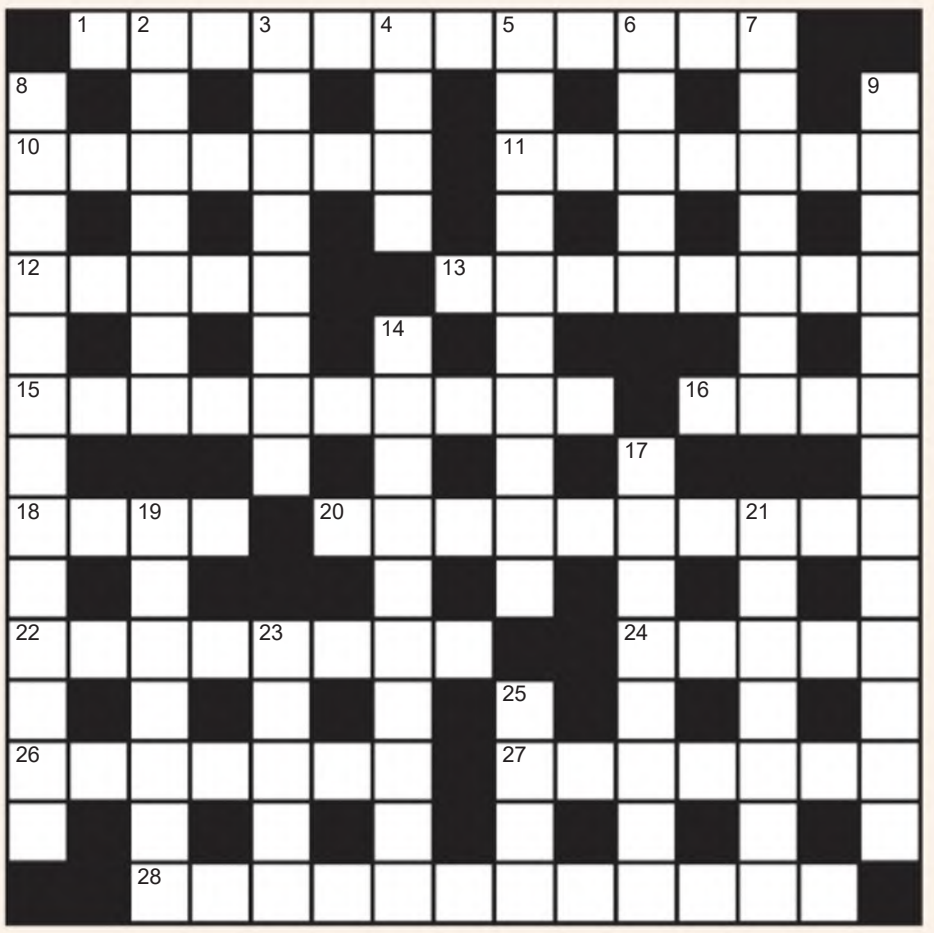
The back pages Puzzles

Quick crossword #62 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

1 Genus of extinct ape, possibly a human ancestor (12)
10 Austin family car of the 70s and 80s; serif typeface (7)
11/26 Nickname given to the Victorian biologist T.H. Huxley (7,7)
12 Divisions of an organ such as the brain (5)
13 Widespread occurrence of an infectious disease (8)
15 Value below which a given percentage of data points fall (10)
16 Acoustic reflection (4)
18 4047m², approximately (4)
20 Black volcanic rock (10)
22 Specialised stalks of a climbing plant (8)
24 Alfred ___, Austrian psychotherapist (5)
26 See 11
27 Lifeless; unable to support life (7)
28 Term describing voice synthesis (4-2-6)

DOWN

2 Safety component that strengthens a car's frame (4,3)
3 Ate; took in (8)
4 Archetypal assistant to a mad scientist (4)
5 Water-powered technologies (10)
6 Healed; remedied (5)
7 Relating to earthquakes (7)
8 Part of the female reproductive system (9,4)
9 Psychological measurement (13)
14 Tubular lamp (5,5)
17 At, atomic number 85 (8)
19 Butterfly in the family Nymphalidae (7)
21 Term for rock composed of ooids (7)
23 Base (in mathematics) (5)
25 Fourth rock from the sun (4)

Quick quiz #60

1 What is your scapula?

2 What name is given to the calculation of the proportions in which substances combine to form products in a chemical reaction?

