New Scientist

WEEKLY 3 July 2021

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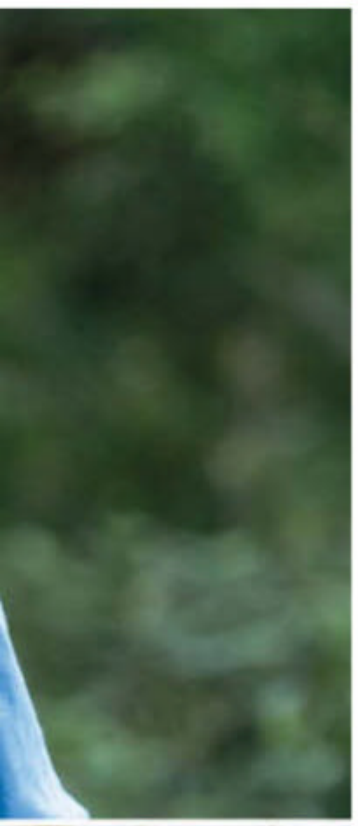

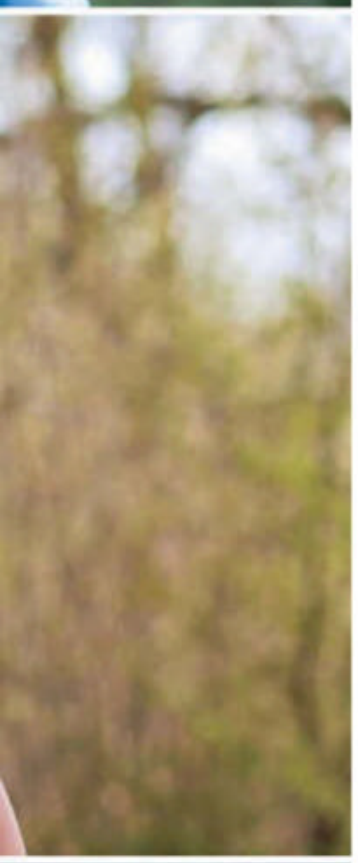

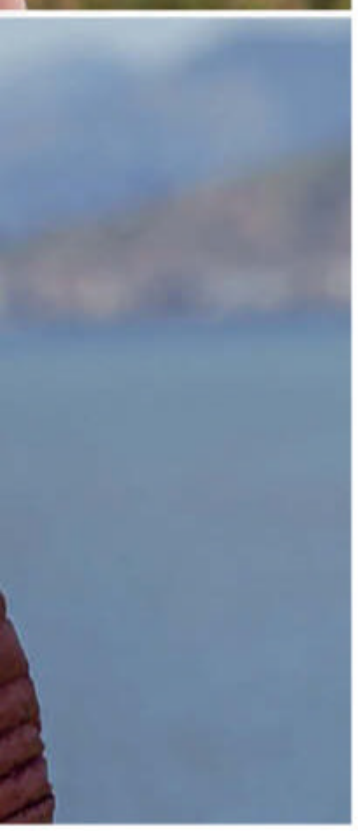

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Hindou Oumarou Ibrahim, from Chad, uses indigenous peoples' traditional knowledge to map natural resources and prevent climate conflicts in the Sahel. **Luiz Rocha**, from Brazil, works to explore and protect mesophotic coral reefs and their biodiversity in the Indian Ocean, and to strengthen conservation of these largely unknown ecosystems. **Felix Brooks-church**, from the USA, tackles malnutrition in Tanzania through equipping rural flour mills with a "dosifier" machine, which adds critical micronutrients to fortify staple foods. **Rinzin Phunjok Lama**, from Nepal, works to protect the richly diverse ecosystems of the Trans-Himalayan region, home of iconic and globally threatened mammals, by involving local communities. **Gina Moseley**, from the UK, aims to lead the first expedition to explore the planet's northernmost caves to improve our knowledge into climate change in the Arctic.

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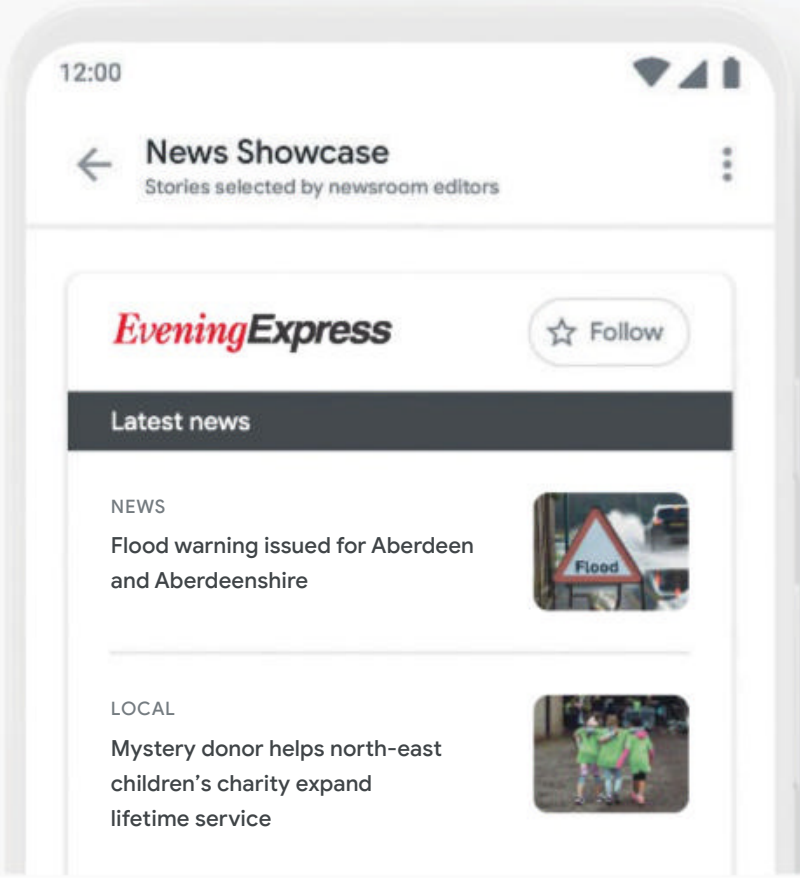

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The secrets of living a healthy life

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Weekly

The team takes a careful look at long covid: what actually is it and how can it be treated? Author Nichola Raihani drops in to explain the evolutionary basis for collaboration. Plus: computing pioneer Alan Turing is featured on the Bank of England's new £50 note.

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Online

Covid-19 daily briefing

All the latest, most crucial news in the pandemic rounded up into one essential briefing. Plus: links to our exclusive news, interviews and features. Updated daily at 6pm BST.

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Sheer lunacy? Sam Wong contemplates blowing up the moon

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Climate emergency Expert group aims to give quick-fire advice

Newsletter

Fix the Planet

Sign up for Adam Vaughan's free climate newsletter. This week, he talks to former UK chief scientist David King, who has set up the Climate Crisis Advisory Group, another expert body on climate change. It aims to provide rapid scientific advice, but do we really need yet another expert group?

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Video

Science with Sam

Should we destroy the moon? There are fair reasons to want it gone, not least for astronomy. But as Sam explains, the moon has been good to us, particularly in ameliorating Earth's seasonal weather swings. All of our video explainers are available to stream for free now.

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Newsletter

"What can a new climate supergroup add to the public debate? Can it affect things that matter, like policies?"

Essential guide

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ENTRIES CLOSE
16 JULY

WE'RE LOOKING FOR THE *best ideas in the world* ON BEHALF OF OLDER PEOPLE

The Ryman Prize is an international award aimed at encouraging the best and brightest thinkers in the world to focus on ways to improve the health of older people.

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

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

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

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

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

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

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

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

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

Go to **rymanprize.com** for more information.

Our complex history

New fossil finds tell us we're far from understanding how modern humans evolved

LAST week saw the announcement of not one but two groups of ancient humans, both new to science, and there is no reason to think the discoveries will stop any time soon (see page 10).

In Israel, a team of researchers discovered bones from a member of a population that apparently lived in the area between 420,000 and 120,000 years ago. These hominins, which the team calls Nesher Ramla *Homo*, looked a bit like the Neanderthals, and the team claims that members of the new-found group were the Neanderthals' ancestors. Not everyone agrees, however, and other interpretations have already been put forward.

Meanwhile, in China, a huge skull from an individual being labelled the Dragon Man has been analysed. The hominin may belong to the mysterious group known as the Denisovans, or, as some of its discoverers claim, it might be a new species called *Homo longi*.

It is all thoroughly complex, rather uncertain and a little confusing. The past few years have seen many developments that have complicated the story of human evolution, and the latest discoveries only add to the intricacy of our story. For millions of years, it seems the world was populated by a great diversity of human and human-like groups. These groups sometimes interbred, blurring our ideas about what constitutes a species.

"These groups sometimes interbred, blurring our ideas about what a species is"

It is to the credit of the Israeli team that it has refrained from giving the Nesher Ramla *Homo* a species name. With only a handful of bones to go on, not enough even to determine the individual's sex, giving it such a title would surely be premature. The population it came from appears to be a distinct group, but for now that is all we can say. If we are being consistent, the same is true for the Dragon Man.

Furthermore, we should be wary of any attempt to impose a simple narrative onto human evolution. Our data set is plainly still incomplete and can be reasonably interpreted in many ways. The worst thing we can do is to become wedded to our ideas about how to make sense of it, because they may well be blown out of the water by the next big find. ▮

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Clouds on the planet are far drier than we thought **p19**

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People sign up for covid-19 tests in Cascais, Portugal, to combat the delta variant

Coronavirus

Delta to dominate world

This surging variant of the coronavirus is on course to outcompete all the other versions of the virus globally, reports **Adam Vaughan**

THE more transmissible delta variant of the coronavirus is on track to become the dominant form globally, experts tell *New Scientist*. First seen in India and now in at least 85 nations, its spread has led to new lockdowns and other curbs across the world.

"Globally there is a lot of concern about the delta variant, and the World Health Organization is concerned about it too," said Tedros Adhanom Ghebreyesus, director-general of the WHO, at a press conference on 25 June.

Currently, delta is recorded as the second most dominant variant of concern globally. At around 80,000 cases detected to date, it still lags behind the 1 million detected cases of alpha, the variant first identified in the UK.

But delta's rapid dominance in the UK shows how fast it can spread, even in a country with high vaccination rates. Delta was first detected in the UK in mid-April. It now accounts for 95 per cent of all new cases and has delayed the easing of restrictions.

The variant is also spreading fast through Europe. In Portugal, it amounts to 70 per cent of cases in Lisbon. The European Centre for Disease Prevention and Control projects that, by the end of August, delta will be responsible for 90 per cent of European Union cases. It is calling for an acceleration of EU vaccination programmes, noting that a double dose provides nearly the same protection against the delta variant as against older ones.

Other parts of the world are also struggling with delta. Lockdowns have been imposed in Greater Sydney, Australia, following more than 100 new cases of the variant. Israel has reintroduced a mandate on face masks just 10 days after lifting it, following imported cases of delta. In the US, the number of cases of the variant has increased from about 10 per cent of infections on 15 June to around 20 per cent now.

Even Singapore, which fared well in controlling earlier stages of the pandemic, has seen the variant become dominant, though daily case numbers remain very low.

"Unless something else comes along, delta is probably going to outcompete all the other viruses around," says Ravi Gupta at the University of Cambridge.

A study by Gupta and his colleagues, yet to be peer reviewed, found delta not only spreads more easily than earlier variants, but evades vaccine protection better. However, while vaccine efficacy was reduced, Gupta says the findings show that it is still protective against severe disease.

Eric Topol at the Scripps Research Translational Institute in California says it is just a matter of time until the variant makes significant inroads across South America. "I don't think there's any question that delta will be globally dominant as it has shown exponential growth on multiple continents now," he says.

The toll the variant takes will largely depend on vaccination status and how many people have immunity from previous infections, adds Topol. "Places with high vaccination rates are unlikely to see a significant rise in deaths, and hospitalisations are clearly flatter when the older, high-risk people are predominantly vaccinated," he says.

The big danger from delta's global spread is for countries where few people are vaccinated, says Gupta. "It's going to lead to a great disruption and a large number of deaths in places where there isn't much vaccine," he says. Gupta is also concerned about high levels of delta leading to new mutations of the variant. ▮

Daily coronavirus news round-up
Online every weekday at 6pm BST
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Human evolution

More tangles in our human story

Two newly unveiled human fossil discoveries suggest we still haven't unravelled all the twists and turns in our family tree, find **Alison George** and **Michael Marshall**

A NEW member has been added to the human evolutionary tree, but *Homo longi* has received a frosty welcome. Many researchers think that although the enormous skull used to name the species doesn't seem to have been from a modern human or Neanderthal, it was unnecessary to give it a new species name. Some speculate that the skull belonged to one of the mysterious Denisovan people who once inhabited eastern Asia, and that it offers us our first glimpse of a Denisovan face.

The discovery, made in China, is one of two extraordinary finds announced last week that reveal new information about our extinct human relatives in Asia, alongside evidence of a previously unknown human group unearthed in Israel.

The Chinese fossil, also known as the Harbin skull, was discovered in mysterious circumstances in Harbin City in the Heilongjiang province in the 1930s. The man who unearthed it reportedly hid it in a well, only revealing its location on his deathbed. It was recovered in 2018 and has now been analysed for the first time.

"It's a really amazing discovery. It is one of the most complete crania I have ever seen," says Xijun Ni at the Chinese Academy of Sciences, who was part of the team that studied the fossil. It is also the largest known *Homo* skull ever found.

"This is the biggest human skull I've seen – and I've seen a few," says Chris Stringer at the Natural History Museum, London, also a member of the team.

The team thinks the skull belonged to a man who was about 50 years old when he died, between 296,000 and 146,000 years ago. Its features are a mix of those seen in archaic and modern humans. It has thick brow ridges,

HERSHKOVITZ, I ET AL.

YOSSI ZAIDNER

The Nesher Ramla site (above) and fossils (below), found in Israel

for example, yet "the face looks so much like a bigger version of a modern human face", says Stringer. Its brain size was similar to ours too.

"It's got such an interesting combination of features," says Stringer. "It's not Neanderthal and it's not [modern human], it's something quite distinctive."

To tie down the skull's place in our family tree, the team studied its physical characteristics – and those of a number of other human fossils – and used the information to reconstruct their evolutionary relationships. The Harbin fossil sits on a distinct branch between Neanderthals and modern humans (*The Innovation*, DOI: 10.1016/j.xinn.2021.100130).

Significantly, a fossil jawbone from Tibet also sits on this branch: a 2019 analysis of ancient proteins extracted from the Xiahe jawbone suggested it may have belonged to a Denisovan – an ancient human group that we know little about, and for which we still lack any complete fossil skulls.

"It's an exciting possibility that [the Harbin fossil] could be our first Denisovan skull," says Shara Bailey at New York University, who wasn't involved with the study. "It could be the face of a Denisovan."

In one sense, that would be a little surprising: ancient DNA

"It's a really amazing discovery. It is one of the most complete crania I have ever seen"

studies have tended to suggest the Denisovans and Neanderthals were closely related, with both sitting on the same branch of our family tree. Because the Harbin fossil sits on a distinct branch, it might suggest that Denisovans were more closely related to living people than Neanderthals were.

Further support for this idea might come from an analysis of DNA in the Harbin skull, although

Stringer cautions that any DNA the ancient skull once carried may have fallen apart after so long.

However, while many researchers are comfortable with the idea that the Harbin skull may be a Denisovan, a subset of the research team – including Ni but not Stringer – wrote a second paper in which they placed the skull in a new species: *H. longi*, a name that derives from a Chinese term for "dragon" (*The Innovation*, DOI: 10.1016/j.xinn.2021.100132).

Many palaeoanthropologists prefer not to name new human species so readily, particularly given that *H. longi* seems to be more closely related to modern humans than the Neanderthals were, and that we know modern humans and Neanderthals interbred successfully on many occasions. The convention is to refer to such distinct groups as "populations" or "lineages", which is one reason why the Denisovans themselves are rarely referred to as a distinct "species".

"You can be a separate lineage and not have achieved species status," says Bailey.

This doesn't make the discovery of the Harbin skull any less important, though: it adds to an emerging picture that Eurasia was home to several genetically distinct human "lineages" during the Stone Age.

The find in Israel represents news of another such lineage. This one may turn out to be ancestral to the Neanderthals. It also survived long enough to meet and interact with modern humans.

The remains were found at Nesher Ramla in Israel, in a quarry operated by a cement factory. The site was once a shallow depression in the landscape that gradually filled with sediment. "It was used by hominins for quite a long time, and it's very rich in terms of archaeological material and very well preserved," says Yossi Zaidner at the Hebrew University of Jerusalem, a member of the team.

The group found parts of the roof of a hominin skull and a nearly complete jawbone. "We believe it's of the same individual," says Hila May at Tel Aviv University, another author of the work – although the gender of the individual is unclear.

The sediments in which the bones were found are between 140,000 and 120,000 years old, which means the ancient individual lived after modern humans first arrived in the Israel region, at least 177,000 years ago. But the Nesher Ramla individual was no modern human, says May. For instance, the jawbone lacked the chin that is characteristic of living people.

Just as the Harbin skull team did, the Nesher Ramla team analysed the fossils' physical features and compared them with those of other human fossils. There seemed to be some similarities

50
years old – the age at death of the owner of the Harbin skull

146,000
years old – the minimum age of the Harbin fossil

120,000
years old – the minimum age of the Nesher Ramla *Homo*

with Neanderthals, but some in common with hominins that lived earlier in prehistory.

The team argues that the Nesher Ramla fossils – and a few similar fossils previously unearthed in the area – should be considered together as a new hominin group, which lived in western Asia between 420,000 and 120,000 years ago. The hominin at Nesher Ramla was "a residue or survivor of this source population", says Rachel Sarig, a member of the team, also at Tel Aviv University.

The team opted not to give the group a species name, but instead refer to it as the "Nesher Ramla *Homo*" (*Science*, doi.org/gkfq).

The Neanderthal-like features of the Nesher Ramla *Homo* can be explained if they were the ancestors of the Neanderthals, the team argues. On this account, the usual story of the origin of the Neanderthals – that they evolved from earlier European hominins – is wrong. Instead, they originated in western Asia as a subgroup of the Nesher Ramla *Homo*, and entered Europe only when the climate became favourable.

The Nesher Ramla *Homo* may also explain other unusual fossils. The bones from the caves of Skhul and Qafzeh in Israel have sometimes been classed as *Homo sapiens*, but don't look typical of our species. The team suggests they are the result of interbreeding between modern humans and the Nesher Ramla *Homo*, which would add even more tangles to our complex evolutionary tree.

The Nesher Ramla study also highlights another aspect of life for human groups living in Stone Age Eurasia. Ancient DNA evidence has helped lift the lid on the amount of interbreeding that took place between modern humans, Neanderthals and the Denisovans. But genetics can't give us a sense of the exchange of cultural ideas that must have taken place.

The archaeological evidence, however, suggests that the Nesher Ramla *Homo* and modern humans were interacting and using the same techniques to make similar tools, says Zaidner (*Science*, doi.org/gkfr). This suggests that one group learned the skills from the other, and these days researchers no longer assume that modern humans were always the teachers. "We don't know... who learned from who," says Zaidner. ▮

The Harbin skull – one of the largest human skulls ever found

XIJUN NI

Coronavirus

The neurological impact of covid-19

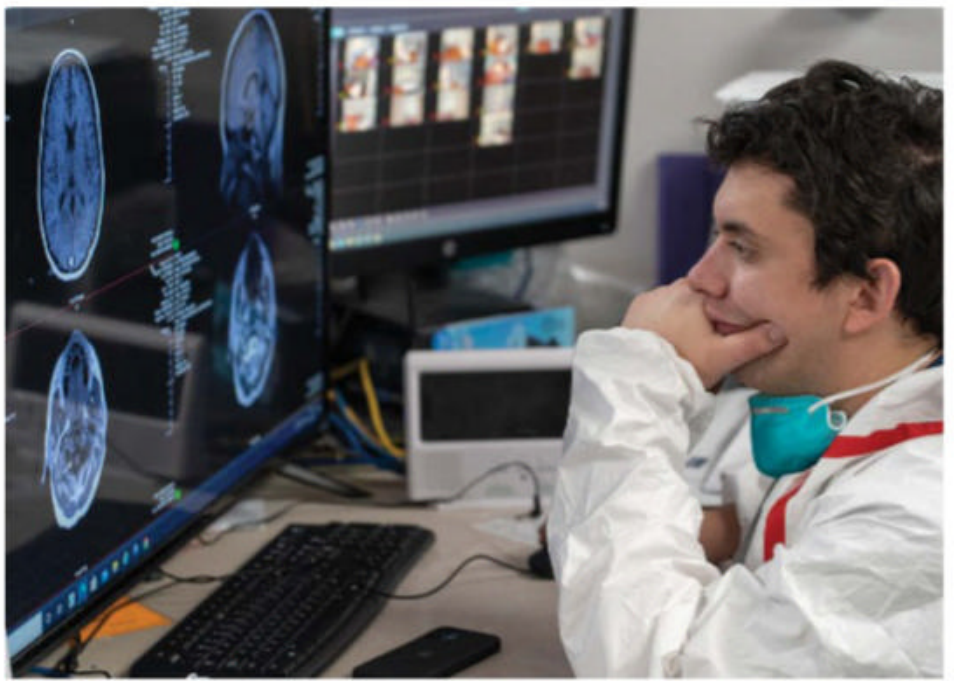
Changes to consciousness, cognition and behaviour can result from even mild cases

Michael Le Page

NUMEROUS studies show that covid-19 often affects the brain, having a profound influence on people's consciousness, cognition and behaviour – and possibly even their risk of dementia later in life.

"Mercifully, those affected are a minority of those infected," says Benedict Michael at the University of Liverpool in the UK, "but those affected are severely affected."

In addition, given the number of people who have been infected by the coronavirus, the impact of cognitive complications may be large and could have substantial effects on health systems.



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A doctor studies brain scans from covid-19 patients at a clinic in Texas

How often does covid-19 affect the brain?

Very often. Paul Harrison at the University of Oxford and his colleagues analysed the records of 236,000 people with covid-19. In the six months after infection, 34 per cent were diagnosed with a neurological or psychiatric condition. For 13 per cent, this was their first such diagnosis.

Most people with covid-19 never get tested or seek care, so the 34 per cent figure doesn't apply to everyone infected. Nevertheless, the findings still suggest that a large number of people globally have been or will be affected.

What neurological complications can occur?

In a study of 267 people who were hospitalised by covid-19 in the UK, Michael and his colleagues found that bleeding and clots in the brain were the most common brain complications, affecting around half of the people in the study.

Other complications included delirium, brain inflammation, peripheral nerve damage, psychosis, depression and anxiety. Milder neurological effects included headaches and the loss of smell or taste.

Who is most at risk of neurological problems?

