New Scientist

WEEKLY October 3 – 9, 2020

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Earth's vanishing river monsters

REASONS TO BE CHEERFUL
Ruby Wax on mindfulness and mental health

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LIFE BEYOND EARTH

The discovery on Venus, and the race to understand it

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Why we will (probably) never make contact with intelligent aliens

LOCKDOWN OR LET IT RIP?
Difficult decisions as European coronavirus cases rise once more

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Decoding reality

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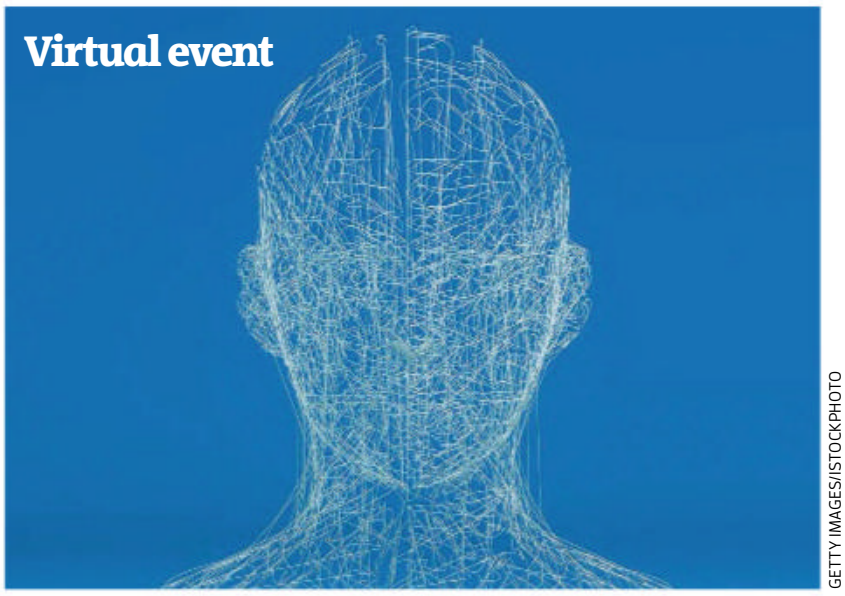

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Inherently weird The bizarre rules of quantum theory explain reality

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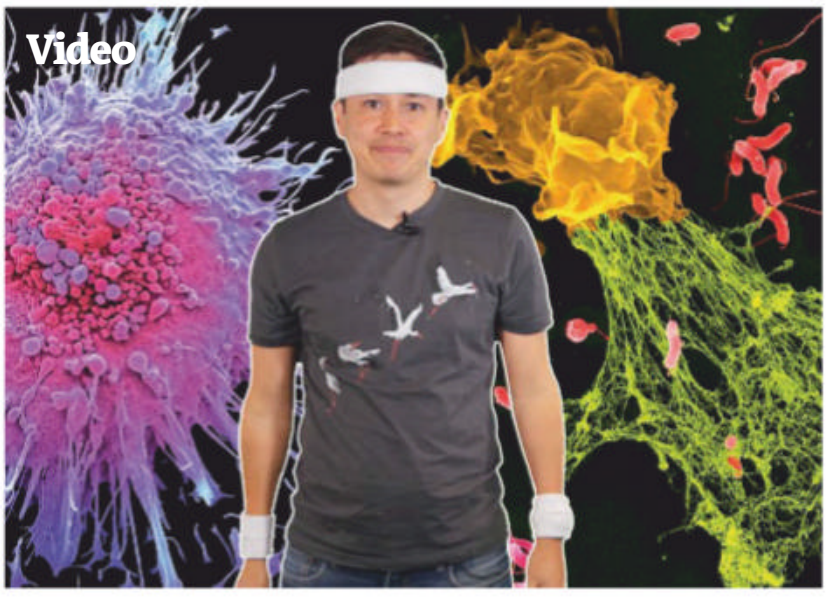
Build it back better How to repair the climate after the pandemic



Fighting fit Sam Wong gives his immune system a pick-me-up

Video

Science with Sam

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youtube.com/newscientist

Online

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Watch this space

Alien life could be present on Venus, but intelligence may be harder to find

SCIENTISTS and science journalists often share a weary refrain whenever a story with a whiff of the extraterrestrial raises its head: it isn't aliens. It is never aliens.