3 The asteroid 57424 Caelumnoctu is named after what long-running TV programme broadcast by the BBC, which was presented by the same person for 55 years?

4 The 2015 film *The Man Who Knew Infinity* tells the story of which Indian mathematical genius and his collaboration with the Cambridge professor G.H. Hardy?

5 Often found in soaps and detergents, what name is given to a substance that lowers the surface tension between two substances?

Answers on page 54

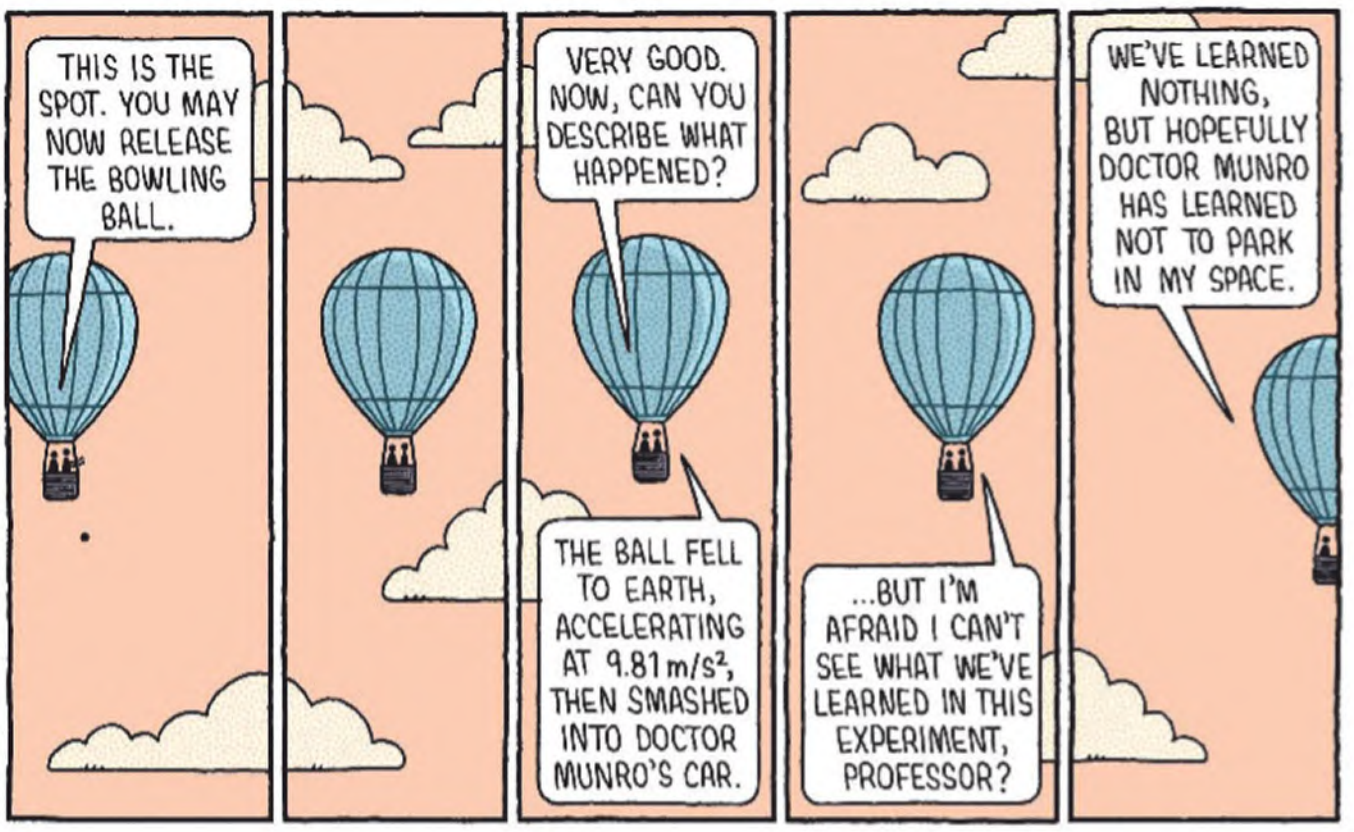
Cryptic Crossword #35 *Answers*

ACROSS **7** Short and sweet, **8** Astatine, **9** Lain, **10** Egghead, **12** Helix, **14** Laser, **16** Ratchet, **19** Mica, **20** One-sided, **22** Undercarriage