There is a link between disease severity and the severity of cognitive issues, says Michael, but his team has identified some 800 people in the UK for whom the severity of brain complications is disproportionate to the severity of their covid-19. His team is studying whether they have gene variants that predispose them to getting severe brain complications.

One small study in Italy found that brain problems related to covid-19 were worse in those aged under 50 than in older people. Elisa Canu at the San Raffaele Hospital in Milan and her colleagues followed up 50 people in hospital with covid-19. Two months after leaving hospital, half had cognitive issues ranging from impaired memory to trouble judging depth, Canu told a meeting of the European Academy of Neurology.

"Scans show a loss of grey matter in some parts of the brain of those who have been infected"

However, Canu suspects this may partly be the result of younger people returning home to recover rather than staying in hospital.

Is covid-19's effect on the brain unusual?

Not particularly. Many other viruses, including the measles, polio and Zika ones, can also affect the brain. For instance, hospitalisation with pneumonia, which can be caused by viral infection, can lead to cognitive impairment that lasts at least a year in a third of those over 60 and a fifth of younger people.

How does the damage actually occur?

The coronavirus can infect the cells lining the blood vessels that supply the brain, says Frank Heppner at Charité University of Medicine in Berlin, causing inflammation and potential complications such as strokes. But the virus doesn't seem to cross the blood-brain barrier and attack brain tissue directly.

When Andreas Keller at Saarland University in Germany and his colleagues examined eight people who died of covid-19, they found major changes in gene expression characteristic of those seen in neurodegenerative conditions such as Alzheimer's disease. They think that certain signalling molecules, triggered by the virus, relay information into the brain and cause inflammation and other damage that could help explain symptoms such as the brain fog and fatigue many report.

Can covid-19 lead to Alzheimer's?

As part of a long-term study called the UK Biobank, the brains of 40,000 people had been scanned before the pandemic. Now 800 of those people, 400 of whom tested positive for the virus, have been rescanned. The results show a loss of grey matter in some parts of the brains of those infected, including in younger people and those with only mild disease.

A preprint describing these findings has raised alarm bells with some (medRxiv, doi.org/gkx6). "It's very concerning," Scott Gottlieb, former head of the US Food and Drug Administration, told CBS News. "It suggests... covid is a disease that could create persistent symptoms." The researchers aren't discussing the results yet.

Michael thinks that direct infection of the olfactory nerve is causing damage that then affects adjacent areas of the brain, including memory regions.

What has most alarmed people is the possibility that this brain damage could lead to later consequences. The preprint states that the findings raise the possibility that SARS-CoV-2 infection "might in time contribute to Alzheimer's disease

or other forms of dementia".

Other researchers say this is plausible, but think at worst it will affect a tiny number of people. "We cannot exclude the possibility," says Heppner. But many viruses have similar effects on the brain without causing such conditions, he says. "It won't apply to every covid patient for sure."

Can we treat cognitive problems?

Those severely affected – because of a stroke, say – are likely to have significant lifelong disability, says Michael. But for those with milder symptoms, the outlook is brighter. "In that group, one would have to be very hopeful that symptoms would improve."

In a few cases, there are effective treatments. For instance, the virus can cause the immune system to attack the lining of nerve cells, leading to a condition called acute disseminated encephalomyelitis. This is like a one-off hit of multiple sclerosis and can be treated with steroids and immunosuppressive drugs, says Michael.

When it comes to loss of smell, recovery depends on the extent of the damage, says Heppner. If most olfactory nerve cells and the cells that give rise to them are harmed, the problem will be long-lasting.

In Canu's study, the proportion of former hospitalised patients with cognitive issues fell from half at two months to just over a third at 10 months. However, 16 per cent reported being depressed and 18 per cent as having post-traumatic stress disorder at two months, and those numbers barely changed at 10 months.

For those with such issues, cognitive stimulation therapy might be helpful, says Canu. This can be done in hospitals or on smartphone apps. Physical exercise is also important, she says. ▮

Geoengineering

Plan to dump iron in the oceans to capture carbon

Adam Vaughan

A FORMER UK chief scientific adviser is planning experiments to drop iron in oceans to tackle climate change and restore marine life, in a major geoengineering project that is likely to prove controversial.

Ships will be sent to three locations across the world's oceans in the next four years to trial the technique – known as ocean iron fertilisation – David King at the Centre for Climate Repair at Cambridge (CCRC), UK, told *New Scientist*.

The plan is to emulate and accelerate natural processes, such as the way wind transports dust from the Sahara desert and deposits iron in the Atlantic Ocean. The iron fertilises the growth of phytoplankton, which absorbs carbon dioxide from the air, locking it away in the ocean.

King, a former UK chief scientific adviser who launched the Climate Crisis Advisory Group in June, says the technique could also help "restock the oceans with fish and animals" – including ultimately helping whale populations – because of the phytoplankton bloom.

Studies have shown that iron fertilisation can work, but past real-world trials have proven controversial and been accused of violating international rules. King describes his planned experiments, coordinated by the CCRC, as a "big international effort" to explore the approach.

"If the programme works, it's quite possible with just this one technique that we could be taking up 10 to 30 billion tonnes of greenhouse gases a year," says King. "We'd have to be covering 2 to 3 per cent of the world's deep ocean surface with small particles containing iron in order to achieve that. And we are keen to see if we can do that. It'll be very cheap because iron is very cheap."

3%

Proportion of deep ocean surface that could be fortified with iron

Wil Burns at American University in Washington DC says the scheme may have to clear international governance hurdles to go ahead. A global agreement known as the London Convention, which covers the dumping of waste and other materials at sea, would be relevant, he says. It allows for small-scale and research-focused projects, but it is unclear whether this latest plan would be approved.

The scheme may also have to engage with criteria set by the United Nations Convention on Biological Diversity and the UN Convention on the Law of the Sea, says Burns.

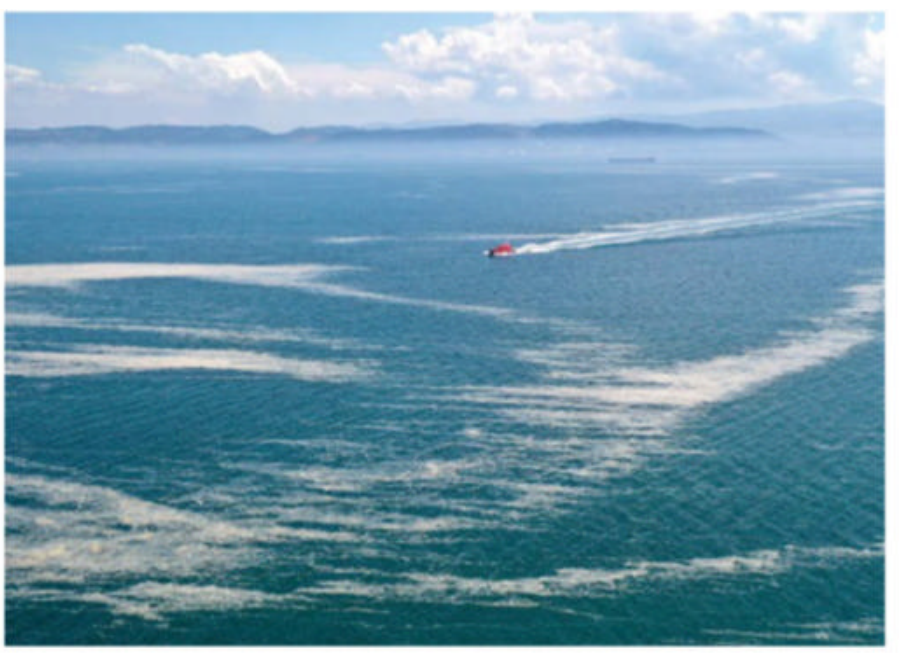
Whether further experiments on ocean iron fertilisation are needed has also been called into question by other researchers. A paper by Rob Bellamy at the University of Manchester in the UK and his colleagues, published in February, concluded that "we might reasonably question whether further research is necessary in order to rule this out as an option".

The technology isn't at a credible stage, says Bellamy. "There have been quite a few experiments already, but huge uncertainties remain over how much CO_2 is captured, and how long it stays down at the bottom of the ocean. The latest best estimates put its potential at a measly 1 to 3 billion tonnes of CO_2 removed per annum." Burns also thinks that King's CO_2 removal estimates are too high, calling them "pie in the sky".

One of the main stumbling blocks could be public attitudes, as surveys have shown that the approach is very unpopular, says Bellamy. "People don't like it."

King says he is aware of the sensitivities around putting iron in oceans to fight climate change and his team has already begun research on public attitudes. ▮

Phytoplankton in the Marmara Sea, off the coast of Turkey



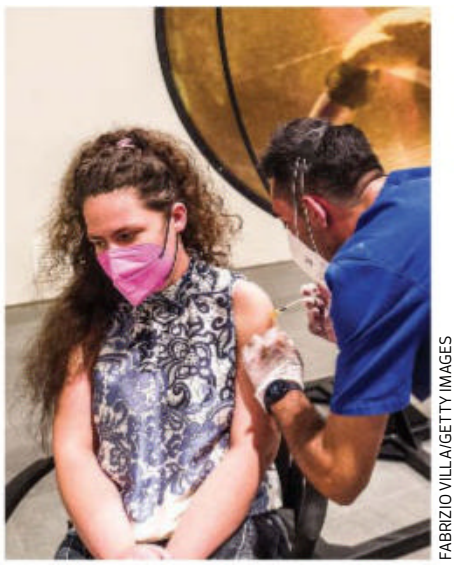
YOZOGLU/ANADOLU AGENCY VIA GETTY IMAGES

Briefing

Covid-19 vaccines and periods

Is there a real link between covid-19 vaccination and changes to menstrual cycles? **Chrissie Giles** investigates

IN FEBRUARY, Kate Clancy at the University of Illinois tweeted that she had got her period early and was bleeding heavily following her first dose of the Moderna coronavirus vaccine, and asked if others had experienced a similar thing. Such was the response that she decided to set up a research survey to study the issue. Preliminary data – which hasn't been peer-reviewed – shows that Clancy isn't alone in noticing changes in menstruation patterns after a covid-19 vaccine.



FABRIZIO VILLA/GETTY IMAGES

A healthcare worker vaccinates a woman in Messina, Italy

What data do we have about covid-19 and menstruation?
Up to 17 May, nearly 4000 reports of altered periods linked to covid-19 vaccination were made to the UK's Medicines & Healthcare products Regulatory Agency (MHRA). People reported delayed or heavier periods and unexpected bleeding.

Which vaccines have been linked to period changes?
In total, 2734 reports mentioned the Oxford/AstraZeneca vaccine, 1158 were related to Pfizer/BioNTech and 66 to Moderna, according to data seen by *The Sunday Times*. However, the MHRA says the current evidence "does not suggest increased risk of either menstrual disorders or unexpected vaginal bleeding following the vaccines".

What could be causing heavier periods?
It could be part of the body's normal response to vaccines. Gynaecologist Jen Gunter has suggested that immunisation could lead to menstrual disturbance by causing inflammation of the endometrium – the lining that is shed during a period.

Could the link just be a coincidence?
Given that these are new vaccines, we should be open-minded about potential side effects, says Pat O'Brien at the UK's Royal College of Obstetricians and Gynaecologists. "Having said that, many women at some point will go through a time where their periods become a bit unusual... and of course, many, many women are having a vaccine. It could be just chance, or it could be cause and effect, but we just don't know at the moment."

> **"We need to do a better job of systematically collecting information on menstrual health"**

What else could explain this?
Stress, diet and exercise can all affect the menstrual cycle, so it isn't unreasonable to think that the stressors of the pandemic could trigger changes in periods. A recent study found that about half of 749 athletes reported changes to their menstrual cycles during lockdown. The authors say that stress was the main contributing factor.

Do other vaccines affect periods?
There is a lack of scientific literature on the topic, though it has been seen in at least one instance. A 1913 study recorded cases of menstrual disturbance following immunisation against typhoid, including periods that were early or late, more painful or missed altogether. "Similar to today, the conclusions were, 'we're not really sure if these are normal changes or if these are caused by the vaccine'," says Leslie Farland at the University of Arizona.

How can we know for sure if covid-19 vaccines cause these changes?
Farland is undertaking a study to explore whether menstrual changes occur after covid-19 vaccination. She says the current situation is a sign we need to do "a better job of systematically collecting information on menstrual health as well as reproductive health" in clinical trials and public health surveillance.

Should vaccines be timed with the menstrual cycle to avoid any side effects?
The American College of Obstetricians and Gynecologists says there is no reason for people to schedule vaccinations based on their menstrual cycle. As ever, anyone experiencing unusual vaginal bleeding should seek medical advice, especially if they are post-menopausal. ▮

Solar system

Jupiter's strange atmosphere was born in shadows

Jason Arunn Murugesu

THE MIX of gases that make up Jupiter's atmosphere has long been a puzzle, but the giant planet's shadowy birthplace may be responsible.

Jupiter has a high proportion of nitrogen and noble gases in its atmosphere compared with the sun, but models of how the solar system formed suggest that they should be similar, because the system started out as a dense cloud of dust and gas that collapsed to form the sun and then the planets.

These gases in Jupiter's atmosphere would once have been frozen inside small pebbles, but this can only occur at -240°C, much colder than the current average temperature in Jupiter's clouds, around -150°C.

So the mystery is how these gases ever survived to make it into Jupiter's atmosphere. Previous ideas have suggested that Jupiter formed further out in the colder reaches of the solar system and then moved to its current location, but that doesn't fit with our understanding of how planets migrate, says Kazumasa Ohno at the University of California, Santa Cruz.

Now, Ohno and Takahiro Ueda at the National Astronomical Observatory of Japan say that Jupiter may have formed in a shadow created by dust in the protoplanetary disc surrounding our young star (arxiv.org/abs/2106.09084).

This would provide the cold environment required for large amounts of nitrogen and noble gases to build up while also allowing Jupiter to have formed near to where it currently orbits.

The researchers say that the dust will have built up in a region of the disc where ice sublimates from solid to gas, creating a "traffic jam" of rocky grains when the dust passes through the water vapour. We have seen similar shadows in other star systems, says Ueda. ▮

Medicine

Liver dialysis is one step closer

A new form of a treatment for liver failure has shown promise in a small trial

Clare Wilson

PEOPLE with liver failure may in future be able to recover by being hooked up to dialysis equipment to clean their blood of toxins.

The idea is akin to kidney dialysis, when people with kidney failure regularly go to a clinic or hospital to have their blood cleaned of the waste products normally removed by the kidneys. The liver performs more complex functions, which couldn't previously be mimicked.

Now, a new technique has shown promise in a small clinical trial, where it boosted the recovery process for people with liver failure.

Liver failure can be triggered by infections, drug overdoses or a worsening of long-term conditions such as cirrhosis, a scarring of the liver that can be caused by drinking too much alcohol.

One of the liver's main functions is to remove harmful compounds from the blood that come from food and drink or are made when the body processes food. In severe liver failure, there is a build-up of toxins, which can lead to damage to other organs and death.

If the liver's detoxifying role could be temporarily replaced by dialysis, it would help people to recover because livers can naturally regenerate, says Banwari Agarwal at the Royal Free Hospital in London. In people with permanent liver damage, dialysis could keep them alive until they get a transplant.

Many toxins from food and drink are transported in the blood while bound to albumin, a protein made by the liver. Initial attempts to replace the liver's function have involved simple forms of dialysis, where the blood is passed through a filter containing clean albumin, unbound to toxins.

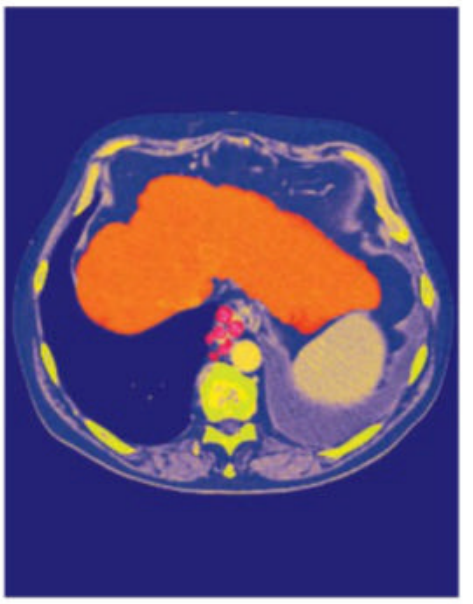
Improved treatment

The idea is that toxins pass from the albumin in the blood to the clean albumin. This treatment is on offer in certain hospitals globally, but some trials have failed to show it provides benefit and the UK's National Institute for Health and Clinical Excellence has concluded there isn't much good evidence to support it.

The problem is that people with liver failure make too little albumin and what they do make doesn't function properly, says Agarwal. "Whatever albumin is being produced is of low quality."

So Agarwal and his colleagues developed a different approach, removing the toxin-bound albumin from the individual's blood and replacing it with an infusion of fresh albumin. A second filter removes the toxins made by the person's body that aren't bound to albumin.

CT scan of a person with cirrhosis of the liver (orange)



SOVEREIGN/ISM/SCIENCE PHOTO LIBRARY

The technique was tested in 30 people in intensive care with liver failure caused by a flare-up of alcoholic cirrhosis, using a machine called Dialive made by a UK firm called Yaqrit that has commercialised the approach. Half the group had three to five dialysis sessions, while the rest received standard care.

Ten out of the 15 people who got dialysis recovered from their flare-up after 10 days, compared with five out of the 15 who got the standard care. The results were presented at the International Liver Congress, which was held virtually at the end of June.

The work is at an early stage, but the results are promising, says Tobias Böttler at the University of Freiburg, Germany, who wasn't involved in the trial. "We are really desperate to find something to bridge to transplantation." ▮

Artificial intelligence

AI could help to clear up fingerprint mysteries

AN AI that can repair blurred or distorted images of fingerprints lifted from crime scenes could make identifying people easier, but it is unclear whether such evidence would stand up in court.

Amol Joshi at West Virginia University and his colleagues trained an AI to clear up distortions of fingerprints caused by incorrect camera focusing and other errors.

The team took a data set of 15,860 clean fingerprint images from 250 subjects and created blurred versions of them synthetically at varying levels of distortion. Almost 14,000 of these pairs of images were used to train an AI and the rest were used to test its performance.

The researchers created a generative adversarial network, where one neural network is pitched against another. One attempts to generate realistic deblurred fingerprints, while the other assesses them for realism.

Because the ridges and valleys in fingerprints are key to identification, the team used a separate algorithm to highlight those features during training and check that the deblurring algorithm didn't modify that information.

The researchers found that their model could achieve 96 per cent accuracy at the lower end of the range of blurring intensity and 86 per cent at the higher end (arxiv.org/abs/2106.11354).

But David Goodwin at Forensic Equity, a UK firm providing forensic science services, says that blurred images due to human error should be avoidable with training. He also warns that the black-box nature of neural networks would present a problem in court, where any manipulation of fingerprint images would be the focus of scrutiny.

"UK courts would be unlikely to accept evidence that has been manipulated by AI without an audit trail"

Goodwin says UK courts would be unlikely to accept evidence that has been manipulated by AI unless there is an audit trail or an explanation of what processing has been done, which is often difficult with neural networks. ▮

Matthew Sparkes

Animal behaviour

Captive meerkats don't put as much effort into social niceties

Christa Lesté-Lasserre

MEERKATS in zoos fight over food more aggressively, are pickier about which of their peers they groom and have less stable relationships than those living in the wild.

This may be due to living such a comfortable life, free of predators and with food and housing reliably available without having to work together for it, says Xareni Pacheco at the Autonomous University of Mexico State. "In a confined space, where conditions rarely change and are fairly predictable, individuals may freely adjust their social dynamics with the group members at any moment, without losing benefits like food, reproductive mates or predation protection," she says.

Pacheco built her study of meerkats on the decade-long work of her colleague Joah Madden at the University of Exeter, UK. Madden's team observed the social interactions of more than 100 wild meerkats living in eight groups in South Africa. It was a "unique opportunity" for studying non-primates in the wild, because the groups had become habituated to humans and let the researchers study them up-close and in detail, he says. He and his colleagues used this information to develop a behaviour checklist specifically for studying meerkat social networks.

Using Madden's chart, Pacheco spent 300 hours observing 113 meerkats living in 15 groups across 13 zoos in the UK and Mexico, most of which had enclosures that closely resemble their native southern African habitats. She recorded 5689 social interactions.

Pacheco found that the meerkats in captivity were more selective when choosing which friends to groom, resulting in less popular meerkats rarely getting groomed. Dominant meerkats also fought with fewer individuals but more aggressively, growling at, "hip-slamming" and biting other individuals (*Behavioural Processes*, doi.org/gksn).

Previous studies have compared the behaviour of wild and captive primates, birds and fish, but this is the first one to directly compare specific interactions using animals in so many groups.

The findings provide a "really interesting comparison" that highlights how the care provided in zoos might affect natural animal behaviour, says Samantha Ward at Nottingham Trent University in the UK. "This study shows that meerkats in captivity do not necessarily need to develop as advanced social networks as they would in the wild to survive."

More research is needed to determine the full well-being implications of social networks in managed zoo animals, she says.

Although "we probably do not need any new zoos", the existing ones play an important role in benefiting wild animals in general, says Pacheco. "We need to support and focus on those zoos that are prioritising animal welfare, research and conservation education efforts. And, most importantly, we need to simultaneously support more conservation in the wild." ▮

Damp meerkats huddle together to keep warm after a rain shower

SHUTTERSTOCK/NATTANAN726

Astronomy

Rare supernova may reveal make-up of Milky Way's halo

THE remains of a supernova – an exploded star – in an unusual location could help us examine the oldest part of our galaxy.

Eugene Churazov at the Space Research Institute in Moscow, Russia, and his colleagues analysed data from an all-sky survey done with the eROSITA X-ray telescope aboard the Spektr-RG space observatory. The researchers discovered a large, circular object almost 10,000 light years away.

They say its shape suggests it is a supernova remnant, but it doesn't look like an ordinary one. It appears to be far larger and older than is typical. The object is about 40,000 years old and around 320 light years wide (arxiv.org/abs/2106.09454).

The researchers believe it is located in the Milky Way's halo, which surrounds the central disc. The halo is thought to be the most ancient part of our galaxy, although we know very little about it other than that it is made up of hot and low-density gas, says Churazov. Models predict that supernova remnants are rare in the halo.

"The remnants of [supernovae] may look different in the disc and halo of the galaxy," says Churazov. The halo is made up of a homogenous mix of gas, while the disc is far more varied, meaning the shape of a supernova can be distorted by its environment.

Because gas in our galaxy's halo is so diffuse, it may have been largely unaffected by the star exploding. And due to the large size of this supernova remnant, it is still emitting X-ray radiation that we can measure, so it could be used to find the temperature, density and elemental make-up of the portion of the Milky Way's halo it sits in.