While firm evidence of life beyond Earth would be the discovery of the century, we have been burned too many times before – most notably in 1996, when excitement about supposed fossils in a Martian meteorite inspired the-then US president Bill Clinton to make a statement from the White House lawn.

President Donald Trump hasn't made any public pronouncements about the discovery of phosphine, a molecule that may have a biological origin, on Venus. Yet it has tested the resolve of the "never aliens" crowd. Could it really be that after all the time we spent looking for life on rocky Mars, it was waiting to be discovered in the hellish clouds of Venus?

Working out what is happening there will require much more investigation, with studies of Venusian chemistry (see page 12) and a fleet of spacecraft explorers (see page 14) now in the planning stages. But even if we confirm that the phosphine is produced by alien microbes, not some as-yet unknown geological process, this isn't *Star Trek* – we won't be chatting to these new aliens. If we want to find intelligent life forms, we must almost certainly look further afield.

"Just because life may be common, it doesn't follow that intelligent life awaits us in the stars next door"

Here, the size of the universe is both a blessing and a curse. Our galaxy contains billions of planets, so even if the odds of life arising on a particular world are tiny, there is a good chance it has happened many times over. The possible detection of the first planet outside our galaxy (see page 17) only increases the odds.

Yet just because life may be common, it doesn't follow that intelligent life awaits us in the stars next door. New work suggests intelligence is rare and any civilisations are likely to be thousands of light years apart (see page 36). Barring a way to break the speed limit of the universe – which, granted, isn't an impossibility – we will probably never receive a message from another world, let alone galaxy-crossing visitors landing a flying saucer at the White House.

So even if we do find aliens, they probably aren't going to be *alien* aliens. For all intents and purposes, then, we may really be alone. ■

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Street art on a wall at the Saint-Antoine Hospital in Paris, France

Second wave

Europe braces again

Daily covid-19 cases are rising across Europe, but is that just because countries are performing more tests? **Michael Le Page** investigates

IN EUROPE, the long-predicted second wave of the coronavirus pandemic is now well under way.

"In some member states, the situation is now even worse than in the peak during March," said Stella Kyriakides, the European Union's commissioner for health and food safety, on 24 September. "This is a real cause for concern."

Spain, the Czech Republic, France, the Netherlands and the UK are reporting higher numbers of daily confirmed cases per million people than they did in March, with around 240 per million in Spain. Portugal has the next highest infection rate, but hasn't yet exceeded earlier peak levels.

However, during the first wave, testing was mostly limited to those in hospitals, meaning many cases were missed. Antibody surveys, which estimate the proportion of people who have had the SARS-CoV-2 virus, show that the actual number of cases at the time was much higher than official figures suggest.

"There is undoubtedly more testing being done now than in February and March," says Martin Hibberd at the London School of Hygiene & Tropical Medicine. "The numbers are difficult to compare."

The figures should serve as a wake-up call, said Hans Kluge, the World Health Organization's regional director for Europe, on 17 September. "Although these numbers reflect more comprehensive testing, it also shows alarming rates of transmission across the region."

"Obviously, if you don't search, you don't find," says Giulia Giordano at the University of Trento in Italy. "However, this does not necessarily mean that now we are discovering more infection cases because we are testing more. The cases may really be more."

One indicator of how many cases are being missed is the proportion of positive tests, she says. This is rising in most European countries, but isn't yet as high as it was in March.

In Spain, for instance, a third of tests were positive in March. By June, this had fallen to one in 100, but it has now risen to one in 10. In the UK, it is up to two in 100.

If actual case numbers aren't yet as high as they were in March, this would help explain why the numbers of hospitalisations and deaths have remained low even as case numbers have soared. Spain is reporting around two deaths per day per million people, compared with 18 per day per million during the peak of the first wave.

> "There is undoubtedly more testing being done now than in February and March"

Another reason could be that younger people returning to work and education are the ones being infected while older, more vulnerable people continue to shield. "We do not yet know how impactful the current set of measures will be in reducing SARS-CoV-2 transmission to vulnerable groups," says Hibberd. "However, with case numbers still rapidly rising, it seems unlikely that they will be sufficient to prevent later increases in hospitalisations and deaths."