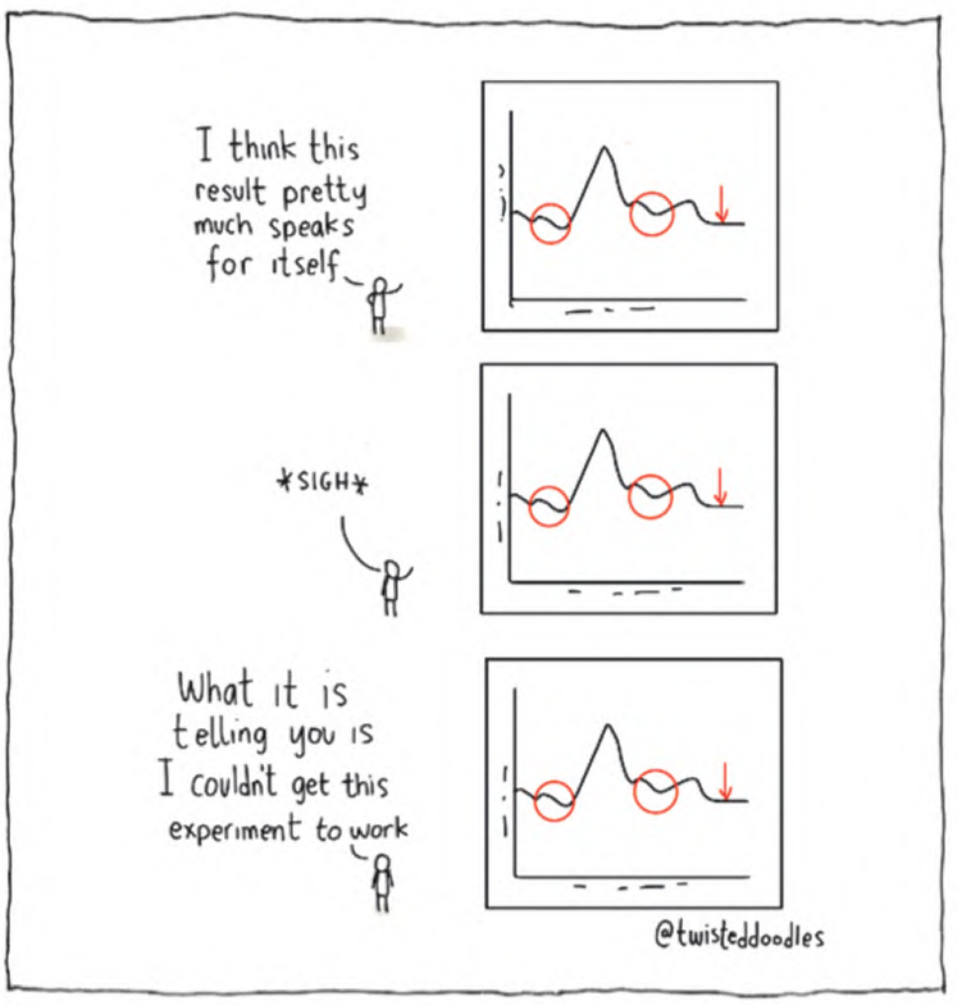
DOWN **1** Ohms, **2** Preach, **3** Maximal, **4** Adder, **5** Twelve, **6** Medicine, **11** Gradient, **13** Careers, **15** Enamel, **17** Clinic, **18** Cocci, **21** Edge

The back pages

Tom Gauld
for New Scientist



Twisteddoodles
for New Scientist



Quick quiz #60
Answers

1 One or other of your shoulder blades

2 Stoichiometry

3 *The Sky at Night*. The International Astronomical Association bestowed the honour on Patrick Moore's astronomy programme on its 50th anniversary in 2007

4 Srinivasa Ramanujan

5 A surface-active agent, or surfactant

Puzzle
set by Rob Eastaway

#68 Diamonds

"Once upon a time," began Ivan the storyteller, with children at his feet, "there lived a queen called Factoria who had six daughters and many palaces. In each palace, she kept as many crystal vases as she had palaces, and in each vase were as many diamonds as there were vases in that palace. Then one day the Queen died, leaving a will: 'I leave one vase of diamonds to my loyal servant Fidelio. The rest of the diamonds I will share equally between my daughters. Any remaining diamonds, Fidelio will put in this box.'"
Ivan reached into his pocket and pulled out a small wooden casket.
"And this is the box!"
"How many diamonds are there?" screamed the children.
"If you can tell me, I will give you the box," said Ivan.
"But you haven't told us how many palaces..." they cried.
Ivan winked.