"Other measurements at other wavelengths are needed to confirm the findings, but if it is confirmed, it can give us a unique probe into the Milky Way and the interface between its disc and halo," says Samar Safi-Harb at the University of Manitoba, Canada. ▮

320

Width in light years of an unusually large supernova remnant

Jason Arunn Murugesu

Cyberwarfare

UK ship hit by GPS spoof

The location of HMS Defender appeared to have been altered

David Hambling

A RECENT naval dispute between Russia and the UK in the Black Sea may have involved a cyberattack, an analysis of vessel tracking data has found.

On 22 June, Russia claimed to have fired "warning shots" at the UK Royal Navy destroyer HMS Defender for being inside "Russian waters", although the UK Ministry of Defence denies any shots were fired at the Defender or that the ship was in such waters. The event took place off the coast of Crimea, Ukraine, which is disputed territory.

But on 19 June, an international vessel-tracking system appeared to show HMS Defender and the Royal Netherlands Navy's HNLMS Evertsen travel across the Black Sea to sail within a few kilometres of a Russian naval base at Sevastopol. This would have been a provocative act, but the voyage never actually happened – both ships remained docked at Odessa, Ukraine, as confirmed by a live webcam feed. The tracking readings seem to have been faked, in a possible cyberattack.

The readings in question come from the Automatic Identification System (AIS), which transmits position data from the vessels' GPS along with an ID and other details at regular intervals. But GPS can be fooled by a transmitter imitating a GPS satellite and sending false information, which would in turn result in incorrect AIS tracks.

Previous false AIS incidents have seen ships "teleported" elsewhere, but this time, the spoofing was more subtle, with the vessels' coordinates being changed gradually to mimic normal travel, suggesting a deliberate attempt to mislead.

"HMS Defender was alongside [moored] in Odessa at the time of the alleged AIS track. Why this occurred would be a question for the originator of the track imagery," says commander A. J. Stevens of the Royal Navy.

"This kind of thing could lead to a shooting war by making things more confusing in a crisis"

Dana Goward at the Resilient Navigation and Timing Foundation in Virginia speculates that the GPS spoofing could have been done by Russia. "It took a lot of effort to do this," he says.

Todd Humphreys at the University of Texas at Austin says the tracks could have been generated by GPS spoofing, or from a fake AIS transmitter.

"AIS messages don't carry a digital signature, so there is no way to authenticate a message as having come from the ship claimed," says Humphreys. "This means it's easy to gin up a fake AIS signal".

H. I. Sutton at USNI News, who discovered the data oddity, says AIS is sometimes the only way of telling where a vessel is. "In this case, we were able to use other open-source intelligence, public webcams, to disprove the AIS tracks," says Sutton.

Spoofing could be used to make a ship run aground on a reef or sandbank, or collide with another vessel. Alternatively, someone could use fake tracks to support claims that a boat wasn't fishing in a prohibited area. But the military context of this incident is worrying, given heightened tensions.

"This kind of thing could easily lead to a shooting war by making things more confusing in a crisis," says Goward. "NATO ships conduct 'freedom of navigation' patrols by sailing through disputed waters. Sometimes they come close to agreed-upon territorial seas on purpose. Something like this could cause an incident that could escalate out of control."

The Russian and Dutch defence ministries didn't respond to a request for comment. ▮

ITAR-TASS NEWS AGENCY/ALAMY

HMS Defender moored in Odessa, Ukraine, on 18 June

Animal behaviour

Birds' bright feathers become dull after wildfires

Cameron Duke

ALL fire and no rain makes fairy wrens very dull birds. As the climate warms and wildfires become increasingly common, these birds are coping by ditching their bright plumage to better blend in with the burnt landscape.

Jordan Boersma at Washington State University in Pullman was studying the physiology of the red-backed fairy wren (*Malurus melanocephalus*), an energetic bird native to the grasslands of northern and eastern Australia, when he and his team made this discovery.

"I was in the middle of another experiment when this wildfire came through and burned up all of the breeding territories," he says.

With all of the nest sites burned just before the birds' breeding season, Boersma and his colleagues decided to shift focus.

They observed the birds move into their breeding season and noticed that the males, which typically become more vibrant at this time, with jet-black feathers and the eponymous splash of red across their backs to attract females, just didn't. Instead, they stayed drab and brown.

The researchers had taken blood samples from the birds before the fire and compared them with samples from after the nesting sites had been destroyed. They found that the drab male birds had suppressed testosterone levels, but all other signs pointed to good health (*Journal of Avian Biology*, doi.org/gkf8).

"This is a species that's adapted to fire because it evolved in savannahs that tend to burn," said Boersma. He argues that if there is no place for the birds to nest, it might not be worth the risk of switching to bright colours that may catch the eye of a hungry predator. Instead, delaying or skipping the breeding season altogether would be a safer bet. ▮

Computers

AIs don't understand simple physics

People can predict how objects interact as they roll and collide, but AIs struggle to do so

Chris Stokel-Walker

ARTIFICIAL intelligence struggles to comprehend how objects interact with each other as they roll, collide, drop and drape, flunking a set of benchmark tests designed to see how intelligent it really is.

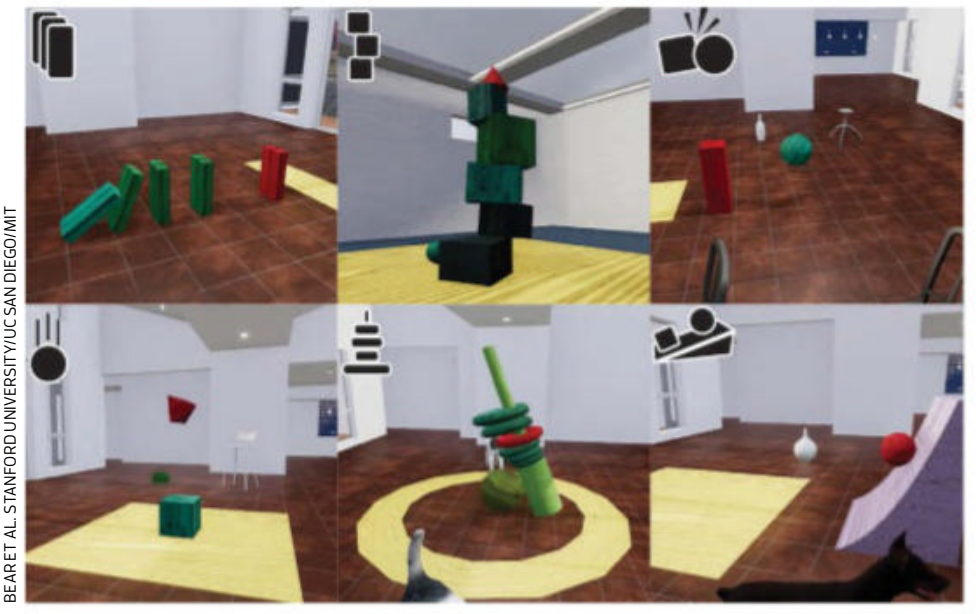
The so-called Physion benchmark was designed by Daniel Bear at Stanford University in California and his colleagues. It uses eight scenarios to showcase physical phenomena most humans understand innately.

AIs were given the opening moments of the scenarios, computer-generated in 3D, featuring objects that were designed to interact with each other. The scenarios (six pictured) included a napkin being draped over objects on a table, a set of dominoes teetering towards collapse and a ball rolling down a slope. The tests were designed to probe how well computer code understood what it was "seeing" and how good it was at predicting what would happen next.

"Algorithms have gotten very good at seeing a scene and saying, 'This is a bottle, this is a car,'" says Bear. "I was interested in a very different type of behaviour: how well can an algorithm interact physically with scenes?"

Some academics believe that having a firm grasp of what the objects in view are leads automatically to a deeper understanding of how the world works and how objects interact. This would suggest that once an AI gains a semantic understanding of the world, it would naturally gain a physical understanding of it too. "For various reasons, I was suspicious of that," says Bear.

Those suspicions appear well founded. Bear and his colleagues asked both humans and AIs to watch a 1.5-second snippet of a scene and then predict what would happen next. The tests, which were hard enough that 25 per cent of the guesses human participants made were wrong, proved too difficult for most AIs.



BEAR ET AL., STANFORD UNIVERSITY/UC SAN DIEGO/MIT

Stills from some of the Physion scenarios designed to test AIs

The worst AI predictions included that an object would dissolve or that it might pass through another object without any effect. Some AIs predicted that an object would disappear entirely (arxiv.org/abs/2106.08261).

"That, to me, is a very worrying failure," says Bear. "[Some AIs] don't think that objects are things that continue to exist beyond the moment you're looking at them."

"This project represents a significant leap forward for researchers in mobile robotics, autonomous navigation and computer vision in general," says Serge Belongie at the University of Copenhagen, Denmark.

The field of AI is moving from a data set-driven model to one based on simulation, he adds. "In the latter setting, we must work to close the simulation-to-real gap."

This is the goal that Bear is aiming for. "I want to help design algorithms that are able to perceive the world more like people do, including understanding that an object is a physical thing that's not just going to dissolve," he says. ▮

Animals

Magnetic vision could help migrating birds navigate

WE MAY finally know the secret to how migrating birds can sense Earth's magnetic fields: a molecule in their eyes that is sensitive to magnetism, potentially giving the animals an internal compass.

The process may result in the animals seeing darker or lighter areas in their vision when they look in the direction of magnetic field lines, says Henrik Mouritsen at the University of Oldenburg in Germany.

"You may be able to see where north is as kind of a shading."

Previous work has shown that some species of birds, such as the European robin (*Erithacus rubecula*), use Earth's magnetic fields when they migrate, as well as other cues. At least part of this ability is thought to lie in their eyes, because their magnetism sensing is disturbed in the absence of light.

Attention has fallen on a molecule called cryptochrome 4 because it is present in the eye's light-detecting cells and has a structure that suggests it can be affected by magnetic fields.

Now Mouritsen and his colleagues have shown how the molecule reacts to magnetic fields in the lab.

The team found that in the presence of light, electrons can jump between parts of the molecule, and between it and another molecule called flavin adenine dinucleotide (FAD), leading to the production of a compound called CRY4-FADH*. The process is suppressed by weak magnetic fields.

"Migrating birds may be able to see where north is as kind of a shading on their vision"

Changes in the level of CRY4-FADH* potentially give a way that light-sensitive cells in the eye could alter their output – making the view lighter or darker – depending on the direction and strength of the magnetic field in the bird's field of vision, says Mouritsen (*Nature*, doi.org/gkdk).

But the group hasn't yet demonstrated that cryptochrome 4 is being used for magnetic sensing in real life. "We only looked at this molecule in isolation, we didn't look at it inside a bird, which is extremely difficult," says Mouritsen. ▮

Clare Wilson

Physics

Unsinkable metal films can 'jump' out of water

James Urquhart

STAINLESS steel foil that normally sinks in water has been made so water-repellent that not only is it unsinkable, it appears to defy gravity by jumping out of water too.

Jiann Shieh at the National United University in Taiwan and his team chanced on the phenomenon after coating stainless steel foils thinner than a human hair with extremely water-repellent nanowires. These silica wires were grown on the steel wafers and then treated with a silicon-containing chemical called silane, which made them incredibly water-repellent.

"When we clearly saw the foil jumping out of the water after submerging it, we felt that something interesting had been discovered," says Shieh.

Usually an external force is needed for a thing that isn't alive to breach water because gravity must be overcome, as must surface tension, an elastic membrane caused by water molecules bunching tightly together at the surface where they meet air.

The team found that the source of the foil's power was the energy in surface tension, which is harvested by the nanowire coating. When the group placed the foil underwater using tweezers, it floated back up, and when it touched the surface of the water, the water-repellent wires propelled the metal into the air (*iScience*, doi.org/gkbx).

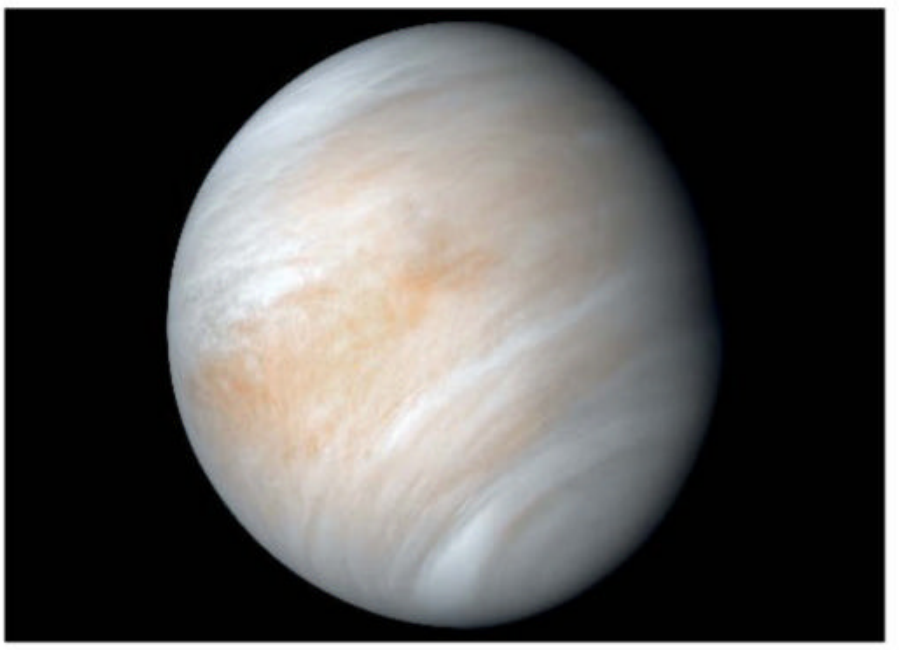
"A jumping motion that comes from the unsinkable metal converting water surface energy into motion is fascinating," says Chunlei Guo at the University of Rochester in New York, whose lab first made such metals in 2019.

Shieh's team says this reveals for the first time that power can be generated from water's surface like this. This could open new ways to separate and recycle metals in liquid, or help design small robots that can exit water, he says. ▮

Solar system

Clouds on Venus don't have enough water to support life

Leah Crane



NASA

The toxic clouds of Venus are drier than Earth's driest desert

THE clouds of Venus, which are mostly made of sulphuric acid, have far less water and far more acid than even the most extreme lifeforms on Earth would be able to survive. This is according to a new analysis of the habitability of the planet's atmosphere. The finding puts a damper on recent signs of potential life there.

In 2020, a team led by Jane Greaves at Cardiff University in the UK found evidence of a compound called phosphine in Venus's toxic clouds. On Earth, phosphine is a by-product of life, and the team couldn't come up with another way to produce it on Venus, so suggested that it could hint at life there.

However, a new study by John Hallsworth at Queen's University Belfast, UK, and his colleagues based on a combination of laboratory experiments and observations from probes sent to Venus in the late 1970s and early 80s suggests that life might be impossible in those clouds.

They based this conclusion on calculations of water activity in the clouds' droplets, a measure similar to humidity. Pure liquid water would have a water activity of 1, and perfect dryness would have a score of 0. They found a water activity of less than 0.004 for Venus's clouds, partly because acid in a droplet lowers its water activity (*Nature Astronomy*, DOI: 10.1038/s41550-021-01391-3).

0.004

Water activity in Venus's clouds on a scale of 0 to 1

This is a concentration of water 100 times below what is needed for the most resilient microorganisms on Earth, said Hallsworth in a press conference. "It's an unbridgeable distance from what life requires to be active."

In an area that arid, the membranes that hold cells together would fall apart, he said. "Even the most dry-tolerant microbe on Earth wouldn't stand a chance on Venus."

Of course, a microbe on Earth has no need to be hardy enough to survive Venus. "Literally nowhere on Earth has the extreme conditions of the clouds on Venus," says Janusz Petkowski at the Massachusetts Institute of Technology. "Those clouds are more than 100 times more dry than the Atacama desert, which is the driest place on Earth."

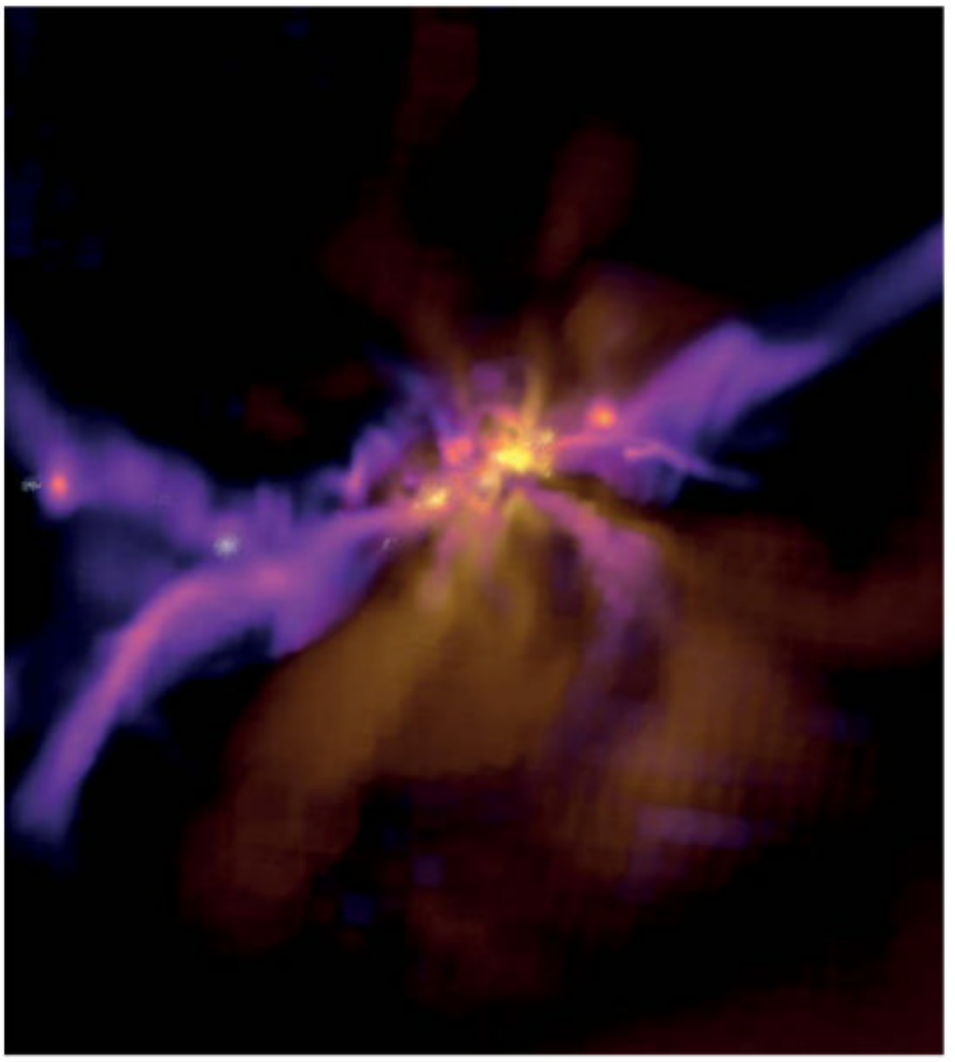
It is possible that life could arise on Venus that is hardier than it is here, or there could be organisms that aren't based on water at all, unlike all life that we know of.

"Certainly any Earth-like life – even our sturdiest extremophiles – would not have an easy time," says Clara Sousa-Silva at the Harvard-Smithsonian Center for Astrophysics. "But we don't know what the universal laws of biology are." Unfortunately, we also don't know how to detect non-Earth-like life.

While things aren't looking good for the potential of life floating in the Venusian clouds, there may still be a glimmer of hope. "The acidity for the Venus cloud droplets is highly uncertain," says Greaves. "It's also likely that conditions are not uniform – as on Earth – and so parts of the clouds could be much more favourable than others."

Three missions are scheduled to launch to Venus in the next decade or so, which may help unravel the mystery of the clouds' habitability. If there is life unlike that on Earth, those missions won't be able to spot it, but they will be able to clear up whether there is anywhere in the scorching atmosphere that Earth-like life could stand a chance. ▮

Space



HARLEY KATZ, BEECROFT FELLOW, DEPARTMENT OF PHYSICS, UNIVERSITY OF OXFORD

Far-flung galaxies give us a date for when cosmos lit up

BETWEEN 250 and 350 million years after the big bang, cosmic dawn broke. Measurements of six distant galaxies have allowed the most precise calculations of this moment, when stars first formed.

"Before cosmic dawn, the universe was dark and contained only hydrogen clouds, and now, of course, we are surrounded by all this beautiful cosmic structure and trillions of stars in the night sky," says Richard Ellis at University College London. "The question is, when did all this begin?"

Ellis and his colleagues looked at six galaxies, all more than 25 billion light years away. Because their light took a long time to reach us, we see those galaxies as they were billions of years ago, making them a window on the early universe.

Four of Earth's most powerful telescopes were used to measure the distances to these galaxies as precisely as possible and determine how old their stars are. These are some of the first stars, so their ages can tell us the date of cosmic dawn, a simulation of which is pictured left. The team calculated this lighting up occurred around 13.5 billion years ago (*Monthly Notices of the Royal Astronomical Society*, in press).

None of our current telescopes are powerful enough to observe the first stars directly because they are simply too far away. But Ellis and his colleagues have calculated that, given the timing that they found for cosmic dawn, the upcoming James Webb Space Telescope should be able to see them. It is due to launch in November, and the team has secured time on it to look for stars beginning to switch on. Leah Crane

Exoplanets

ETs may have beady eyes on us right now

ALIENS could be watching us. A survey of stars within about 325 light years of Earth has found that 2034 of them have been, are now or will be in the right position to spot our planet in the same way we usually find exoplanets, and 75 of the closest could even detect the radio waves that we constantly send out into the cosmos.

The easiest way to spot a planet outside our solar system is to catch it passing between us and its star, blocking out some of the star's light. Lisa Kaltenegger at Cornell University in New York and Jackie Faherty at the American Museum of Natural History in New York examined data from the Gaia space telescope on nearby stars to figure out which of them could find Earth in this way.

They found 1402 stars that are currently in the right position to see Earth pass in front of the sun, plus 313 that were in such a position in the past and 319 that will be someday.

They then extrapolated the movements of those stars over a period of 10,000 years, and the average time any given member of the sample could see Earth during that span is 6914 years – plenty of time to notice us, if there are inhabitants of those systems with powerful enough telescopes. Seventy-five of these are also close enough to detect radio waves sent from Earth in the past 100 years.

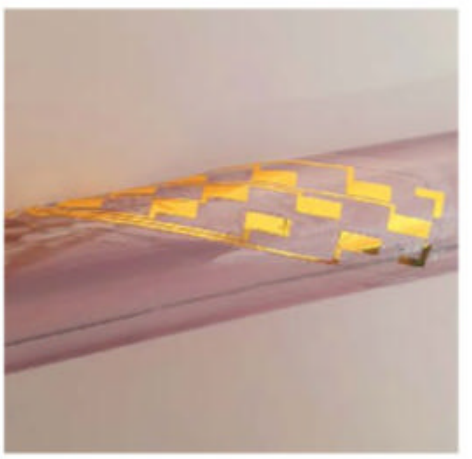
The team estimates that there could be more than 500 rocky worlds orbiting in the "Goldilocks zone" of those 2034 stars, where life as we know it could be possible (*Nature*, doi.org/gkdt). All could be good targets to study for alien signals. "These worlds might be worth the trouble of studying further, because we know they can see us," says Kaltenegger. "Who would have the most incentive to send us a signal? The ones who could have found us." **LC**

Medicine

Injectable device could tackle pain

A TINY, inflatable implant that can be injected into the spinal column could provide long-term relief from chronic pain. It works by emitting electrical signals that tell the brain to stop sensing the pain.