Death rates also lag several weeks behind infections. Yet the number of deaths among those infected – the infection fatality rate – is expected to be lower during the second wave. "This would mean we won't see the same impact even if cases did soar," says Jason Oke at the University of Oxford.

There are many reasons for this. Medical staff have more experience with the disease, for instance, and treatments such as dexamethasone have been shown to reduce the death rate.

The rising case numbers indicate either that people aren't following the measures meant to prevent the spread of the coronavirus or that those measures are insufficient, the European Centre for Disease Prevention and Control said in its latest summary. ■

Second waves

How best to lockdown again

As cases rise across western Europe, are second lockdowns inevitable and what should they look like? **Adam Vaughan** reports

IT IS no shock that many European countries are again facing rising coronavirus cases – this is exactly what researchers anticipated. Modelling in March by Mark Woolhouse at the University of Edinburgh, UK, suggested that a two-month UK lockdown would lead to low cases and an imperceptible rise over the summer before new measures were required at the end of September. Which is roughly what happened. Other models foresaw similar patterns. "I'm not claiming a prediction, but it's a scenario that was predictable," says Woolhouse.

"Epidemiologists have been expecting a big increase, but it's been bigger than most of us expected"

The speed and size of the wave in Europe has been a surprise though. "Every infectious disease epidemiologist has been expecting a big increase, but it's been bigger and sooner than most of us would have expected," says Paul Hunter at the University of East Anglia, UK. While we don't know how big the epidemic will get this time round in the UK, he says it will probably dwarf the one in March and April. Deaths may be lower this time, Hunter adds, due to a higher proportion of younger people being affected and better treatments.

The key question now is whether second national lockdowns are inevitable and, if so, will they differ from the first time? Israel is the only high-income country to have begun a full national second lockdown. It started on 18 September, with a further tightening of restrictions a week later. It is too soon to know the impact of this lockdown.

Several countries, including Australia and the UK, have opted for local lockdowns as cases rise. On 22 September, England stopped far short of a second national lockdown, instead announcing modest measures around pub closing times and numbers at weddings. UK Prime Minister Boris Johnson made it clear that he didn't want a full lockdown, but didn't rule one out.

The severity of a second lockdown may depend on how well countries managed their first one. The UK's initial peak lasted longer than those in many other countries, and measures were relaxed when cases were still relatively high compared with other nations, says Stephen Griffin at the University of Leeds, UK.

"Is lockdown inevitable? It's inevitable if you've not acted properly the first time round," he says. "Countries that have got it under control from the outset – New Zealand, Singapore, South Korea – have not only returned to normality far better, but also when they've had another outbreak, they've controlled it."

New cases are growing much faster in the UK, France and Spain than in Italy and Germany. Experts think the diverging paths are due to differences in testing and tracing, demographics, public health messaging, but also, importantly, public behaviour and compliance with the restrictions that remained after lockdown eased. In England, researchers have found that adherence to self-isolation guidance was "poor", with only a fifth of people with symptoms fully self-isolating. Other studies have uncovered similar behaviour.

The recent measures Johnson announced, which also include encouraging people to work from home if they can, are seen by many researchers as too little, too late, and unlikely to do much to prevent cases in England from doubling every week. For example, the 10 pm closure of pubs is so modest a change, it is impossible to model, says Woolhouse. "We are approaching [more] severe restrictions," says Griffin.

Such restrictions may well be more targeted than the strict lockdowns of March, April and May. "You can't expect a second lockdown to be identical to the first, that would imply we'd learned nothing," says Woolhouse. It is thought unlikely that nations will return to the blanket instruction of everyone staying at home aside from essential shopping and limited exercise outdoors.

Bans on unnecessary gathering indoors and mixing with other households – things Scotland has already done – are sensible steps, says Griffin. Hunter expects the UK hospitality industry to close again.

Scientists have learned that the virus transmits poorly outdoors and that although children do transmit the virus, they aren't driving the epidemic, Hunter adds. "The clear implication of that is we don't have to be too restrictive on outdoor activities. And we don't need to close schools."