How many diamonds are in the box? How can you be certain?

Answer next week

#67 My prime

Solution

"My prime" could be 23, 43, 67 or 89, but whichever it is, the two digits must differ by 1.
You could discover this by trial and error, but there is a short cut. Let us call the number's larger digit "a" and the smaller "b". The difference between their two squares is $a^2 - b^2$, which is the same as $(a + b) \times (a - b)$. However, we were told this difference is a prime number, so the only two factors of ab are itself and 1. Therefore a + b must be the prime itself, while a – b, the difference between the digits, is equal to 1.

Going forward

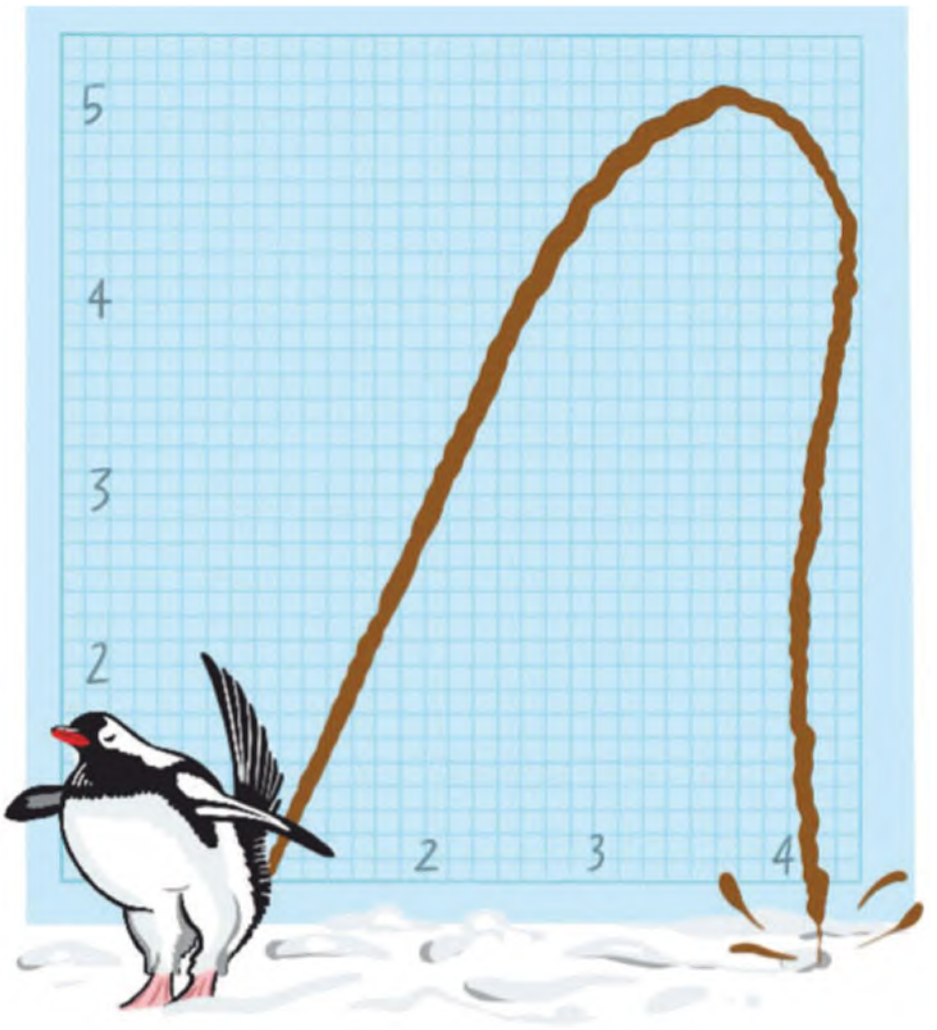
Feedback is always grateful to readers who take the time to write in, but this week we give our particularly heartfelt thanks to Robert Pleming. Much to our delight, he discovered a competition run in this very column back in 1993, wherein we challenged readers to imagine what the world would look like in 2020 – 27 years thence.