The idea isn't new, but its effectiveness has been hampered by practicalities, says Damiano Barone at the University of Cambridge. For such devices to work well, they must have up to 32 electrodes that snuggle up to the spinal cord. That equates to an implant of about 12 millimetres in width, meaning complex surgery and general anaesthesia and some risks, like spinal cord damage.



BEN WOODINGTON, UNIVERSITY OF CAMBRIDGE

Now, Barone and his team have developed an inflatable device (pictured) that needs minimal surgery under local anaesthesia. It is made of ultra-thin plastic and gold sheets, rolling up to be less than 2 millimetres thick.

It is designed to be injected into the epidural space – a region around the spinal cord – then unroll and fill out when pumped up with air. It could be powered by an implanted battery.

The team tested it using a water balloon as an artificial epidural space. Barone, a neurosurgeon, then practised injecting the implant via a needle into the lower back of six human cadavers. It was easy to do and rolled out fully, fitting over the spinal cord (*Science Advances*, doi.org/gkr9). **Christa Lesté-Lasserre**

Really brief

ITAR-TASS NEWS AGENCY/ALAMY

UK risks missing climate target

The UK has a legally binding goal of a 78 per cent cut in carbon dioxide emissions by 2035. But a new report by the Climate Change Committee, an independent public body, suggests the target will be missed because only a fifth of the emissions cuts required are addressed by effective policies.

Kidney donor voucher success

A kidney donor voucher scheme in the US seems to be working. Kidney donors often want to help a friend, but they might not be compatible. The scheme encourages people to donate to genetically matched strangers in return for a voucher to allow their friend to be helped by a stranger too (*JAMA Surgery*, doi.org/gkd4).

Plant roots are a major carbon store

Almost a quarter of the mass of the world's forests, shrublands and grasslands is in the roots of these plants, according to a new global map. The carbon stored underground is equal to a decade's worth of human carbon dioxide emissions (*Nature Ecology & Evolution*, doi.org/gkd5).

Solar system

Mars crater ripe for life for million years

PARTS of Mars may have been habitable for thousands or even a million years, based on an analysis of clays found in one of its craters.

In 2016, NASA's Curiosity rover used its drill to sample the Martian surface inside Gale crater, which it is exploring. Studying the sample with X-rays using the rover's onboard instruments, scientists have found the presence of a particular mineral related to so-called glauconitic clays, which point to a period of habitability.

The crater was already thought to have contained an ancient lake for up to 10 million years about 3.5 billion years ago, when the planet's atmosphere was thicker and able to support liquid water on its surface. But it was unclear if the lake had suitable conditions for life, such as a moderate temperature and neutral acidity.

However, the presence of mineral remnants of glauconitic clays is a good sign. They suggest that stable conditions – with temperatures around -3 to 15°C and water with a neutral pH – may have existed in Gale crater, possibly persisting for up to a million years (*Nature Astronomy*, DOI: 10.1038/s41550-021-01397-x).

"Glauconitic clays can be used as a proxy for stable conditions," says Elisabeth Losa-Adams at the University of Vigo, Spain, the study's lead author. "Conditions under which these form are friendly for the presence of life."

While this is an indicator of past habitability, it isn't evidence of life. Finding such evidence is the goal of Perseverance, another NASA Mars rover now exploring Jezero crater. **Jonathan O'Callaghan**

Palaeontology

JAMES HAVENS

Dinos may have braved cold to live in the Arctic year round

INFANT dinosaur fossils found in the Arctic suggest some species might have thrived year-round in the frigid tundra rather than migrating in and out to avoid the harsh winters.

Migration was thought to explain dinosaur fossils in the Arctic, but it has problems, not least the distance involved. "To migrate from our field site [to below the Arctic circle], is a minimum 3000-kilometre round trip," says Patrick Druckenmiller at the University of Alaska Museum of the North.

The rethink comes after he and his colleagues found hundreds of small bones and teeth at the Prince Creek Formation in northern Alaska. These included the remains of seven species of dinosaur that had either died within the egg or soon after hatching, suggesting the animals weren't visitors, but year-round residents able to weather the Arctic winter. The species were from eight families, including Ornithopoda, Hadrosauridae, Tyrannosauridae and Deinonychosauria (*Current Biology*, doi.org/gkdr).

Druckenmiller argues that if they laid their eggs in spring when most vegetation appears, these would hatch with winter on the horizon. Migration at that time is something a newborn is unlikely to survive. Cameron Duke

Society

Ethnic disparities in early dementia signs

BLACK and Hispanic people in the US show symptoms of dementia that may be associated with Alzheimer's disease earlier than their white counterparts.

Sangeeta Gupta at Delaware State University analysed responses to a national survey in the US in which 179,852 people aged 45 and older self-reported symptoms including memory loss and confusion. These are early signs that someone could go on to develop Alzheimer's disease.

She found that Black and Hispanic people were more likely to report early symptoms of cognitive decline between the ages of 45 and 54, while white people were more likely to be over 65 (*BMC Public Health*, doi.org/gkdw).

These Black and Hispanic people were more likely to have less education, lower household incomes and a lack of access to healthcare. Less than half had discussed their symptoms with a healthcare provider.

Adverse social circumstances along with chronic conditions, such as diabetes, seem to increase the risk of developing Alzheimer's and related dementias among ethnic minority individuals while reducing their quality of life, says Gupta. **Krista Charles**

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Comment

A new era for stargazing

We haven't found proof of life on other planets, but a wave of new telescopes will give us the best chance yet, says **Chima McGruder**

IT IS only human to look up at the night sky and wonder if we are alone. Is our planet the lucky one in a trillion that has life? Or is the cosmos filled with other lifeforms? Although we have been looking for signs of extraterrestrial life for years, the search is soon going to get a dramatic boost.

There are about 25 billion stars in our galaxy that are just like our sun, and astronomers suspect that about 20 per cent of them are orbited by an Earth-sized planet. But considering that there are 200 billion stars smaller than ours, which host more terrestrial planets, there are hundreds of billions of potential "Earths" out there. So, with that many planets, why aren't we finding new life every other day? The truth is our technology just isn't advanced enough – yet.

Fortunately, new telescopes will soon allow us to discover if we share our universe. Exoplanets – planets outside our solar system – are too far away to visit, so we must rely on studying their atmospheres to find signs of life. Currently, we can only probe the atmospheres of gas giants. But in the coming months and years, astronomers and engineers will have the giant optics needed to look more closely.

In October 2021, a NASA flagship telescope called the James Webb Space Telescope (JWST) is scheduled to be launched into space. At 6.5 metres in diameter, it is twice the size of the previous largest telescope ever launched. Its large size will make it possible to measure the extremely dim atmosphere of planets hundreds of trillions of kilometres away.

MICHELLE D'URBANO

And, being in space, its view won't be hindered by Earth's atmosphere, so will produce extremely crisp images and accurate measurements. NASA is so excited about finding signs of life with the JWST that it allocated 25 per cent of the telescope's assigned observation time to study exoplanet atmospheres.

However, the JWST can't do it alone – it will probably only be able to observe a handful of ideal terrestrial sized planets. The cavalry will soon be on its way, though. Construction is due to finish on two other revolutionary telescopes before 2030: the Giant Magellan Telescope (GMT) and the Extremely Large Telescope (ELT). These names aren't exaggerations – these ground-based devices will be massive. The GMT, at 24.5 metres, is more than twice the size of the current largest optical telescope, and the ELT will be even bigger at 39.2 metres.

They will have deformable mirrors that can bend and morph in response to the variability of Earth's atmosphere, allowing them to capture the sharper images needed to identify the very fine imprints that molecules have on exoplanet atmospheres. The larger size and deformable mirrors will make their images even sharper than those from the JWST.

In the meantime, there is work we scientists must do to prepare. First, the analysis techniques used to process the incoming data need to be perfected. This is important, because improper analysis can lead to debatable conclusions. For example, the recent detection of phosphine on Venus (which is indicative of life) was refuted by some, on the basis of improper analysis of the data.

Second, we need to understand what molecular combinations we spot in these atmospheres most strongly suggest the presence of life. The presence of molecules like water or oxygen alone don't mean a planet is inhabited, and understanding the most indicative signs that an atmosphere was altered by life is crucial. Fortunately, there is a lot of work currently being done on both fronts.

After centuries of staring at the sky wondering what is out there, we are now about to enter a new era where we might actually find out. ▮

Chima McGruder is a PhD student at the Harvard University Department of Astronomy

No planet B

The climate after the pandemic

As well-vaccinated countries see a path back to normality, the hoped-for greener lifestyle changes seem to be slipping though our fingers, says **Graham Lawton**

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

Graham's week

What I'm reading
Vesper Flights *by the wonderful nature writer Helen Macdonald*

What I'm watching
Football and tennis

What I'm working on
The finishing touches to my new book, Mustn't Grumble: The surprising science of everyday ailments and why we're always a little bit ill

This column appears monthly. Up next week: Annalee Newitz

IN PREVIOUS columns I have covered the environmental impacts of my cat and my car. I've been spending a lot of time with both recently, ferrying the increasingly decrepit old thing (the cat) to and from the vet's. The traffic is invariably terrible, with what should be a 10-minute drive taking three times that. The bus is quicker, but feels risky. I don't want him to catch covid-19.

My memory may be clouded by the blissfully car-free streets of lockdowns, but I'm pretty sure the traffic in my part of London is worse than ever. Even though the UK appears to have almost vaccinated itself back to normal, it seems many people are still reluctant to use public transport. Or maybe we have fallen victim to what behavioural scientists call "habit discontinuity" – a fancy name for behavioural changes that become ingrained during disruptive life events such as moving house or living through a pandemic. When cases were high, using a private car was much more appealing than public transport. Now, perhaps, we do it by default.

If so, we are in trouble. Behavioural change has long been regarded as an essential tool for solving the climate crisis, and increasingly biodiversity loss too. The personal sacrifices that are required are well-rehearsed: eat mostly plants, stop flying, consume less, recycle (and cycle) more and, of course, drive less.

The pandemic restrictions have presented a once-in-a-generation opportunity to shift our collective behaviour in this direction. The hope was that we would see the quieter streets, shorter commutes, cleaner air and lower levels of consumption, and like what we saw. We would also notice that major lifestyle changes are not only possible, but sometimes attractive, setting the scene for a move to a sustainable post-pandemic society.

Of course, the coronavirus is still with us and enduring changes may yet happen. But the heavy traffic says not. In well-vaccinated countries, many businesses are now contemplating a return to office working. Foreign holidays are back in the diary. We risk not just a return to business as usual, but a further ratcheting up of our planet-trashing lifestyles.

According to some behavioural scientists and psychologists, the problem is that their discipline hasn't been ambitious enough on climate issues. There is too much focus on individual consumer choices and not enough on wider economic and structural ones. In a recent article, a team from the Centre for Climate Change and Social Transformations (CAST), which is based at Cardiff University, UK, argues that, as a result, our models of behavioural change have "limited utility" in securing meaningful change.

"We risk not just a return to business-as-usual, but a ratcheting up of planet-trashing lifestyles"

As just one example, consider the aforementioned habit discontinuity. Psychologists know that the best time to break old, bad habits and establish new, good ones is during times of disruption, but efforts to leverage the pandemic mostly fail to take this into account. Unfortunately, the window of opportunity is closing. The best time to consolidate new habits is within three months of the upheaval.

Some even argue that a focus on individual behavioural change is dancing to the tune of the fossil fuel industry. In another recent paper, science historians Naomi Oreskes and Geoffrey Supran analysed 180 climate change-related documents produced by oil giant ExxonMobil, including internal memos, peer-reviewed research and paid-for advertorials on the topic from 1972 to 2014. The pair found that these consistently emphasised that individual action is the answer to the problem.

Despite the company's protests, the pair say the messaging was deliberately honed to appeal to the "rugged individualism and self-reliance that pervade US culture and ideology" – while shifting the blame for climate change away from fossil fuel producers and on to consumers. There would have been every reason to think this would do the job, as it had already been used successfully by the tobacco industry. It worked.

That isn't to say that individual actions have no role in mitigating climate change. But person power needs to be kept in perspective. According to the International Energy Agency's recent road map for getting the global energy sector to net zero, more than half of the changes required will be delivered by consumer behaviour. But most of these are big, costly choices such as buying an electric vehicle or retrofitting homes with energy-efficient technologies. Easier adjustments, such as giving up beef and flying, will deliver an important but modest 4 per cent.

As the CAST team concludes, "addressing climate change requires profound behaviour change". The cat needs picking up from the vet, and I am taking the car. My conscience will be clear, but my heart will be heavy as I sit in traffic and watch our once-in-a-generation chance slip away. ▮

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Editor's pick

On the search for what makes junk food bad

12 June, p 36

From Brian Horton, West Launceston, Tasmania, Australia

It is clear that highly processed food isn't as good for us as unprocessed food, but the reasons why remain unclear, with different experts arguing over protein, fibre, type of fibre, gut bacteria and so on.

Perhaps the answer lies in nutritional dark matter, the 99 per cent of components in food we don't actually know much about (25 July 2020, p30). Processed food has measured amounts of the main ingredients, but presumably less of these unknown elements. So we may need to look to these poorly understood components to find out why processed food is deficient.

From Elizabeth Belben, Nettlebridge, Somerset, UK

One group of ultra-processed foods to which you paid little attention was meat substitutes. Unlike stereotypical junk foods, soya "meats" are typically high in fibre and protein and low in carbohydrates and fat, but are generally higher in salt than meat. As more people move to a vegetarian or low-meat diet, perhaps the environmental benefits of less meat consumption would outweigh the health risks of eating these processed foods.

From Michael Chiu, London, UK

You highlighted the debate about the detrimental effects on our health of ultra-processed foods. I wonder whether the extolling of gourmet meals in restaurants and the emphasis on deliciousness promoted in cookery programmes on TV are equally to blame for the rise of obesity and related health issues.

I grew up in the 1950s and 60s with the idea that a "treat" was a Nice biscuit with a cup of tea, or a teaspoon of salad cream on a lettuce and tomato salad.

Maybe the time has come to take food off its pedestal and emphasise that we eat to live, not the other way round.

From Robert Sebes, Sydney, Australia

You used the phrase "dangerously delicious" to headline your article on junk food. But junk food isn't particularly delicious, although it does appear to be addictive.

Let's see what happens when we try to convince people to eat less processed food. The fight put up by the tobacco industry to counter the science on the harms of smoking is nothing compared with what we will see.

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

It is time to stop throwing around the term "junk food". If it is supposed to mean any food that isn't good for you, then people generally don't know which foods are good for them and which aren't. Besides, any food is good for a person who is starving.

If it is supposed to mean "ultra-processed", then it would include things like bread, soup, cheese, olives, coffee and most haute cuisine. If "junk food" is anything that makes you want to eat more of it, then it would include all the great recipes of the past.

Burning wood isn't the answer to our problems

5 June, p 13

From Martin van Raay, Culemborg, the Netherlands

UK energy firm Drax wants to build the world's first carbon-negative power station by burning wood and storing the carbon dioxide that is produced.

But CO_2 isn't the only byproduct of burning wood, a whole list of carcinogenic and other harmful substances is also produced. Surely it would be better to put the money for this plant into realising the hydrogen economy?

From Donald Simpson, Rochdale, Lancashire, UK

The proposals proclaiming Drax power station as potentially "carbon negative" seem to fall short in my view.

Even if Drax's carbon emissions can be tackled using carbon capture and storage (CCS), there is no merit in fuelling the station by chopping down trees in North America and shipping the wood pellets made there to the UK to be burned. Better to leave the trees doing their own carbon sequestration and fuel a CCS Drax with gas instead.

Less urbanisation may help in future pandemics

12 June, p 42

From Iain Climie, Whitchurch, Hampshire, UK

Your article raises the mantra of a shift to greater urbanisation. Yes, greener cities could have huge benefits in a world with increased urbanisation, but covid-19 has highlighted the risks of pandemics spreading rapidly in crowded areas; there will be more to come.

Divestment is still a great way to end fossil fuel use

5 June, p 40

From Gabriel Carlyle, St Leonards on Sea, East Sussex, UK

You raise questions about the effectiveness of the global fossil fuel divestment movement. By making a public commitment to divest from fossil fuels, institutions like universities and pension funds can send a powerful signal to the world's governments, helping to pave the way for the legislation and international agreements that will be needed if the world is going to rapidly phase out these industries and ensure a just transition. This is a strategy with ample historical precedents.

By contrast, years of "engagement" with fossil fuel companies, the approach favoured in your article, have failed to put a single big oil firm on track to align their emissions with a 2°C pathway by 2050, let alone a 1.5°C one.

A cause of methane spike may be under our noses

22 May, p 16

From Frank Aquino, Perth, Western Australia

Regarding an unexpected spike in methane emissions, I wanted to add another possibility: small but continuous leaks from domestic gas pipes. This could be due to deteriorating seals or pipes in the vast buried network of pipes, maybe due to a network's age.

It is possible that small leaks all over a city, all over a country, all over the world, every minute of every day could be a significant contributor.

Stigma is a global issue for mental health

12 June, p 25

From Harold Maio, Fort Myers, Florida, US

You say that in spite of awareness-raising efforts, stigma and mistrust are still key reasons why people don't seek mental health treatment. Sadly, there is almost nowhere in the world one can go to escape such stigma.

For the record

- **An avalanche of 27 million cubic metres was blamed for the deadly 2021 flood that struck Uttarakhand, India (19 June, p 21).**
- **In our report on the UK's first long covid clinic (26 June, p 14), we should have said that Rachel Lommerzheim is an occupational therapist and Maddison Rigg is a physiotherapist.**

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CHRISTOPHER MASON

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Thursday 15 July 2021 6-7pm BST, 1pm-2pm EDT and on-demand

Earth will eventually come to an end when the sun swells and dies billions of years from now, but must that mean the end of Earth's life?

In this talk, Christopher Mason details a 500-year programme that would modify our frail genomes and those of other life forms to tolerate the extremes of outer space – with the ultimate goal of settling new solar systems. Indeed, he argues, as the only species aware of our planet's fate, humanity has a moral duty to engineer life to reach new worlds.

For more information and to book your place visit:

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BIG THINKER SERIES
CHRISTOPHER MASON

Surfing sharks

Photographer Laurent Ballesta

THE grey reef sharks in this shot seem to be just hanging in the water in a behaviour never reported before in these animals.

Working in an international team of researchers, Laurent Ballesta at Andromede Oceanology in France snapped this cohort of grey reef sharks (*Carcharhinus amblyrhynchos*) in the South Pacific Ocean. They were swimming against water currents, but barely moving their tails.

The research revealed that the sharks were floating using the upward movement from currents, effectively "surfing" and cutting their energy consumption by about 15 per cent (*Journal of Animal Ecology*, doi.org/gkdq).

More than 500 grey reef sharks live in the southern channel of Fakarava atoll, a coral reef in French Polynesia. The team studied them using tags, cameras and observations. Surfing the channel with minimum effort gives the sharks a break from the continuous swimming that provides them with oxygen.

During a diving trip, lead researcher Yannis Papastamatiou at Florida International University observed the sharks using a conveyor belt-like system to surf: the one at the front lets the current carry it to the back of the line and another shark takes its place.

The study reveals what Papastamatiou calls energy seascapes: spatial representations of the energy it costs an animal to move through a marine environment. It might explain, says the researchers, why large groups of sharks gather in certain areas of ocean.

Gege Li

Tangled up in forests

Jungle connects the human story with tropical forests, from their origins to their current perilous conditions, says **Michael Marshall**

TRISTAN SAVATIER/GETTY IMAGES

Book

Jungle: How tropical forests shaped the world – and us
Patrick Roberts
Viking

FOR many of the people reading this, tropical forests are remote places. A few may have visited the Amazon on holiday, or ventured into the Bornean rainforests to see orangutans, but for most, tropical forests seem far removed from everyday life.

In *Jungle*, his first book for a general audience, archaeologist Patrick Roberts sets out to tear down the barriers and show us how our lives are intertwined with tropical forests, "to convince you that the history of tropical forests is your history too".

To do so, Roberts has written a history of the world according to the tropics and their jungles. He begins with the first land plants and the origins of trees, sketching how they affected the dinosaurs, early mammals and first primates.

The middle third of the book is devoted to the role of tropical forests in human evolution. A key message is that tropical forests aren't inhospitable: people have lived in them for hundreds of thousands of years. Roberts attacks the long-standing idea that our ancestors left the trees to live on grasslands. Early hominins clearly spent less time up trees than apes such as chimpanzees, but the evidence suggests that our ancestors lived in many places, from the most open savannah to dense forests. More recently, people living in tropical forests have built city-like settlements, as in the Amazon.

Roberts moves on to document how the European empires of the past few centuries wrought havoc on the people and ecosystems of the tropics: for instance, by setting up the global trades in sugar and rubber, and exploitative labour systems such as slavery on which they relied. He brings the story up to date by outlining the multiplying threats the forests face from climate change, agriculture and wildfires, ending with pleas for their preservation. If we don't save the tropical forests, warns Roberts, "climate change, declining food sources, economic catastrophe, political instability, mass migration and an explosion of pandemic diseases will very soon be knocking at your own door".

"*Jungle* is enormously ambitious for a first popular book: it spans millions of years and many disciplines"

In short, *Jungle* is enormously ambitious for a first popular book: it spans hundreds of millions of years and ranges across many disciplines. Does Roberts pull it off? Sort of.

On an intellectual and factual level, he unquestionably succeeds. *Jungle* is deeply researched, and moves with great skill from ecology and evolution to history and politics. Roberts handles them deftly, rarely putting a foot wrong.

Where the book does fall down is its writing style. This is so dry and complicated it might as well be an academic text. Sentences routinely run over five lines and paragraphs sprawl over whole pages. Vast arrays of facts and figures are hurled at the reader, largely unleavened by humour, anecdote or anything else.

This is compounded by a generally grim tone. Even the early chapters on evolution and dinosaurs, in which you might expect joy, thrills or awe before the serious stuff kicks in, are tough going. And the final five chapters, where Roberts outlines how modern capitalism abused tropical forests and its peoples, are an almost unbearable trudge through what feels like an endless series of atrocities.

Humans have lived in tropical forests for thousands of years

I am not suggesting Roberts should have dialled back his message: why should he, when he is so plainly correct? Moreover, some readers may not mind the style, while students looking for a panoramic and detailed survey of tropical forests will get a lot out of *Jungle*. But its difficult style and dourness will limit the appeal, which is a shame because its message should be heard.

For me, *Jungle*'s biggest problem is that while it does a superb job of conveying the factual and rational reasons why we should all care about tropical forests, it doesn't make you feel it in your bones. ▮

Michael Marshall is a science writer based in Devon, UK

A plastic revolution

Bakelite was a breakthrough material when invented in 1907. A documentary hints at its costs, says **Katie Smith-Wong**

Film

All Things Bakelite: The age of plastic

John Maher

Available on Apple TV+, Google TV, iTunes, YouTube and Vudu

IT IS a busy evening in New York and a man is asking people on the street at random if they are familiar with Bakelite. None of them knows what it is, but most think it is related to food. We meet them in a documentary, where the truth is revealed: without Bakelite, the first wholly synthetic plastic, the world would have been very different.

John Maher's *All Things Bakelite* offers a short, absorbing insight into the history of the revolutionary plastic – and into the life of Leo Baekeland, the chemist who invented it in 1907.

Bakelite was a breakthrough. Its electrical non-conductivity and heat-resistant properties quickly made it a popular material for many industries, and the range of colours it could take on gave an artistic edge to designers and manufacturers of appliances such as radios and rotary dial telephones.

Born in Ghent, Belgium, in 1863, Baekeland became an academic chemist. In 1889, he emigrated to the US thanks to a travel fellowship to visit US universities. Four years later, his poor financial situation and a severe case of appendicitis forced him to re-evaluate his career. He decided to revisit photography, in which he had success in 1887, inventing and patenting a process of developing photographic plates with water rather than chemicals.

This interesting digression gives the documentary the excuse to highlight another of Baekeland's inventions, Velox photographic paper. Created in 1893, Velox's ability to develop photographic prints under artificial light made it a commercial success. In 1899, George Eastman, the owner of Kodak, bought it from Baekeland, giving him the financial stability and space to develop other ideas.

The inclusion of Velox in the film's narrative not only explains Baekeland's contribution to modern photography, but also reminds us that neither science nor invention is a straightforward process.

As *All Things Bakelite* moves on to the creation and success of Bakelite itself, it shifts focus from the man to the material. Using stock footage and studio-style close-ups of components and appliances, we see the versatility of Bakelite and how it was applied, from automation to consumer goods.

Interviewees from various areas – chemistry, Bakelite jewellery designers and Baekeland's descendants – all provide insight into its significance. One of the more notable interviewees is Hugh Karraker, Baekeland's great-grandson, who owns the L. H. Baekeland Project, a touring show about Bakelite. But he seems to be there mainly to explain his involvement in the documentary as its producer.

In the end, the focus on Bakelite leaves Baekeland's personal history unfinished. The documentary implies that, despite the material's success, things didn't go well for him due to patent problems and the stress of business. We hear snippets about his eccentric behaviour and increasing isolation, and that he became a recluse after he retired from the Bakelite Corporation.

Overall, the documentary is a celebration of plastic. Amid its retro aesthetic, it emphasises the material's importance and impact. Despite the recyclability of many new polymers offering hope for modern plastics, audiences are left with the sombre legacy of poor Baekeland and his invention's environmental effect.

Katie Smith-Wong is a film critic based in London

Bakelite allowed consumer products to be made in a range of colours

MARCO SECCHI/ALAMY

Don't miss

Watch

Biohackers returns to Netflix for a second season, following a group of students at a German university caught up in the moral and ethical issues around a powerful gene-editing technology. From 9 July.

Read

Our Biggest Experiment, by campaigner and science communicator Alice Bell, is the one we have been conducting on our own climate. She chronicles centuries-old attempts to acquire and manage the energy we need.

Play

Chernobylite – released early on Steam, with the complete version out later this month – is a scary survival game set in a beautiful and accurate 3D-scanned recreation of the exclusion zone around the Chernobyl nuclear power station.

T–B: NETFLIX; BLOOMSBURY; AIG/THE FARM 51

The sci-fi column

Into the wilds

Into the wilds Becky Chambers, the award-winning author of the Wayfarers series, builds a different world in her latest book *A Psalm for the Wild-Built*. But it shares the same warm optimism, finds **Jacob Aron**

Jacob Aron is *New Scientist*'s deputy news editor. Follow him on Twitter @jjaron

ZOONAR GMBH/ALAMY

The relationship between a robot and a monk is at the heart of a new book

I READ a lot of sci-fi and, my, the future can be grim at times. Whether it is characters dealing with alien invasions, technology gone wrong or the ravages of climate change, most modern books in the genre are dour affairs, in stark contrast to the "golden age" sci-fi of the 1940s and 50s, when unrealistic techno-utopianism ruled.

But it isn't all bad. Increasingly, authors are writing "hopepunk" stories (a slightly cringeworthy term inspired by cyberpunk) that "weaponise optimism", according to one *Vox* journalist.

At the forefront of this subgenre is Becky Chambers, award-winning author of the Wayfarers series. But unlike the golden age stories, Chambers's characters live complex lives and know that not all problems can be tackled with the wave of a plot-solving gizmo. Instead, they rely on relationships to succeed, picking each other up and dusting themselves down in the face of adversity.

The Long Way to a Small, Angry Planet, the first book in the series, details the adventures of the crew of the ship Wayfarer. As the title suggests, it is much more about the journey than the destination. In a way, not a lot happens, but all the characters are changed by their interactions with one another.

My favourite character in the book is the charming and tragic Dr Chef (yes, he is the ship's doctor and chef), one of the last of an alien species called Grum, which resemble a kind of six-limbed otter and gradually change biological sex over their lifetime.

"Chambers's characters know that not all problems can be tackled with a plot-solving gizmo"

This is just one example of the incredibly diverse cast of aliens that populate the Wayfarers books, which share a universe but mostly stand alone. There are Aeluons, who communicate by flashing colours on their faces, and the reptilian Aandrisk, whose society is influenced by the fact they lay eggs – children are normally the result of casual sex, and aren't reared by their biological parents.

There are also artificial intelligences that run ships and other hardware, but it is illegal to upload an AI to a humanoid robot. This is key in the second book, *A Closed and Common Orbit*, which is a fantastic examination of identity and autonomy.

Chambers's latest, the novella *A Psalm for the Wild-Built*, takes place in a new continuity outside the Wayfarers universe, but shares much of its DNA. It is set on a moon called Panga where humans realised that their sprawling, oil-burning factories were unsustainable and set up a vast rewilding project. "It was a crazy split, if you thought about it: half the land for a single species, half for the hundreds of thousands of others," writes Chambers. "Finding a limit they'd stick to was victory enough." Around the same time, robots became sentient and withdrew to the new wilderness, with humans promising to leave them alone.

The book is set some time after this Transition, and follows a tea monk, Sibling Dex, who goes from settlement to settlement as a travelling salesperson-slash-roaming therapist. Despite bringing joy and comfort to those visited, Dex is unsatisfied and heads out into the wilds, looking for a new purpose – eventually making contact with a robot, Mosscap, the first time humans and robots had met in centuries.

The heart of the book is the relationship between the two and the way they support each other. It is a joyful experience and, as with all of Chambers's books, I was left with a warm, fuzzy feeling inside. ▮

Book

A Psalm for the Wild-Built

Becky Chambers

Tor.com

Jacob also recommends...

TV

Legends of Tomorrow

This show about time-travelling superheroes embraces the joy of being silly, and it is now one of my favourites. A recent episode has them meet David Bowie in 1970s London and find Spartacus on a spaceship.

Book

Revenger

Alistair Reynolds

The first novel in a trilogy sees sisters Adrana and Fura Ness join the crew of the Revenger, led by the space pirate Captain Rackamore, for swashbuckling sci-fi.

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PHOTO LEFT: DAMIANKUZDAK/ISTOCK

The seven ages of you

No single stage is the prime of life, as each decade brings new strengths. The trick is to identify them, says **David Robson**

WHETHER on page, stage or screen, the story of human health and happiness is often presented as an inevitable arc between birth and death. William Shakespeare captured this best with his "seven ages of man" speech. We enter the world "mewling and puking" as an infant, pass through the awkwardness of childhood and adolescence into our physical and mental prime, before a slow decline.

Until recently, science appeared to confirm this view. For many abilities, we seemed to reach our peak well before midlife. But it is now becoming clear that this picture is far too simplistic. Childhood and adolescence may offer the most rapid periods of development, but our brains can change in positive ways throughout life, with some important cognitive skills continuing to improve into our 50s, 60s and 70s. "The whole idea that the brain is fully mature at age 25 is a joke," says Daniel Romer, a psychologist at the University of Pennsylvania.

Nor does our fitness simply rise, peak and fall in a curve. While 20-somethings may win a sprint, performance in many other sports can reach a high later in life. That's not to mention factors like emotional well-being and mental discipline, which rise and fall in unexpected patterns. And despite nostalgia for the joys of youth, for most of us, our happiest days are actually yet to come.

By learning to recognise these patterns, we can find better ways to nurture our growth and embrace the opportunities available at each stage of life. So what, based on science, are the seven ages of you? And how can you make the most of them?

CHILDHOOD
Original thinking

It is a great shame we can't remember our first few years. In terms of the sheer number of changes to the body and brain, early childhood sees the greatest transformations of our lives. We not only learn essential skills for survival – how to walk and feed ourselves – but also language and how to recognise what others are thinking and feeling.

Neurologically speaking, a lot of this transformation involves the steady strengthening of connections between certain brain cells and the pruning of unnecessary connections between others. For some areas, such as the visual or auditory system, this happens rapidly during the first few years. This could explain why childhood is a peak period for learning, especially for sensory skills such as developing the accent of a language or perfect pitch in music. For other brain areas, such as the prefrontal cortex involved in higher level thinking and decision-making, this neural pruning and strengthening continues beyond our teens.

Much of this childhood brain development may arise from a form of statistical learning that resembles the scientific method: making predictions about the world and updating them according to evidence gained through experience. To gather this information, a baby's attention will drift to anything that is unexpected or surprising – explaining why they are so intensely curious about even the most trivial details. Over time, the process helps them to recognise objects and sounds and to work out what different words mean.

Imaginative play can aid this process, particularly as the child begins to explore the sophisticated thinking that defines our species. Humans engage in counterfactual reasoning, for example, which involves considering complex hypothetical scenarios and exploring the consequences. Playing pretend seems to train that capacity. As developmental psychologist Alison Gopnik points out in her book *The Philosophical Baby*, children spend a huge amount of time in imaginary worlds honing those skills, compared with adults. ›

MATT MURPHY

This might explain why childhood is a key period for creativity and imagination, with youngsters scoring highly compared with older people on tests of original thinking – thinking up unexpected uses for an object such as a brick, for instance (adolescents generally score more highly too).

As a child grasps more words, a growing ability to tell stories will also affect their ability to remember their life; our autobiographical memory seems to grow with our language skills, which may explain why our recollections of the first few years are hazy at best.

ADOLESCENCE
Risks and rewards

We may think that the wayward teen is a modern invention, but the stereotype can be traced at least to the ancient Greeks. The youth, according to Aristotle, are prone to "overdo everything". Shakespeare took a similarly dim view: "I would there were no age between ten and three-and-twenty... for there is nothing in the between but getting wenches with child, wronging the ancientry, stealing, fighting".

Puberty – with all those sex hormones rushing through the veins – might seem to be the most obvious reason for this unruly, impulsive behaviour. Until recently, teens were also thought to undergo some characteristic brain changes that impair their capacity to act rationally. The brain's limbic system, which governs motivation and reward, matures much more quickly than the prefrontal cortex, which is essential for behavioural inhibition and logical thought. As a result, teenagers were thought to have "imbalanced" brains wired to experience uncontrollable emotions, with little capacity to rein them in until their mid-20s, which is when the prefrontal cortex finally catches up with the limbic system. Until that point, adolescents were thought to be incapable of making good decisions – an idea that is still popular today.

In Romer's opinion, it is time to ditch these stereotypes. "They are a very gross generalisation," he says. There is actually limited evidence that most teens have a severe deficit of self-control, he says.

It is true that the capacity for "sensation seeking" behaviour – the desire for varied, new and intense experiences – peaks between the ages of 16 and 19, which may explain the willingness of teenagers to take risks. But Romer thinks that scientists should focus more on the many benefits of teen spontaneity and curiosity when trying to explain their risk-taking behaviours. "Adolescents are exploring and trying things out," he says. "That's going to involve a certain amount of risk. But you have to try things out in order to learn if they're successful and adaptive."

Whether it is their attempts to explore their sexuality or a desire to travel, the drive to seek new sensations helps adolescents to amass a wealth of experience that they can draw on in later life. This is aided by the underappreciated trait called tolerance of ambiguity. Adolescents are particularly good at coping with uncertain outcomes, which is why they are able to embrace new situations so readily.

We also need to appreciate the need adolescents have to establish themselves socially. A stable social network is essential for our well-being as adults. According to some researchers, this could explain why teens are so keen to avoid rejection and are prone to peer pressure, even if it involves acting recklessly. They may simply calculate that the risks are worth it given the possibility of cementing relationships, which isn't necessarily an irrational decision if your goal is to set up a secure friendship circle.

DEEPOL BY PLAINPICTURE/UWE UMSTÄTTER

A teenager's desire to try new things pays off in later life

TWENTIES
Faster and happier?

For many people, the third decade is the most exhilarating period of their lives, when they launch into the wider world, often establishing a career and meeting their life partner. Little wonder that, looking back from old age, most people have much richer recollections of their early 20s, compared with any other decade – a phenomenon known as the reminiscence bump.

Interestingly, the memories within the reminiscence bump are almost universally positive. Perhaps because it makes a more satisfying narrative of this defining decade, we preferentially recall happier events, while the stresses tend to be forgotten. In reality, you are less happy in your 20s than in adolescence or old age. Nostalgia is often harmless, but it can be helpful to take off those rose-tinted spectacles and question some assumptions about these heady years. It is common, after all, to assume your 20s were your physical and mental prime, suggesting that the rest of your life is an inevitable decline. But the truth is more complicated.

Consider your fitness. It is true that elite swimmers usually reach peak performance at 20, and sprinters tend to do the same at 24 to 26 – after which there is often a steady decline in performance in these sports. This is the result of biological changes, such as the loss of some "fast twitch" muscle fibres, which create the sudden bursts of energy necessary for high speed and explosive strength.

For professional sprinters, this soon creates an insurmountable barrier. "At that level, even a 0.5 per cent decline in overall performance can hold you back," says Gennaro Boccia at the University of Turin in Italy, who has recently studied age-related changes in the performance of Italy's top athletes. But such

AVPICS/ALAMY

Many people think of their 20s as the best time of their life

impacts are generally irrelevant for the rest of us in our everyday attempts to remain fit and active. "In the general population, you only start seeing a decline in your performance after 40," Boccia estimates.

The brain's trajectory after 20 is similarly complex and doesn't represent a simple decline. In a series of experiments, Laura Germine at Harvard Medical School has tested tens of thousands of people to examine the differences in cognitive abilities between age groups. Her findings confirm that 20-somethings do seem to have the edge in measures of reaction time and capacity to solve novel problems quickly. Yet many important skills – including working memory capacity, face recognition, emotion perception and the ability to sustain concentration – reach their zenith much later in life.

"Many important cognitive skills reach their zenith in later life"

THIRTIES
Staying power

If your 20s were defined by speed – both physical and psychological – then your 30s might be considered the decade of endurance.

This is evident in the peak performance of long-distance athletes. For male marathon runners, the ideal age appears to be 31 years old. For women, it is slightly less, 27 years, although champions like Paula Radcliffe have continued to win until their mid-30s. The peak age for a 100-mile ultramarathon, meanwhile, is 37 for men and 38 for women.

Why would this be? The loss of fast-twitch muscle fibres will have little impact for sports that rely on stamina. But people in their 30s do face a drop in aerobic capacity – the body's efficiency at delivering oxygen to the muscles – which could reduce performance. The extra years of experience may, however, bring the advantage of improved emotional regulation and planning, and these can help athletes to pace themselves during endurance events and to cope with the inevitable stress and exhaustion. This could offset the early stages of the physiological decline, creating a sweet spot in an athlete's 30s.

The brain is also hitting its stride on an important measure of cognitive ability. Germine has found that performance on certain working memory tasks – such as the capacity to hold multiple pieces of information in mind at once – peaks in our early 30s. It isn't hard to see how this might be beneficial, as demands of home and work start to build over the decade.

Sure, by this age our mental processing speed is a bit slower, but this loss is a small trade-off for the many other abilities we acquire as we age. "You may not be as fast as you were when you were 20, but you don't need that [speed] when you are doing the things that you have already specialised in," says Germine.

FORTIES
Pay attention!

"The really frightening thing about middle age," the actor and singer Doris Day is said to have quipped, "is that you know you'll grow out of it." We may gallantly try to claim that life begins at 40 – but for many people, it can feel more like the beginning of the end.

Midlife wasn't always seen this way. In Renaissance paintings depicting the stages of life, you often see the decade symbolised as a lion, a sign of courage and strength. It isn't clear why we have a more negative view today, but Margie Lachman, director of the lifespan development lab at Brandeis University in Massachusetts, suggests it may be linked to the pressures that begin piling up in our 30s. "Midlife is a period of high stress today, more so than in the past," she says. "One is literally in the middle of work and family careers. This can take a toll on one's ability to focus on one's own well-being."

There are, however, many reasons to feel positive about this pivotal period. Germine's studies have included the famous "mind in the eyes" test, for instance, which gets people to infer emotional states from small differences in facial expressions. She found that people in their late 40s scored highest. This may be due to practice, she suggests. "When you think about the amount of social nuance that one has to learn across the lifespan – that's where we think that comes from."

Germine found similar patterns in a task demanding sustained attention. In this, the participants had to watch different scenes fade into one another and adapt their response according to what they saw – pressing a space bar when they saw a city and releasing it when they saw a mountain. Despite the effort (and potential tedium) of the task, 40-somethings found it much easier to "get into the zone" than younger people.

It is interesting to note that middle-aged people frequently bring in the most supplies in traditional hunter-gatherer societies. According to various anthropological studies, hunter-gatherers often take decades to learn their skills, and these abilities continue to grow into their 40s.

PLAINPICTURE/MARCO GOVEL

Continuing to master new skills throughout life boosts brain health

There are some downsides to hitting this age, of course. Our skin tends to lose some of its elasticity and our body fat starts to be redistributed around the midriff. But after a dip in life satisfaction, happiness is already set to rise at the end of this decade and the beginning of the next.

Contrary to popular opinion, humans seem to have evolved to flourish into middle age and beyond.

FIFTIES AND SIXTIES
Crystallising intelligence

Unless you are extremely lucky, your body will have started to slow down by your 50s and 60s. But that is no reason to stop caring for your health. A growing number of studies show that our psychological outlook and physical lifestyle continue to have enormous consequences in later life. "To a large extent, the way one ages is in one's own hands," says Lachman.

Scientists didn't always promote the benefits of exercise in later life. With the assumption that this was a time of inevitable decay, people

were generally encouraged to take it easy. "We used to think vigorous exercise would be dangerous for older adults, that they might suffer a heart attack or fall or break bones," says Lachman.

Lachman's own research has helped to change these views. In the middle of the 1990s, her team began following more than 3000 people aged between 32 and 84. Over the course of a decade, the participants' general health was measured as well as three potentially protective factors: their physical activity, their social support and their sense of control over their life.

In terms of overall health, Lachman found that those in their 50s and 60s who scored well on those three factors looked much more like those who were in their 30s to 40s in the study than people of their own age.

The potential for interventions is obvious. "Promoting group exercise or sharing one's exercise successes with friends and family can be a way to increase activity and social support, both of which are beneficial for health," says Lachman. Talking therapies, meanwhile, might help to change people's sense of control, encouraging them to see the potential to make positive change in their lives.

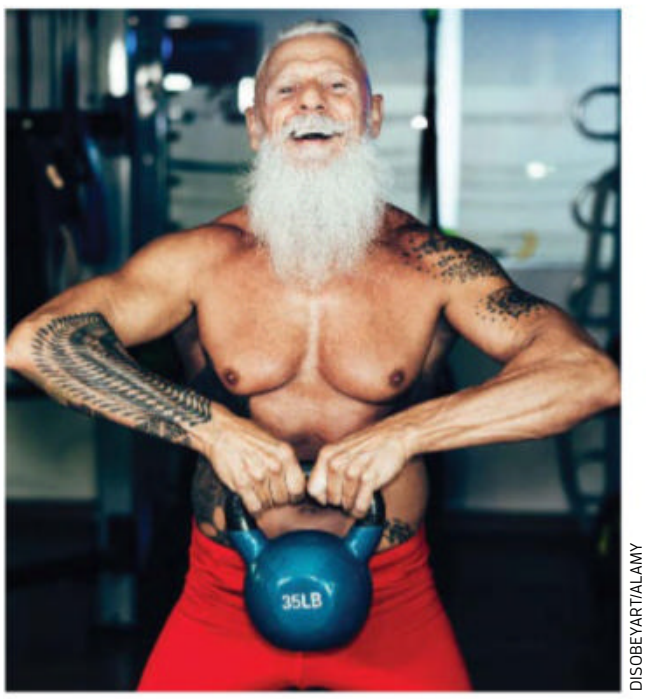
We can be similarly proactive about our cognitive functioning. According to Germine's studies, measures of "crystallised intelligence" – the knowledge, facts and skills that we accumulate through life, such as vocabulary size – peak in our 50s and 60s. That should give you greater expressive power than those in their 20s or 30s. This accumulation of knowledge might also be responsible for some of the reduced processing speed of older people measured in cognitive tests. After all, when recalling information, it takes longer when you have more information to sift through.

You may, of course, encounter the odd moments of forgetfulness. But research by Dayna Touron at the University of North Carolina, Greensboro, suggests that older people are overly pessimistic about the state of their memory, which can needlessly discourage them from exercising their minds. When driving, for instance, they may use a GPS for fear of forgetting directions; yet they often can remember the correct route when pressed.

"To a large extent, the way you age is in your own hands"

This habit, called memory avoidance, could speed decline, so it is important not to let pessimistic judgements become a self-fulfilling prophecy. Fortunately, there is now plenty of evidence that people who continue to learn new, challenging skills tend to maintain healthier brains in later life. This could be learning a language or musical instrument or a craft like quilting – anything that is complex enough to tax your mind.

With our brains as well as our bodies, it really is a case of use it or lose it.



DISOBEYART/ALAMY

It is never too late to reap the benefits of getting stronger

SEVENTY-PLUS
The older the...

If you want to remain healthy, then regular, challenging activity is essential into your 70s and beyond. "It is never too late to make some changes," says Lachman. One study, for instance, found that a programme of strength training improved the mobility of people in their 90s. At the same time, you might come to appreciate the wisdom that has accrued during your life and try to put it to good use.