As with all imaginings of the future, the clipping he has sent in is deeply redolent of its time. It imagines a 2020 where the *National Enquirer* is still obsessed with the allegedly late Elvis Presley, Euro-Disney is a hot new attraction and the scientific status of global warming remains uncertain.

In other ways, though, it is scarily on the money. Take this entry, for example, meant to capture the goings-on of April 2020: "The virtual office arrives. Office staff no longer have to leave the home to work. Donning a virtual reality suit, they can attend their office, interact with their colleagues and retain social contact."

We don't know about you, but that reflects Feedback's April to a tee. Apart from the virtual reality suit, of course. We've spent most of the year so far in our pyjamas.

All of the predictions can be found on the *New Scientist* website in the issues of 18 and 25 September 1993, and they make for terrific reading. If any readers with similarly long memories dig up other predictions that Feedback once made for the future, do please bring them to our attention.



JOSIE FORD

Got a story for Feedback?
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Consideration of items sent in the post will be delayed

Motion sickness

Every year, as regular Feedback readers will be aware, the *Annals of Improbable Research* magazine awards the IgNobel prizes as a wry counterpoint to the annual Nobel bonanza in Stockholm.

In 2005, the IgNobel prize for fluid dynamics was awarded to Victor Benno Meyer-Rochow and Jozsef Gal for – and we quote the contemporary *New Scientist* article on the topic – "a theoretical analysis of penguin poop propulsion". The work in question, however, didn't delve sufficiently deeply into the subject for the tastes of two other researchers. Earlier this month, Hiroyuki Tajima and Fumiya Fujisawa uploaded a paper to the arXiv preprint server in which they point out that Meyer-Rochow and Gal neglected to consider the arcing trajectory of a penguin's motions, satisfying themselves exclusively with the horizontal component of said motions', well, motion.

Redoing the calculations, while also taking into account Bernoulli's theorem and viscosity corrections via the Hagen-Poiseuille equation, they come up with a penguin rectal pressure of 28.2 kilopascals. This is 40 per cent greater than previously measured. Translating this into human terms, the researchers calculate that a person with the same rectal pressure could projectile poop a distance of 3.13 metres. "He/she should not use usual rest rooms," they point out. We would say not.

Love in a cold climate

Staying with penguins – bit nippy in here, isn't it? – Twitter teaches us this week that the Kyoto aquarium in Japan has a flowchart on display to represent the former and existing relationships between its current penguin occupants.

The image's scale and complexity remind us why we never stuck with graph theory. It resembles nothing more than the allegedly helpful family trees to be found in the opening pages of great Russian novels, laying out which of the two Vladimir Trofimoviches is the wealthy cousin of the Duchess Alexandra and which is the violent deserter hell-bent on revenge for the devaluation of the rouble.

Nick names

A few weeks ago, Feedback raised a sceptical eyebrow as to the alleged existence of a police station on the aptly named "Letsby Avenue". Rab Scott writes in to silence our doubts with a screenshot of Sheffield's South Yorkshire Police Operations Complex (postcode S9 1XX, for them that's counting), located between Europa Link and – of course – Letsby Avenue. It's a fair cop, Rab, thank you for the clarification.

A debt of gratitude is also owed to Stuart Arnold, who informs us that the Cambridgeshire town in which he grew up once had a police station on Pig Lane. "The situation didn't last for long however," says Stuart, "as the spoilsports renamed the part of Pig Lane where the police station was 'Broad Leas' ".

Going backward

Having opened the floodgates to your frustrations about misused language, it is only fair that we bail the floodwater out again in your general direction. The phrase getting on multiple people's goats this week is "going forward". Chris Rundle succinctly describes it as "a ridiculously overemployed alternative to 'in the future' ". Meanwhile, "it has not escaped my notice that 'forward' is the only direction one can go in a temporal sense", says Alan Laird. "Going sideways or up or down just hurts my head!"

We feel your collective pain, goat-havers of the Feedback community. We promise that going forward – or, rather, over the inevitably contiguous increments of monodirectional time currently bearing down on us – this phrase shall not appear in any of our content verticals. Thanks to all of you for reaching out.