This may sound like a cliché, but Igor Grossmann at the University of Waterloo in Canada, has designed tests that measure various elements of "wise reasoning", and the age-related changes are revealing. In a typical test, participants are presented with a text describing a conflict – either personal or political – and asked to discuss the potential outcomes. Their answers are then scored on qualities such as intellectual humility (the capacity to admit what we don't know), the ability to adopt many perspectives and the ability to find a compromise. Together, these traits are believed to capture the general concept of wisdom that has been promoted by philosophers throughout the ages.

Grossmann has found that people's wise reasoning scores are often more strongly linked with various measures of life satisfaction and the quality of people's social relationships, than traditional measures of cognitive ability like IQ. And older people seem to ace these tests compared with younger or middle-aged participants. The overall quality of our decision-making really does seem to increase steadily throughout life.

Our impressive abilities at all seven ages of life make it clear that there simply is no single prime period: every decade could be considered a golden age in one form or another. From our entrance into this world to our exit, humans have great potential. ▮

David Robson is author of *The Intelligence Trap: Revolutionise your thinking and make wiser decisions*. To buy a copy, go to shop.newscientist.com/the-intelligence-trap

PETE REYNOLDS

Engineering immunity

Antibodies are a vital weapon in our immune system's arsenal. Now we can redesign them from scratch to better fight disease, says immunologist **Daniel M. Davis**

THE wonders of the world tend to be quite conspicuous. You can hardly miss the Grand Canyon, say, or the Great Pyramid of Giza. You could, however, be forgiven for overlooking the great wonders of human biology. It is easy to take the brain or DNA for granted. And yet over the past year or so, living through the coronavirus pandemic, we have all come to better appreciate the marvel that is our immune system, a vast and diverse array of cells and molecules that defend us against viruses and other invaders.

One molecule in particular has taken centre stage: the antibody. These Y-shaped proteins, which we produce in response to infection, are a vital part of our defences. They are also the basis of many of the most important medicines. But we haven't exhausted their potential yet – far from it.

Typically, we have used antibodies in medicine pretty much as they come in nature, even if we select and mass-produce the versions we need. Now we can do much more. By manipulating genes in the cells that produce antibodies, or splicing together fragments of the proteins themselves, we can re-engineer their structures to create bespoke immune molecules.

In my lab at the University of Manchester, UK, we use super-resolution microscopes to see how the immune system works on a molecular scale. We are just one of thousands of labs doing such work, which is fuelling a new age of antibody engineering. With researchers currently producing all kinds of tailor-made antibodies – from those that lure cancer cells to their doom to those that can actually infiltrate cells – we are on the cusp of a revolution in our capacity to fight disease.

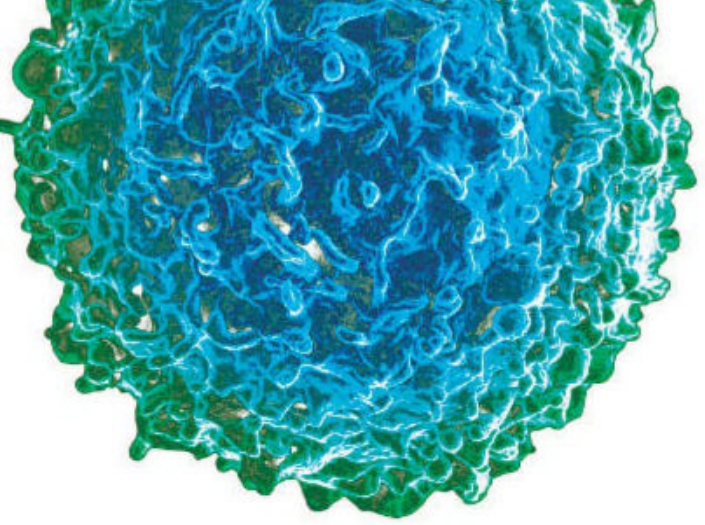
Your immune system is intricate, to say the least. Your body's familiar responses to a cut or an infection – redness, inflammation – belie a rich choreography beneath the skin, where swarms of cells move in to fight off germs, repair the damage and deal with the debris. Even for experts, the details are overwhelming. There is an incredible diversity of components to comprehend, all in delicate interplay with one another. Antibodies are just one element, but they are especially important.

We have been working to understand them for almost 140 years – a quest that could be said to have begun on the evening of 24 March 1882. That night, physician Robert Koch addressed the Physiological Society of Berlin to claim that tuberculosis, then considered an inherited illness, was caused by a minuscule bacterium. Another physician, Paul Ehrlich, rushed back to his lab and stained samples from tuberculosis patients. Early the following morning, under the microscope, he could immediately see clumps of bacteria, probably those that cause tuberculosis.

Ehrlich, Koch and others later found that some types of bacteria produce harmful toxins. Ehrlich then noticed something intriguing: if he increased the dose of a toxin in mice slowly, over many days, the mice could survive a level that would normally kill them. Whatever it was that the mice developed to bestow this resilience, Ehrlich named an antibody.

Today, we understand much more about what they are and how they work. For starters, we know that antibodies are made by specialist cells called B-cells in humans and other animals. We also know that every B-cell produces an antibody with a particular shape at the double-pronged end of the Y, called the variable region. This is the part of the antibody that sticks to its target, whether that is a toxin or a protein on the surface of a pathogen, known as an antigen.

In fact, the way that antibodies are made is a marvel in itself. As each B-cell is created in our bone marrow, the genes that code for antibodies are shuffled around so that the cell produces a specific antibody – one of billions made in the body overall. Every B-cell is then tested in the bone marrow to see if the antibody it produces would stick to anything naturally occurring in the body. If it does, that B-cell is killed off. That way, the only B-cells released into the body are those that make antibodies targeting things not normally found there, such as dangerous germs, rather than attacking the body's own healthy cells. The billions of B-cells in you produce so many different antibodies that, in principle ›



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"The trick is to very deliberately bring together immune cells and cancer cells"

at least, there is at least one that latches on to any given invader.

The strategy isn't always completely effective. Some viruses, like HIV, evolve rapidly such that proteins on their surface can change shape. This variation in the virus, even within a single infected person, makes it a hard target for antibodies. Another thing to bear in mind is that it takes some time for the body to produce extra antibodies against a threat. A B-cell that happens to make the right antibody has to multiply in number so that its antibody is available in bulk, and that doesn't always occur quickly enough.

Creative surge

On the bright side, we don't have to rely entirely on our body's natural production of antibodies. For a while now, we have been able to harvest the B-cells of animals immunised with whatever pathogen we want to target, replicate them in bioreactors and mass-produce antibodies by design. It is no exaggeration to say that monoclonal antibodies – antibodies made from a population of cloned B-cells – have become an essential part of modern medicine. They serve as treatments for any number of illnesses from psoriasis, arthritis, Crohn's disease and multiple sclerosis to cancer. In 2019, seven of the world's 10 best-selling drugs were antibodies.

But we can do better still. These days, it is possible to transform the basic structure of antibodies like never before. The truth is that we have been able to manipulate their structure for some years now – through genetic engineering or by separating and recombining parts of the protein. Even so, the tools have now reached a level of sophistication that has encouraged a surge of creativity.

One of the most promising strategies is to redesign antibodies so that they recognise and bind to three different molecular targets, known as antigens. This could be particularly useful when it comes to treating cancer by boosting our natural immune defences, known as immunotherapy.

Cancer immunotherapies are already in vogue. The 2018 Nobel prize for medicine was awarded for the development of antibodies called checkpoint inhibitors. These work by blocking proteins that act as brakes on immune activity: if someone's cancer has managed to switch off an immune attack, checkpoint inhibitors can turn it back on.

This is great when it works well, but it doesn't always. There can be side effects, sometimes serious, and boosting an immune response is unlikely to help if a person's immune cells haven't detected their cancer in the first place. The problem is that cancer is rarely caused by a pathogen, but instead by an abnormal expansion of a person's own cells, which means there is nothing as obvious as a molecule from a virus, bacteria or fungus for the immune system to react against.

One way to overcome that problem is to find a way to bring together immune cells and cancer cells, which is where trispecific antibodies come in. In 2019, a team led by Eric Vivier, an immunologist at Aix-Marseille University and chief scientific officer at Innate Pharma, both in France, reported the development of an engineered antibody that simultaneously binds to three separate targets: two receptors on immune cells called natural killer cells and an antigen on cancer cells. The idea is that this new molecule brings the body's natural killer cells into contact with cancer cells and delivers a strong signal to attack.

Vivier and his colleagues made their trispecific antibodies by taking a fragment of one antibody that targets an immune cell receptor and stitching it together with another targeting a cancer antigen. They then used genetic engineering to ensure the stalk of the Y-shape is functional so that it targets a second immune cell receptor. This new antibody was then put to the test in mice with a B-cell lymphoma. It worked impressively well: doing better at inducing tumour cell killing than other treatments it was compared against. The potential for side effects was assessed by measuring the level of certain proteins known to cause problems in immunotherapies, and this seemed to be less with the new antibody. Further trials are under way.

Many other trispecific antibodies are in development. For example, another one targets a cancer cell, a receptor that activates immune cells called killer T-cells and a second receptor on killer T-cells that promotes long-lasting activity. By starting, rather than boosting, an immune attack against a person's cancer, it is hoped that these trispecific antibodies could help those who haven't responded to other immune therapies.

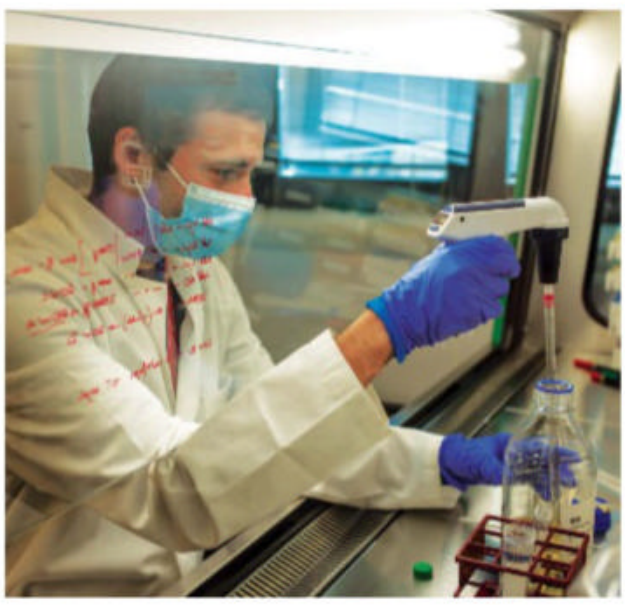
We must always be careful not to hype things while clinical trial results aren't yet in hand. Even so, it is possible that these molecules could take immunotherapy to a new level, making it available to people whose immune systems haven't mounted any kind of attack on their cancer.

It could work for viruses, too. French pharmaceutical company Sanofi has developed an antibody that locks on to three different parts of a protein on the outside coating of HIV. The thinking is that it would be harder for variants of the virus to evade being targeted by something that binds to three things at once. Results are striking. In a lab dish, one trispecific antibody could already neutralise 204 of 208 different versions of HIV.

Another approach to designer antibodies could let us infiltrate cells, by shrinking things down. This tactic was originally inspired by an unusual muse: the llama. Antibodies made by humans and most other mammals are quite large, as proteins go, which means they can't easily access the inside of tumours or get inside cells. The antibodies made by llamas, camels and sharks are much smaller, so many researchers have turned to them for a blueprint to engineer so-called nanobodies.

The way they are produced is complicated and varied. One technique is to use what is

A researcher in Italy developing antibodies to target the coronavirus



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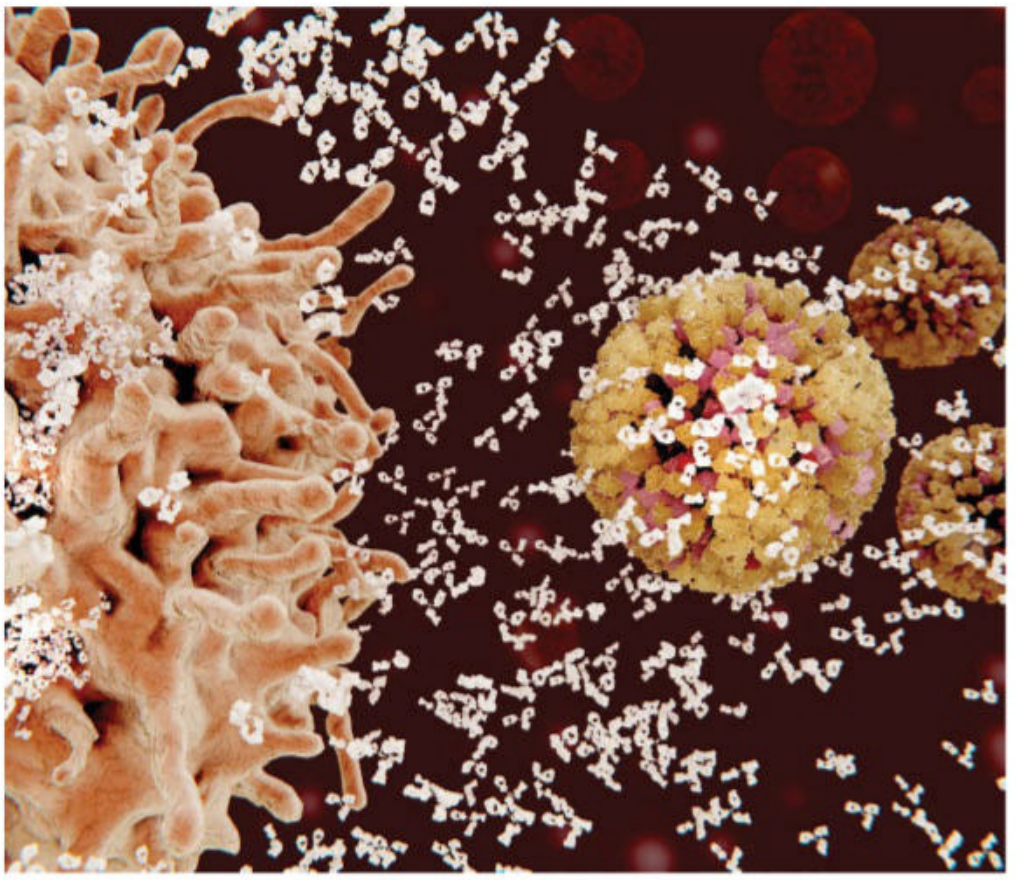

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A simulation of a B-cell (left) secreting antibodies against the influenza virus

known as a phage display library. For this, a large selection of different nanobodies are genetically encoded within bacteriophages, types of virus that infect bacteria. The phages are added to the wells of a plastic dish coated with the target pathogen protein. Those that don't stick are washed off – only the remaining phages must be producing a nanobody of the right type to attach. Finally, the nanobody-encoding genes inside the leftover phages are isolated and used to scale-up production of a desired nanobody.

One synthetic nanobody called caplacizumab has already been approved for treating a rare blood disorder called acquired TTP, in which blood platelets form small clots where they shouldn't. Elsewhere, nanobodies have been produced to target snake venom toxin, parasitic worms or the spike protein of SARS-CoV-2, the virus that causes covid-19. They have been designed to enter cells and stabilise the proteins that would otherwise be destroyed in cystic fibrosis. On account of their ability to penetrate deep into a tumour, nanobodies are also being developed as diagnostic tools that could help doctors determine the best treatment for a person's specific situation. Most of this work remains experimental, but there is clearly a groundswell of activity around these smaller antibodies.

In the meantime, there is fresh inspiration for antibody engineers. Just last month, a team largely at the Duke Human Vaccine Institute in North Carolina announced the discovery of a new class of antibody produced by humans and macaque monkeys. The researchers were studying the immune response to HIV when they stumbled upon antibodies that are I-shaped rather than being the typical Y-shape. In fact, one antibody with this shape was isolated back in 1996. Now it is clear that this observation wasn't just some unusual one-off. The Duke researchers and their collaborators have found that I-shaped antibodies could target the densely packed sugar molecules that cloak HIV, something that the immune system generally struggles with. Other I-shaped antibodies were found to target a pathogenic yeast called *Candida albicans*, as well as SARS-CoV-2.

"These molecules could take cancer immunotherapy to a new level, and could work for HIV too"

The discovery came as a big surprise to most of us, and it shows just how much we still have to understand about antibodies – never mind the wider immune system. Now we have new questions to explore. Exactly how are these differently shaped antibodies produced in the body? And how can we harness their properties for medical purposes?

Speaking of how antibodies are produced, some people are beginning to explore a different approach. The idea, and it is just an idea at this stage, is that B-cells could be harvested from a person, engineered using CRISPR gene-editing technology to express a particular antibody, and then infused back into the bloodstream. Feasibly, this could give someone the ability to make an antibody against any specific pathogen – and it could do away with the need for multiple doses of antibody-based medicines. Maybe a library of B-cells could be infused with the capacity to produce a suite of bespoke antibodies to target different versions of any given virus.

Even if this sort of thing can be made to work, it is almost certainly going to be costly, which brings me to another point. Engineered antibodies are inherently difficult to manufacture, so they are all going to be expensive. What's more, for antibodies, it is much harder to invoke the argument used for widespread vaccine deployment: that by saving ourselves, we are also saving others. Antibodies save lives by treating cancer or autoimmune diseases, but they can't protect the whole of humanity in the same way a vaccine can. So another problem arises: how do we make sure the treatments we are trying to develop don't become a new source of division in the world?

This is something many of us in the field worry about. We need a strong framework f or fair and equitable access to all medicines across the globe, not only covid-19 vaccines. But that's not to say we shouldn't celebrate the scientific unravelling of the human body's secrets and push forward with using our knowledge to create advanced new medicines – not least designer antibodies. For me, and I suspect for many others, we gain something else from fathoming the minutiae of what goes on inside our bodies. We understand ourselves that little bit better. ▮

Daniel M. Davis is an immunologist at the University of Manchester, UK. His new book is *The Secret Body: How the new science of the human body is changing the way we live*

Is the Higgs boson hiding something?

Almost a decade after its discovery, the famous particle has revealed nothing we didn't expect. Now physicists are demanding a tougher interrogation, finds **Thomas Lewton**

FOR half a century, finding the Higgs boson was top of particle physicists' to-do lists. Its eventual discovery in 2012 was celebrated as the final piece of the puzzle to complete the "standard model", our picture of reality at its most fundamental level. The Higgs became famous, a rare household name among elementary particles.

But now, almost a decade on, we still barely know the Higgs boson – and our understanding of the pantheon of particles and forces that makes the universe what it is remains manifestly imperfect. We were hoping that, alongside the Higgs, new particles and forces would reveal unexpected exotic phenomena and bring into focus an even bigger picture. Alas, the Higgs is behaving exactly as expected, undermining a notion that its unseen interactions would help us uncover new physics.

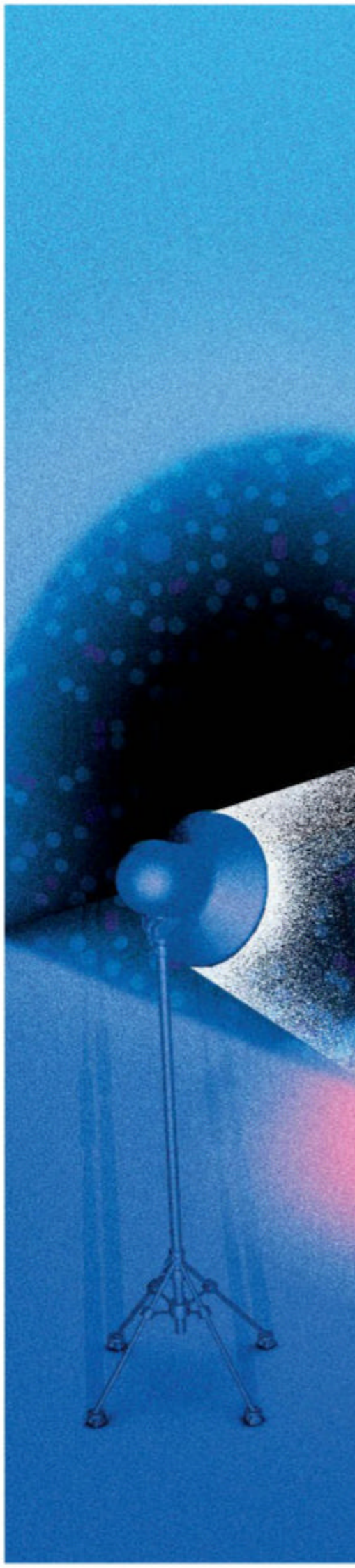
Is the Higgs as boring as it seems? Possibly not. Closer inspection could expose its true self, and the shadows of strange siblings or exotic "pink elephant" particles, any of which would shake up our understanding of the universe. We need to "get the Higgs on the table, dissect it, prod it, see where it starts to disagree", says Ben Allanach, a particle physicist at the University of Cambridge.

With that in mind, many in the field are now pushing for a new particle collider to churn out Higgs bosons in industrial quantities, so we can interrogate it like never before. But will such a Higgs factory open doors to new physics? Or is the Higgs as mundane as it seems, which might itself tell us something about our ability to understand the universe?

The standard model of particle physics is our best description of all the known particles in the universe and the ways they interact, and it is impressively accurate. Since its formulation in the 1970s, it has been a guiding light for particle physicists. Faith in the notion that there must be elegant mathematical rules governing particles and forces drove the construction of more powerful and more precise particle accelerators, each designed to find particles predicted by the standard model. Time and again, we found them.

In its most simplified form, the standard model comprises an equation with four terms. The first describes three of the known forces in the universe: electromagnetism, and the strong and weak nuclear forces. The second sketches out the elementary particles and how the forces act on them. The two final terms are only just being written now. They largely tell the story of the Higgs – the particle thought to hold the clues to a better understanding of what the standard model is missing.