Written by Gilead Amit

Fading force

My horseshoe magnet isn't as strong as it once was. Does magnetism decay over time, like radioactivity?

Charlotte Ward
Associate professor of physics, Emerita, Auburn University, Alabama, US
Ferromagnetism, the kind displayed by metals including iron, cobalt and nickel, has its origin at the atomic level.

In general, a magnetic field exists in the presence of an electric current. In a piece of iron, atomic-sized electric currents can be found in any and every direction. Yet when you put that piece of iron in a strong magnetic field, the atoms line up. The iron becomes magnetised.

A horseshoe magnet is made this way, but the ever-reliable second law of thermodynamics assures us that over time, at any temperature above absolute zero, atoms will move around and randomise their positions. So any magnet will slowly weaken over time.

However, heating or dropping a magnet will hasten this process. That is why your physics teacher glared at you when you carelessly knocked a magnet off the lab desk.

John Eaden
Manchester, UK
A horseshoe magnet is made by heating a ferromagnetic alloy above a certain temperature, placing it inside a magnetising coil and allowing it to cool. The coil's strong magnetic field makes microscopic regions inside the metal crystal, called magnetic domains, line up their magnetism with each other. This results in a powerful new magnet.

During everyday use, the magnet will be dropped and banged about. This jostles the magnetic domains and means that they gradually become jumbled up. The more often this happens, the weaker the magnet becomes.

A radioactive element has atoms with an unstable nucleus. This leads it to emit radiation and become more stable. The amount of radiation emitted depends on the number of unstable atoms that are left. Over time, there are fewer unstable atoms and so the sample becomes less radioactive as a result.

Both the weakening of the horseshoe magnet and radioactive decay involve a system inevitably moving from a higher energy state towards a lower one.

Chris Daniel
Glan Conwy, Clwyd, UK
The magnetic field in a permanent magnet does tend to decay over time, but not with a predictable half-life as with radioactivity.

"Permanent" or ferromagnetic materials have tiny regions, or domains, of 0.1 to 1 millimetre in length. In these domains, the magnetic fields of adjacent atoms point in the same direction to create miniature magnets. If the majority of the domains in a piece of metal are aligned with one another, the whole material behaves as a magnet.

If the magnet is exposed to an opposing magnetic field, some domains may preferentially align with the external field, reducing the magnet's overall strength. The domains can also randomly reorientate when energy is imparted to the magnet, such as when it is dropped or struck sharply.

In a similar way, magnetism is gradually lost when the magnet is heated. At a temperature called the Curie point – this varies in different metals, but it is around 770°C in iron – permanent magnetism is lost altogether.

Over a longer period of time, random temperature fluctuations, stray magnetic fields and mechanical movement will cause magnetic properties to decay. However, this effect is very slow.

ALEXEI_TM/GETTY IMAGES/ISTOCKPHOTO

This week's new questions

Dog legs **I attached my activity tracker to my dog. Even though she has very little legs, her step count was almost exactly the same as mine. What is going on?** ***Sue Scott****, Theydon Bois, Essex, UK*

Rear view **Why hasn't evolution given us eyes in the back of our heads?** ***Geoff Broughton****, Abingdon-on-Thames, Oxfordshire, UK*

Why would a dog have roughly the same step count as a human?

If magnets are handled carefully and stored with metal keepers between their poles to constrain the magnetic fields, they will last for many years. Modern magnets made of rare earth alloys may even last for centuries.

Colour match

How do chameleons blend into the background?

Thomas Fox
Fortrose, Highlands, UK
Some animals, such as cuttlefish, primarily use pigments in cells called chromatophores under their skin to change colour. Chameleons, however, employ a slightly different technique. On top of their normal skin, they have two layers of cells known as iridophores, which contain nanocrystals that influence how light reflects off the skin.

When the chameleon is relaxed, the iridophores are tightly packed together and so the crystals reflect shorter wavelengths of light, such as blue and green. If the chameleon becomes agitated or threatened, it stretches these cells out. This means that the crystals reflect yellows and reds, which are warning colours in the natural world.

It is a myth that chameleons change colour to blend in with their surroundings. A cuttlefish can create colours to match its background, whereas a chameleon can only change depending on mood or temperature. The fact that chameleons tend to blend in with their backgrounds can mostly be attributed to natural selection. Violet chameleons were more likely to be spotted by predators. ▮

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Clare Wilson

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