Peter Higgs and others proposed the Higgs boson's existence in 1964 to help explain why fundamental particles have such a range of masses, from zero to quite large. The idea is that all of them are submerged in an invisible "Higgs field", which drags on them to different degrees. This mechanism almost immediately acquired added significance when physicists realised that, at high energies,



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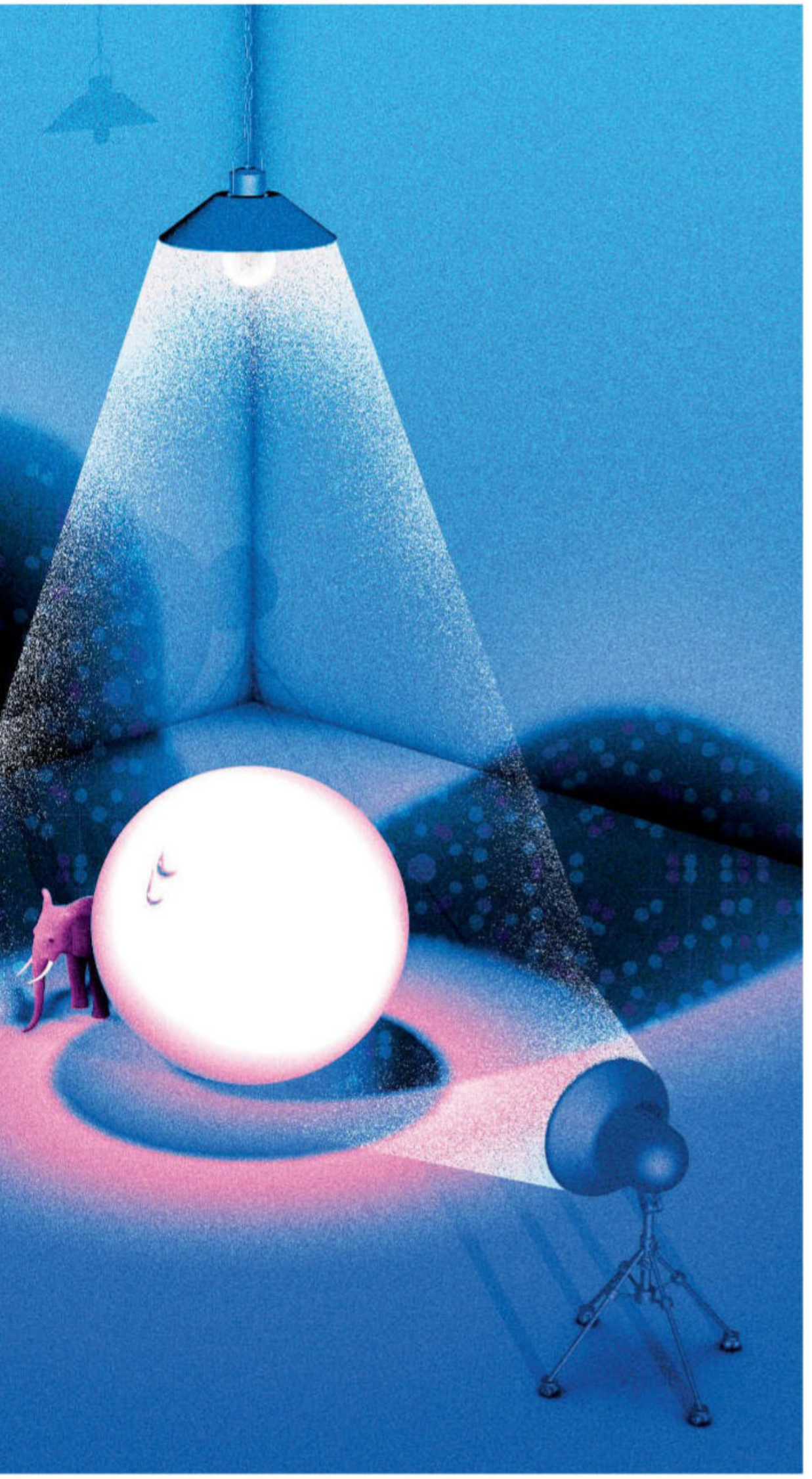

electromagnetism and the weak nuclear force were merged in one unified "electroweak" force. Particles of light, or photons, which carry the electromagnetic force, are massless, whereas the force carriers of the weak nuclear force, the W and Z bosons, aren't. The Higgs mechanism explained this asymmetry.

Hence the relief when the Higgs, the last missing particle of the standard model, was finally confirmed in particle collisions at CERN's Large Hadron Collider near Geneva, Switzerland, in 2012. "Physicists Find Elusive Particle Seen as Key to Universe," declared the front page of *The New York Times*.

The bigger picture

Even then, however, particle physicists knew that this couldn't be everything. The standard model can't account for why there is so much more matter than antimatter in the universe. It doesn't make room for dark matter, the mysterious stuff that keeps galaxies from flying apart. And it doesn't describe gravity.

Unifying the quantum world of particle physics with gravity, which is governed by the laws of general relativity, is the next leap towards a full picture of reality. But gravity is bafflingly weaker than all the other forces and doesn't gel easily with the standard model. In particular, hypothesised particles of quantum gravity aggravate an existing problem: that the Higgs' interaction with "virtual" particles popping into and out of existence in the field around it should make its own mass far heavier than its measured value. Explaining why the Higgs is so light without awkwardly rigging the equations has stumped theorists.

More broadly, the Higgs is connected to many of the most troublesome aspects of the standard model. It is the linchpin for what seems to be a ramshackle arrangement of particle masses, varying according to how strongly the Higgs couples to them. Electrons, for instance, are far lighter than their sister particles called muons, which are far lighter than their siblings called tau particles, and no one knows why. "It's so chaotic," says Beate Heinemann at the University of Freiburg in Germany. "The standard model has all these numbers in it that we don't understand. There are no laws for them. It's like the Wild West".

Physicists hate putting numbers into theories by hand, as opposed to those numbers emerging naturally from a theory. "Fine-tuned" and "ad hoc" are insults in a field that seeks to discover the most basic order of reality. "It's like gravity would act differently on apples, on humans and on planets," says ›

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Heinemann. "It's just so unsatisfactory. What is the origin of these numbers?"

The only difference between electrons, muons and taus in the standard model is the way they interact with the Higgs. The mysterious origin of particle masses suggests that some deeper structure exists, which studying the Higgs in detail may reveal. The idea is that by precisely measuring these interactions, we will see inconsistencies that the standard model can't explain, offering clues towards a new, further-reaching theory.

We have already eavesdropped on some of these interactions. In 2018, the LHC revealed particle processes in which the Higgs is produced along with a top quark and its antimatter equivalent, a top antiquark. The top quark is the most massive fundamental particle, heavier than even the Higgs, which means any deviations from the standard model should show up most prominently here. "It's a great way to hit the Higgs hard and see if it does what we expect," says Freya Blekman at the Free University of Brussels in Belgium. Unfortunately, the top quark measurements revealed nothing untoward. The same was true last year, when we caught a glimpse of the Higgs decaying into lower-mass muons for the first time.

So far, the Higgs boson has shown itself to be resolutely vanilla. That is deeply frustrating. And yet the measurements at the LHC leave plenty of wiggle room to think that the Higgs is hiding something beneath its boring facade. Indeed, there is no shortage of ideas about what the Higgs really is and what it really does. "There are all kinds of tweaks and bells and whistles you can put on it," says Jon Butterworth at University College London.

Particles we have previously considered to be fundamental and unsplittable have peeled open like the layers of an onion. Atoms broke apart into protons, neutrons and electrons. Then protons and neutrons broke open to reveal quarks.

The same could be true of the Higgs, with smaller constituents hidden inside it. For example, "twin Higgs" or "little Higgs" models add intricate new symmetries into the standard model as imaginative solutions to the problem of why the Higgs has such a strangely small mass. By looking for slight deviations in how the Higgs is expected to decay into other particles, we may find that another, more complex Higgs lies at the core of reality.

Hidden in the Higgs' interactions is also the prospect of new particles. The Higgs is the only elementary particle whose quantum-mechanical "spin" is zero. This makes it uniquely promiscuous. If you flip most elementary particles on their head, they will behave differently because of their spin, but a spinless particle is the same no matter how you twist and turn it. This means the Higgs connects very easily to other particles, including those waiting to be discovered.

Pink elephants

If you measure how the Higgs decays into all known particles, but find that some energy has gone missing, it would suggest the existence of novel particles that current detectors aren't able to see. As many as one in four Higgs bosons could decay into such "pink elephants", as Heinemann calls them. Any such elephants would be prime candidates for dark matter.

At high enough energies, theories predict the Higgs boson can even decay into itself. Not only is this a previously unknown type of interaction, but how the Higgs does this determines our cosmic story. This "self-coupling" tells us about how the Higgs field came into being shortly after the big bang. Aside from giving mass to particles – and so enabling planets, stars and galaxies to form – knowing how this shift happened could tell us why there is so much more matter than antimatter in the universe.

The trouble is that, so far, measurements from the LHC have been unable to rule out or pinpoint these various possibilities for what the Higgs is really up to. The LHC does "dirty physics", says Allanach, smashing together protons in high-energy, messy collisions to explore what's out there. Amid this chaos, it is hard to get a handle on the finer details of the Higgs. Most of the Higgs' couplings to other particles have so far only been measured to about 10 or 20 per cent precision, depending on the particle. "It's very easy to say something agrees with the data when the uncertainties are large," says Blekman.

All of which explains why Blekman and others are now lobbying for a new particle collider that would produce Higgs bosons in their droves. It would produce millions of the particles without much "noise" to obscure our view of what they get up to, allowing us to measure their couplings to other particles much more precisely. Moreover, an upgraded

Part of the ATLAS detector at the Large Hadron Collider

Higgs factory that bashes together heavier, and so more energetic, protons instead of electrons would allow us to measure the Higgs self-coupling..

Last June, CERN's 23 member states agreed that their "highest priority" was to pursue the construction of a Higgs factory that collides electrons and positrons, the electron's antiparticle. "Everybody agrees that we need something that makes a lot of Higgs bosons," says Blekman.

Yet for all the confidence that a Higgs factory is the right way to expose the particle's secrets, some physicists acknowledge the prospect that the Higgs may not be keeping anything from us after all – so a factory might find nothing. "It would be equally amazing, although difficult to deal with," says Butterworth.

Until recently, the standard model was the blueprint giving us assurance that there was something out there to discover. Now, with that puzzle complete and few clues as to what comes next, we have been left scrambling in the dark.

Finding the Higgs boson and nothing else at the LHC was dubbed the "nightmare scenario" by theorists at CERN. Many physicists thought they would also see "superpartner" particles predicted by supersymmetry theory, which aims to fill gaps in the standard model. By adding new particles to the mix, theorists could explain the puzzlingly light mass of the Higgs boson. While interactions with already known particles drag the mass of the Higgs upwards, these superpartners drag it back down to the value measured by the LHC. Not only did supersymmetry offer an elegant way to unify the four forces of nature, but its superpartners also gave an identity to dark matter.

With no hints of other particles at the LHC, the most plausible supersymmetry theories have crumbled. The only way to resolve the small measured Higgs mass is to plug in by hand a starting value for the "bare mass" Higgs, meaning the mass before you take into account all the interactions with virtual particles around it, that just so happens to cancel out those interactions. "It's too suspiciously fine-tuned to be a coincidence," says Butterworth.

"There is plenty of wiggle room to think the Higgs has a few secrets"

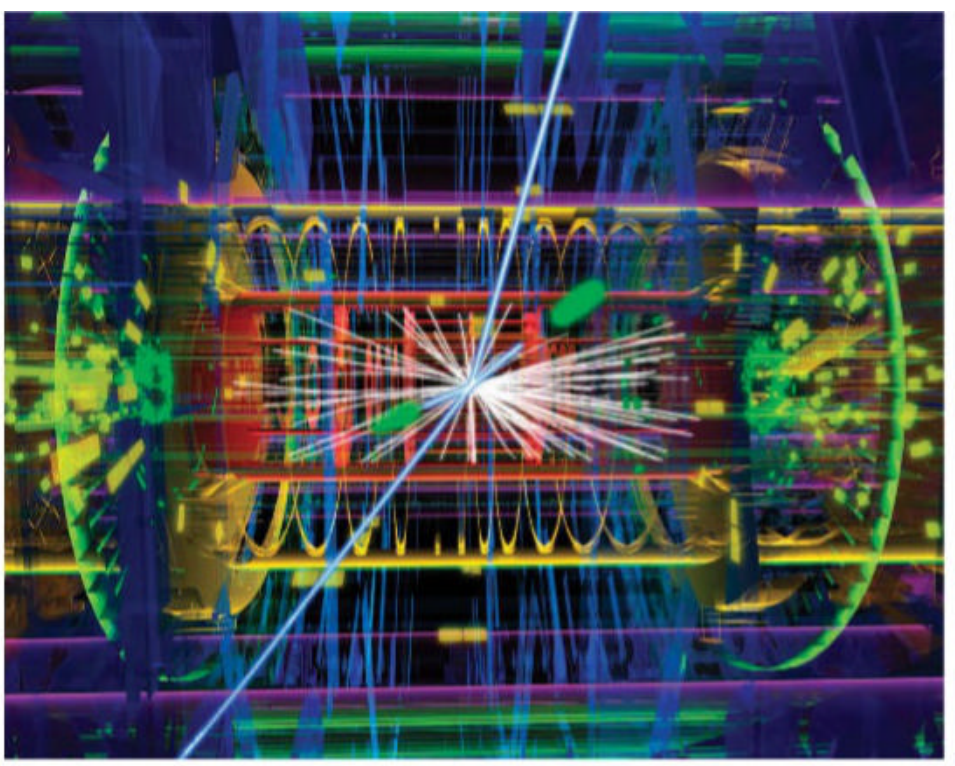
Supersymmetry is rooted in an idea called "naturalness", in which the laws governing the universe are elegant and explicable, as opposed to makeshift and arbitrary. Throughout history, when numbers have popped up that seemed fine-tuned, physicists have suspected that something was missing from their theory – and usually they were right. That's why the continued absence of new particles at the LHC is a "sobering moment", says Nathaniel Craig at the University of California, Santa Barbara. "There is now a great reluctance to use aesthetic criteria," he says.

With naturalness under question, it is hard to know whether new particles beyond the standard model exist at energies that particle colliders could ever reach. "One of the things we've learnt is that the standard model could be valid all the way up to very high energy scales," says Keith Ellis, a theorist at Durham University, UK. "It's a depressing prospect." Ultimately, nature may not be as elegant as physicists hope, and some parts may be unknowable – no matter how powerful or precise your particle collider.

Allanach remains hopeful. He has shifted his approach from top-down theories that begin with grand aesthetic principles to what he calls "bottom-up" thinking. It starts from small cracks in the standard model – such as particles that decay too quickly or are more magnetic than you might expect – and builds theories piece by piece. If adding a new particle explains the data better, then it is worth considering, regardless of how aesthetically appealing it is.

A Higgs factory will allow us to examine these small cracks, says Allanach. While not as exciting as discovering new particles, measuring the Higgs precisely is "not to be sniffed at", he says. It offers a bedrock of vital data for new ideas to leap from.

"In my heart, I feel there will be a paradigm like the standard model which will come out of everything, and we will be able to understand it. Of course I do," says Allanach. "But we need a change of approach. I do worry that we've got too locked into doing what the theorists tell us and lost sight of the fact that we're actually exploring unknown territory." ▮



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Generating the Higgs boson in "cleaner" particle collisions could reveal new physics

Thomas Lewton is a writer and film-maker in London

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You will have responsibility for appropriate reporting to the Forensic Services Committee (FSC) and engagement with its members, who are all members of the SPA Board and will represent Forensic Services in Scotland across strategic platforms in the UK and Internationally.

You will lead day-to-day operational activity in line with the organisation's objectives and business plan and always aligned with the Forensic Services' values of Integrity, Professionalism, and Impartiality and be the Senior Responsible Officer for the delivery of the organisation's strategic outcomes managing a revenue budget of circa £30m and to lead on a capital investment and replacement programme.

You will be required to ensure appropriate relationships and engagement with Forensics Services' key partners and stakeholders – as well as Forensic Science bodies and academia, this will include the Scottish Government, Scottish Parliament and its Committees, and other justice and public and private sector organisations.

For more information and to apply please visit **www.spa.police.uk/work-with-us**

Closing date 7th July 2021

New Scientist Discovery Tours

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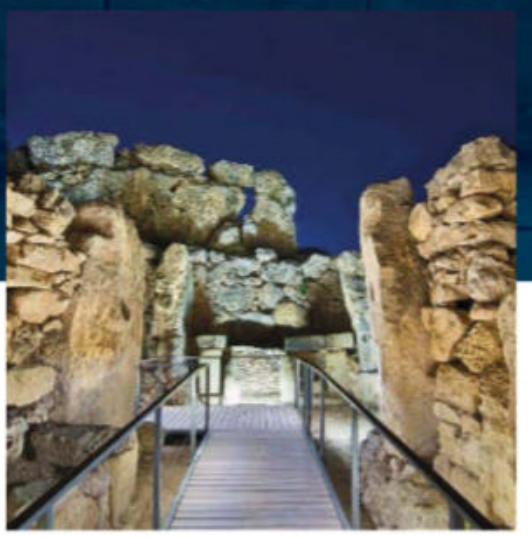
Megalithic Malta: Temples, fortifications and archaeology



Malta and Gozo are small islands that conceal a long and fascinating history including several exceptional archaeological sites. From the ancient and mysterious temples believed to be some of the world's oldest structures, to the fortifications of the Knights of St John which withstood unprecedented bombardment in WWII. Visiting three UNESCO World Heritage Sites, you will discover 7000 years of history including unexplained carved-stone landscapes, and prehistoric death cults, as well as beautiful coastlines, attractive fishing villages and fine Baroque architecture.

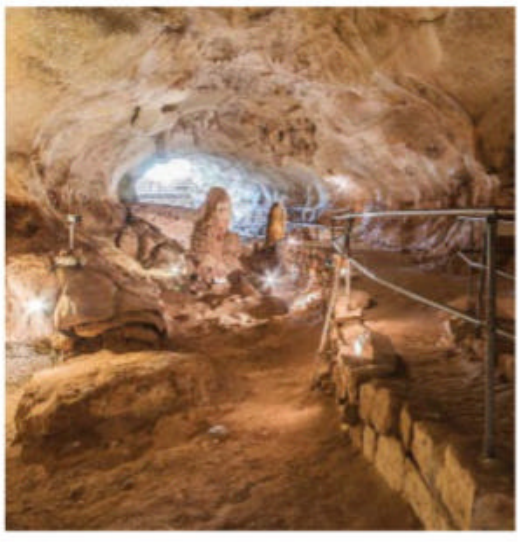
The tour will feature talks and walking seminars from *New Scientist* editor Alison George and will be led by award-winning journalist Juliet Rix.

Highlights

- Explore the temples of Tarxien, Hagar Qim and Mnajdra which enable you to trace the development of temple building on Malta from around 3600BC.
- Marvel at Valletta which has recently undergone a series of major restorations including the impressive ramparts and Renzo Piano's new Parliament building.
- Visit St. John's Co-Cathedral with Caravaggio's masterpiece 'The Beheading of St. John', the Grand Master's Palace and the beautiful jewel-like Teatru Manoel, one of the best surviving Baroque theatres in Europe.
- Tour the Auberge de Provence, the Baroque residence of the Knights of Malta from the Provence region of France. This now houses the Archaeological Museum, including some of the most exquisite finds from Malta & Gozo's prehistoric sites dating back up to 5,000 years.
- Marvel at the prehistoric temples at Ggantija, a UNESCO World Heritage Site, 1000 years older than the Egyptian pyramids and the second oldest stone structure in the world.
- Visit the picturesque fishing village of Marsaxlokk, before visiting the fascinating cave Għar Dalam, where finds include remains of long-extinct species dating back 10,000 years.
- Sail across the narrow strait to Gozo, a verdant island of fertile farmland, picturesque villages and monumental Baroque churches.
- Enjoy a relaxing harbour cruise onboard a traditional Maltese 'Luzzu' from the Grand Harbour, allowing you to fully appreciate the remarkable fortifications of Valletta.
- Take part in a walking tour of Malta's first capital Mdina (The Silent City). A fortified city of just 300 inhabitants. Best known today for its starring-role in the 'Game of Thrones' TV series – with its mix of Norman and Baroque architecture including palaces and a cathedral.

Covid-19 safety protocol includes:

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



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For more information visit newscientist.com/tours

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The science of cooking

Fire up that barbecue!

Enjoy grilling your food outdoors? From charcoal to gas, start by understanding your fuel, says **Sam Wong**

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

What you need

A barbecue
Charcoal (or gas)
A chimney starter (optional)
Newspaper to ignite charcoal
Matches
Tongs
Food for barbecuing
Warm weather

The science of cooking appears every four weeks

Next week

Stargazing at home

COOKING outside can be one of the joys of summer, but, like conducting an experiment outside the lab, it is harder to control all the variables – even if the weather is on your side.

A key question is which fuel to use. Charcoal is made by slowly burning wood in low-oxygen conditions. This drives off most of the water and other volatile compounds until the remainder – about 25 per cent of the original weight – is almost pure carbon, although some unburnt wood may remain in larger pieces of lumpwood charcoal.

You can also use charcoal briquettes. These are made from sawdust and wood scraps that are burned in the same way as when making charcoal, then crushed and mixed with additives to bind the contents, help with ignition or promote steady burning, before being moulded into uniform shapes. Because these shapes are uniform, they usually hold their heat longer than lumpwood charcoal.

For both fuels, the quickest, easiest way to light them is to use a chimney starter, a metal tube with two cavities. You put paper in the bottom one and charcoal in the top, then light the paper. The burning paper sucks in oxygen and ignites the coals, creating an updraft that allows heat to build quickly, so the coals are ready for cooking in about 15 minutes.

Charcoal burns hotter than wood and produces very little smoke. This means that it contributes very little flavour to whatever is cooked on it.

MATHIAS GENTERCZEWSKY/EYEEM/GETTY IMAGES

The smoky taste we associate with barbecues mostly comes from fat and juices that drip from the food onto the hot coals. These drips ignite and produce smoke containing flavourful aromatic compounds that are deposited on the food's surface. Some cooks like to add wood chips on top of the coals to add extra smoky aromas.

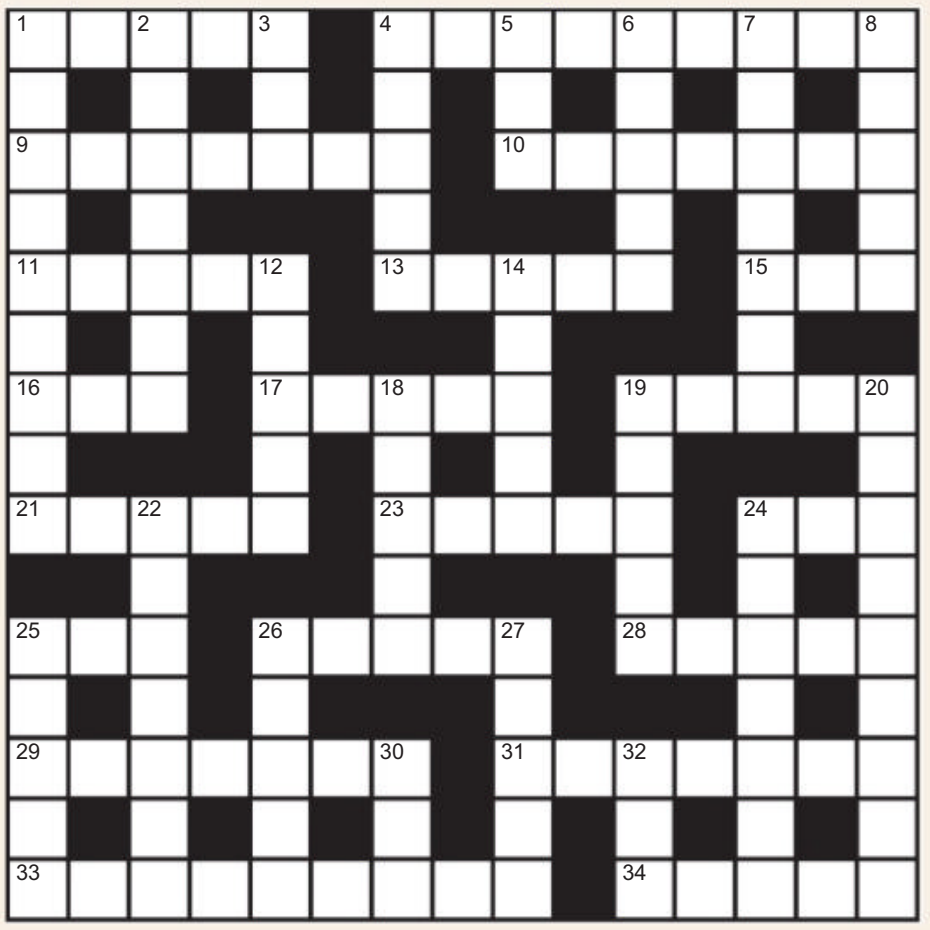
Since charcoal isn't a significant source of flavour, you might prefer the convenience of a gas barbecue, which is quick to light and easier to control. Gas is also much more efficient to produce and cook with: the carbon footprint of gas grilling is estimated to be about a third that of charcoal – though it comes from a non-renewable source.

The other factor that makes barbecued food taste different to food cooked in your kitchen is heat. Glowing coals exceed 1000°C and give off considerable infrared radiation. This searing heat drives the Maillard reaction, which transforms sugars and amino acids into hundreds of delicious flavour compounds. But it can also result in food that is charred on the outside and cold in the middle.

The best way to avoid the latter is to pile coals on one side of the grill. You can then move food from the hot area to a cooler part if the outside is charring too quickly. I would also recommend buying a cooking thermometer, which makes it easy to tell when meat is done all the way through. ▮

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

Quick crossword #86 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

1 Added up (2,3)
4 Sedimentary rock (9)
9 Inflammation of part of the gut (7)
10 Ivy League university in New York state (7)
11 Paul ___, Bristol-born theoretical physicist and Nobel laureate (5)
13 Mountain ash (5)
15 East London metro system (in short) (3)
16 UK health provision network (initially) (3)
17 2:1, for example (5)
19 Describing a cube, or its dimensions (5)
21 ___ alcohol, C_2H_6O (5)
23 ∑ (5)
24 Photomultiplier tube (initialism) (3)
25 Segment of a curve (3)
26 Marie ___, Poland-born double Nobel laureate (5)
28 Trial; aviator (5)
29 Large floe (7)
31 Anticoagulant (7)
33 Large fuel container (9)
34 Nikola __, Serbian-American inventor (5)

DOWN

1 Occurrence (9)
2 1961 sci-fi novel by Stanisław Lem (7)
3 New England research university (in short) (3)
4 Light amplification by stimulated emission of radiation (acronym) (5)
5 Apple computer (shortened) (3)
6 Klaxon (5)
7 Add layers of sound to audio recording (7)
8 Leonhard ___, 18th-century Swiss polymath (5)
12 Colony of marine polyps (5)
14 Incorrect (5)
18 Electroshock weapon (5)
19 Muscle spasm (5)
20 Neuropsychiatric syndrome (9)
22 1995 techno-thriller (7)
24 North Star (7)
25 Growing older – US spelling (5)
26 Semi-solid emulsion (5)
27 $(C_2H_5)_2O$ (5)
30 Part of the digestive system (3)
32 Mine (3)

Quick quiz #108

1 In what year will Pluto complete its first full orbit of the sun since its discovery in 1930?

2 *Megatherium* is an extinct genus of which animal?

3 The secretion of droplets of watery fluid from the pores of plants is known as what?

4 Where in the body are Purkinje cells found?

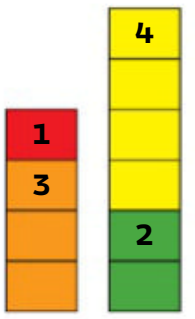
5 How many UNESCO World Heritage Sites are there?

Answers on page 55

Puzzle

set by Mehmet Ismail

#120 More Catch up



You may remember "Catch up" (9 January), played with a set of toy brick stacks. In "Catch up 4", the stacks are 1, 2, 3, and 4 bricks high. Players Ann and Bob begin with no stacks. Ann starts by choosing a stack, which becomes her tower. Then Bob, picks a stack or stacks and adds them to his tower until it is equal to or taller than Ann's, at which point the turn switches. Players take turns until there are no stacks left. The figure illustrates a game in which Ann started by choosing stack 3. Then Bob chose stack 2 followed by stack 4. Because Bob's tower was now taller than Ann's, his turn ended. Ann got to add stack 1 to her tower, but still lost. Bob won with a tower of height 6.

Ann and Bob have just started a game of "Catch up 9" – same rules, but nine stacks. We join the game at 3-3 (Ann picked 3, Bob picked 2 then 1). The remaining stacks are of height 4, 5, 6, 7, 8 and 9. Ann then puts the 5 on her tower, which now has a height of 8. Can she guarantee a win from here?

Solution next week

Expansive objects

Physics tells us the universe is expanding in all directions. Does this include atoms and objects, such as me?

Terry Tucker
Andover, Hampshire, UK
The expansion of the universe is so tiny that it can only be noticed over vast timescales or huge distances, or some combination of both.

The expansion rate is approximately 70 kilometres per second per megaparsec (a parsec is a unit used to measure large distances between astronomical objects). This means that a ruler that is 1 metre long might be expected to expand by about 2×10^{-18} metres every second.

Over one year, a region of space 1 metre across would expand by about the diameter of an atom, pretty much immeasurable from a human perspective.

The atoms in a human won't expand in their lifetime, nor will their remaining atoms aeons after.

"The expansion of the universe is so tiny that it can only be noticed over vast timescales or huge distances, or a combination of both"

Herman D'Hondt
Sydney, Australia
At present, the expansion of the universe is only visible on the grandest scale. There are three forces that keep this expansion under control: gravity, the electromagnetic force and the strong nuclear force.

Gravity keeps planets in their orbits, stars circling around the centres of galaxies and galaxies bound within clusters. The electromagnetic and strong nuclear forces are what bind you and me and other objects together.

While gravity keeps me sitting on my chair, the electromagnetic force controls the atoms and molecules of my body and of the chair, so we don't collapse in a heap. Finally, the strong nuclear force is what keeps the nuclei of atoms together.

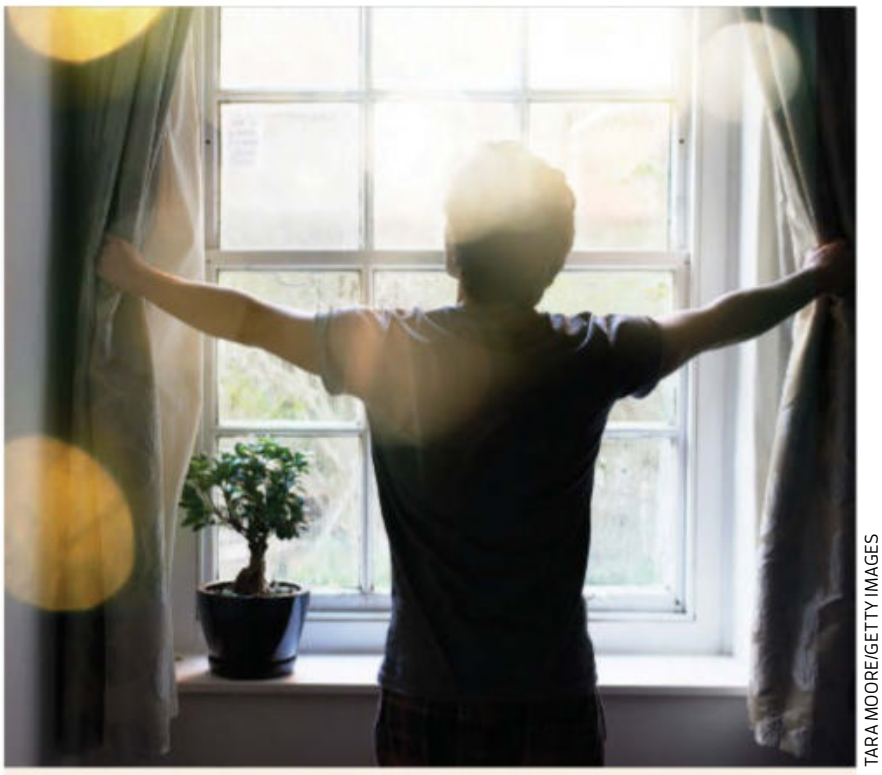
These forces are the reason why objects behave as they do at present, but things may be different in the distant future.

It is now generally accepted that the expansion of the universe began accelerating about 4 billion years ago. The cause of this acceleration is dark energy. Scientists have no idea what dark energy is, and hence cannot predict what will happen to it in billions of years, though there are several possibilities.

One is that dark energy will increase, causing the expansion to speed up further. If that happens, it is possible that dark energy will eventually become so powerful that it overcomes all attractive forces. Over billions or trillions of years, galactic clusters will evaporate, then galaxies themselves will break up. Later still, stars won't be able to hang on to their planets.

If dark energy continues to grow, it will eventually overpower the electromagnetic and strong nuclear forces, and all matter will cease to exist, in a scenario known as the big rip. It is also possible that dark energy will reverse, and start acting against the expansion. If so, the universe may eventually collapse into what is called the big crunch.

Eric Kvaalen
Les Essarts-le-Roi, France
When Edwin Hubble made his estimation of what we call the Hubble constant, which describes the rate at which the universe's expansion accelerates, he needed to take measurements from galaxies as far as the Virgo Cluster, about 50 million light years away. So no, the expansion of the universe doesn't include atoms or objects such as you.



TARA MOORE/GETTY IMAGES

This week's new questions

Bright and early **I am an early riser and am convinced that the day often starts off bright and clear, and gets cloudy by the time most people get up, in the south-east of the UK at least. Is that true, and if so why?** ***Richard Webb****, London, UK*

Travelling light **If the speed of light changed, how would it affect our lives?** ***Martin Van Staeyen****, St Ives, Cornwall, UK*

Is it really brighter and less cloudy in the early morning?

Antarctic bears

The Arctic ice is disappearing, so could polar bears be established in Antarctica to save the species?

Chris Daniels
Glan Conwy, Conwy, UK
Polar bears could be transported to the Antarctic, but they would almost certainly destroy the wildlife that is currently there and then die out themselves.

In the Antarctic, penguins breed in large numbers and have no land-based predators. If the penguins weren't at sea, polar bears would find an all-you-can-eat buffet that they would enjoy until it was wiped out.

The bears would then have to turn to the seals, which, unlike the ones in the Arctic, also have no predators on the ice and would be easy pickings for polar bears until they too were all gone. This would in turn spell doom for the bears.

It would be preferable for efforts to be put into saving the current habitat of polar bears, so that these magnificent creatures can survive in their natural location.

Rex Last
New Alyth, Perth and Kinross, UK
Imagine a northern bear just completing its hibernatory period, eager to emerge from its snow hole. But if transported to the southern hemisphere, it would be time to hibernate again.

Jonathan Wallace
Newcastle upon Tyne, UK
It would be extremely reckless to try to introduce polar bears

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Tom Gauld
for New Scientist

into the Antarctic in order to save them from extinction.

The Antarctic species that the bears would be likely to prey upon have evolved no defences to polar bear predation and would be likely to suffer catastrophic losses.

While not every introduction of animal or plant species into places that are outside their natural range has resulted in disaster, there is a very long history of introductions that have proven ecologically disastrous.

Chris Warman
Hinderwell, North Yorkshire, UK
The bleak Antarctic mainland is a far more challenging environment than the islands and sea ice of the Arctic. Polar bears might do well on islands off mainland Antarctica where there are an abundance of seals and penguins to hunt.

This, however, wouldn't be allowed. The entire Antarctic is an internationally protected area and alien species such as reindeer (introduced by whalers for fresh meat) and rodents (which always just turn up with humans) have already been exterminated. An apex predator such as a bear would do intolerable damage to existing ecosystems.

"Polar bears would find an all-you-can-eat buffet of penguins that they would enjoy until it was wiped out"

Conrad Jones
Cynwyl Elfed, Carmarthenshire, UK
If polar bears were introduced to the Antarctic, it would be the end of the joke: "Why don't polar bears eat penguins?"

The scientific answer is, of course, that they live at opposite poles (for now at least); the funny answer is: "Because they can't get the wrappers off!"

[*Ed: For the benefit of readers who thought that penguins were just a type of bird, in the UK, they are also a popular brand of chocolate biscuit*]

On time

Since I was a child, most measurements have been decimalised. Why not time? (continued)

Simon Cains
High Wycombe, Buckinghamshire, UK
Astronomers and software engineers avoid all the complexity of calculating the time between two events in units of minutes, hours, days, months etc.

Instead, they calculate the Julian date by measuring the number of days and fraction of a day from noon on Monday 1 January 4713 BC – the beginning of the Julian period – for any event. So a typical recent date would have a Julian date of about 2.5 million, with enough decimals as required to specify the precise time.

I am writing this at Julian date 2459352.8548611. The calculation is fiendishly complex, but there are online tools to calculate the current Julian day and decimal. ▮

Answers

Quick quiz #108 *Answers*

1 The year 2178
2 Sloths
3 Guttation
4 The brain
5 There are 1121

Cryptic crossword #60 *Answers*

ACROSS 1 Surer, **4** Coupons, **8** Menisci, **9** Dubai, **10** Tentacle, **11** Step, **13** Creels, **15** Fallow, **18** Plug, **19** Unusable, **22** Renal, **23** Marconi, **24** Sex cell, **25** Minus

DOWN 1 Somatic, **2** Ronin, **3** Rascally, **4** Chilly, **5** Undo, **6** Orbital, **7** Skimp, **12** Bass drum, **14** Equinox, **16** Weevils, **17** Enamel, **18** Perms, **20** Brown, **21** Flee

#119 Nutty neighbours *Solution*

The Shells began with 65 brazil nuts and the Kernels had 119 walnuts. Let the Shells start with S nuts and the Kernels with K.

After the exchange, the Shells have 4S/5 + K/7 while the Kernels have 6K/7 + S/5. Five times the former equals three times the latter, so S/(5×13) = K/(7×17). So S is divisible by 65 and K by 119.

In fact, in order to total less than 200, these values are the only possible ones.

Smart, very smart

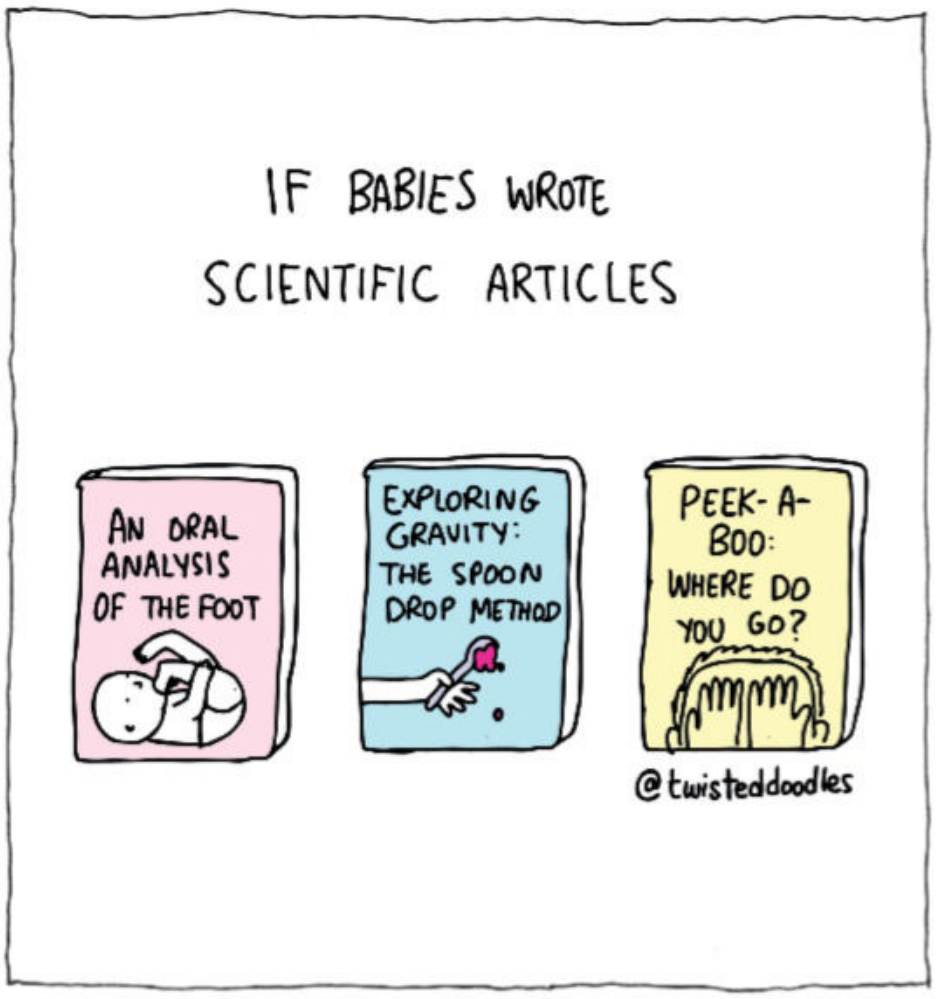
For reasons we can only put down to the universe's trend towards higher disorder, we have arrived on the mailing lists of ever more PR agencies. So Feedback is used to seeing importunate subject lines such as "Are you looking for experts to test your enzymes?". No, as a matter of fact.

A peculiar new sub-genre involves PR operatives suggesting that articles we wrote some time back in the Mesozoic era contain outdated web links. Fortunately, they have just the client with just the web link to restore cosmic order.

Since one such correspondent recently took the trouble to write a second time, in case we missed the initial communication, we feel bound to respond to their thoughtful kindness. A while ago we wrote about the revolutionary product Midnight Sun, which promised you could power your home "24 hrs a day with green energy generated by your solar system" (23 November 2013).

We also highlighted the claim that those blessed with excess solar system energy might use it to supply the grid and benefit from the UK government's electricity feed-in tariffs. We are happy to clarify that the feed-in tariff was replaced on 1 January 2020 by the Smart Export Guarantee. Do let us know how you get on with that, and may the planets direct you to the correct link.

Twisteddoodles *for New Scientist*



Got a story for Feedback?

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

Probably still out there

A sense of deflation hits as, half a year after a mandate from the US Senate, the Office of the Director of National Intelligence released its *Preliminary Assessment: Unidentified Aerial Phenomena*.

UAPs are what used to be known as UFOs before being rebranded to attract a less select group of people. The US Department of Defense UAP Task Force analysed 144 reports from US government (USG) sources between 2004 and 2021, promising a neat categorisation into "Airborne Clutter", "Natural Atmospheric Phenomena", "USG or Industry Developmental Programs", "Foreign Adversary Systems" and a handily sized "Other" pot.

In a robust confirmation of brand Unidentified, the report concluded that, while there was undoubtedly something there in most cases, only one UAP could be identified with high confidence. "In that case, we identified the object as a large, deflating balloon," the report stated, we assume happily. Or, in the precis of Twitter user Jerry Gamblin: "Um... We saw some stuff, one was for sure a balloon not sure about the rest."

Feedback admires the apparent transparency with which the US authorities are laying their ignorance bare. Unless of course the official report equivalent of "IDK" and a shrug emoji is an elaborate double bluff, in which case we also admire it, with our tin foil hat on.

We're also pleased the declared next step is putting AI on the case. If we're holding out for the "Other" category, this seems a sensible way to make a breakthrough. Given the arduousness of the journey to Earth, little green AIs are perhaps the most likely candidate for paying a state visit, and it might take one to know one.

An onion breath away

Covid vaccine incentives are this season's social distancing measures, in the sense that the bribes being given out to persuade the reluctant to get their jabs also have a distinct cultural slant.

Efforts last year to assist people in estimating a safe 2-metre distance brought us units such as the ice hockey stick and the caribou (Canada), the alligator (Florida) and the kangaroo and the angry cassowary (Australia). The still growing list of vaccine incentives, for which we welcome further input, includes hunting and fishing licences (Maine), a pre-rolled spliff (Washington state), a lottery to win a cow (Thailand) and new season soused herring (the Netherlands).

This last one is a win-win: in our one-time experience, *Hollandse nieuwe*, consumed in the traditional manner raw on bread with equally raw onion, is also a highly effective social distancing measure.

Horse-drawn handles

Dave Cross writes that he has been scouring the Amazon for door handles of a particular size. Our reverie on intrepid rainforest expeditions in search of a rare and prized natural wonder is cut short by realising we added in the "the" in haste, but let's hold that thought for another time.

So what wonder has Dave found? Under the "Technical Details" of the "Aexit Cabinet Cupboard Drawer Flush Mount Round Ring Pull Handle" – as fine a concatenation of nouns as you'll see outside the headlines of a mid-market tabloid newspaper, although lacking "fury" at the end – comes the puzzling entry "Horsepower: 0.01 hp".

This rating equates, of course, to roughly 330 imperial foot-pounds per minute or, in our favoured, over-complicated experiential units, the power expended to lift the contents of a standard wine bottle, but not the bottle, to the level of a cupboard door handle 1 metre off the floor in 1 second.

Yet we're still left slightly perplexed. According to a diagram we've just drawn, you'd still need a horse, similar beast of agency or electric motor at the other end of the rope. Or possibly a poltergeist.

In the hope someone has finally made a perpetual motion machine in the form of a door knob, Dave is waiting for the turbo version. Wire it up to the grid, Dave, and remember: what you're looking for is the smart export guarantee. ▮

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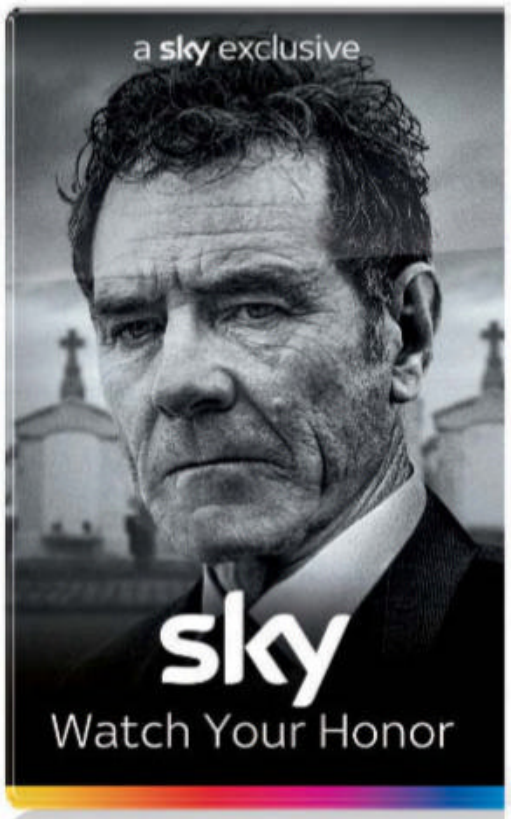

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