While some epidemiologists think the UK government's

JON SUPER/AP/SHUTTERSTOCK

Coronavirus public information messages in Manchester, UK

strategy is to continue suppressing the virus until a vaccine is available, others question how sustainable this goal is. Woolhouse points out that as soon as the next set of restrictions is relaxed, a third wave is a plausible scenario.

In recent weeks, there has been discussion of whether it is time to look at alternatives to suppressing countries' epidemics (see page 10). What might those look like? One is better protections for those we know are more vulnerable to the illness: the over-65s and those with existing health conditions. Countries such as the UK have begun regular testing for care home workers to protect residents. But an equivalent testing scheme for carers, spouses and others in close contact with vulnerable people in the community isn't yet in place. Having millions of tests a day, as the UK has proposed, could be another option. But that doesn't exist yet.

In the short term, says Woolhouse: "All we're left with is increased social distancing, partial lockdown." But all the strategy will do in the medium term is defer the problem, he believes.

One step that governments could take is messaging and interventions that are more tailored to individuals, says Hunter. "It's plausible we could have something like personalised public health interventions," he says. "If you're female, white, fit, 64 years old with no pre-existing disease, then probably you're not in the vulnerable group. If you're an overweight, white, male professor you certainly are more at risk. If you are from a [black, Asian and minority ethnic] background and have diabetes, you are even more at risk. There should be a way of being a bit more focused." ■

Quarantine diary

Strict policies in Australia seem to have worked

Donna Lu

A WEEK ago, with an expired UK visa and after eight unsuccessful attempts to get home, I finally boarded a plane bound for Perth in Western Australia. I now find myself in quarantine, at the sharp end of the country's tough policies to curb a second wave of covid-19 cases.

Australia has limited the number of returning passengers since July, after security breaches in quarantine hotels in Melbourne, Victoria, led to another wave of infections. The city went into a second lockdown, imposing some of the strictest measures in the world, including a curfew between 9 pm and 5 am and hefty on-the-spot fines for people in breach of stay-at-home orders.

The policies seem to have worked. After more than 11 gruelling weeks, cases dropped faster than expected, and the curfew was lifted on 28 September. On that day, there were just five new cases in the state of Victoria, down from a peak of 686 on 4 August.

Compared with the UK, where travellers must quarantine at home for two weeks with little or no checks, Australia's policies are extreme. With some celebrity exceptions – actor Tom Hanks and businessman Alan Sugar among them – only Australian citizens and permanent residents are currently allowed entry.

5

The number of new covid-19 cases recorded in Victoria on 28 September

Incoming flights are capped at around 50 passengers per plane, which led to one of the strangest flights I have ever taken. We were required to wear both a mask and face shield the entire time, except when eating. On the leg to Australia, I counted 22 of us in economy.

As we descended into Perth, an announcement from the Australian government informed passengers that we would need to quarantine in a hotel for 14 days at our own expense. "Failure to do so may result in a fine or a prison sentence," we were told.

At the airport, temperatures were taken and we were asked about covid-19 symptoms. We were interviewed by state police to be granted permission to enter and were later bussed to a hotel with soldiers outside. "Enjoy that fresh air while you can," a police officer told me as I was waiting to be assigned a room.

In some states, people can take regular breaks outside throughout the fortnight. But here in Perth, perhaps wary of an outbreak like Melbourne's, the authorities don't let people leave their rooms for the duration of quarantine.

Food is delivered three times a day. Somewhat desperately, I have figured out that if I stand in a certain spot in my hotel room, the gust from the door slamming shut almost feels like a breeze. From my windows, which are large but don't open, I can see people lining up at a coronavirus testing clinic – the only social distancing I have seen. There is now zero community transmission in Western Australia.

DARRIAN TRAYNOR/GETTY IMAGES

A woman enjoys a park in Melbourne, as restrictions there ease

Testing has been widespread in the country, with more than 7.4 million tests conducted to date. Covidsafe, a contact-tracing phone app, was launched in April and downloaded by more than 7 million Australians – over a quarter of the population. Overall, the country has seen 875 deaths from covid-19 and just over 27,000 total cases.

So while a fortnight alone in confinement isn't how I would ideally spend my time, it seems like a fair price to pay given the efforts Australians have made to keep coronavirus under control. ■

Herd immunity

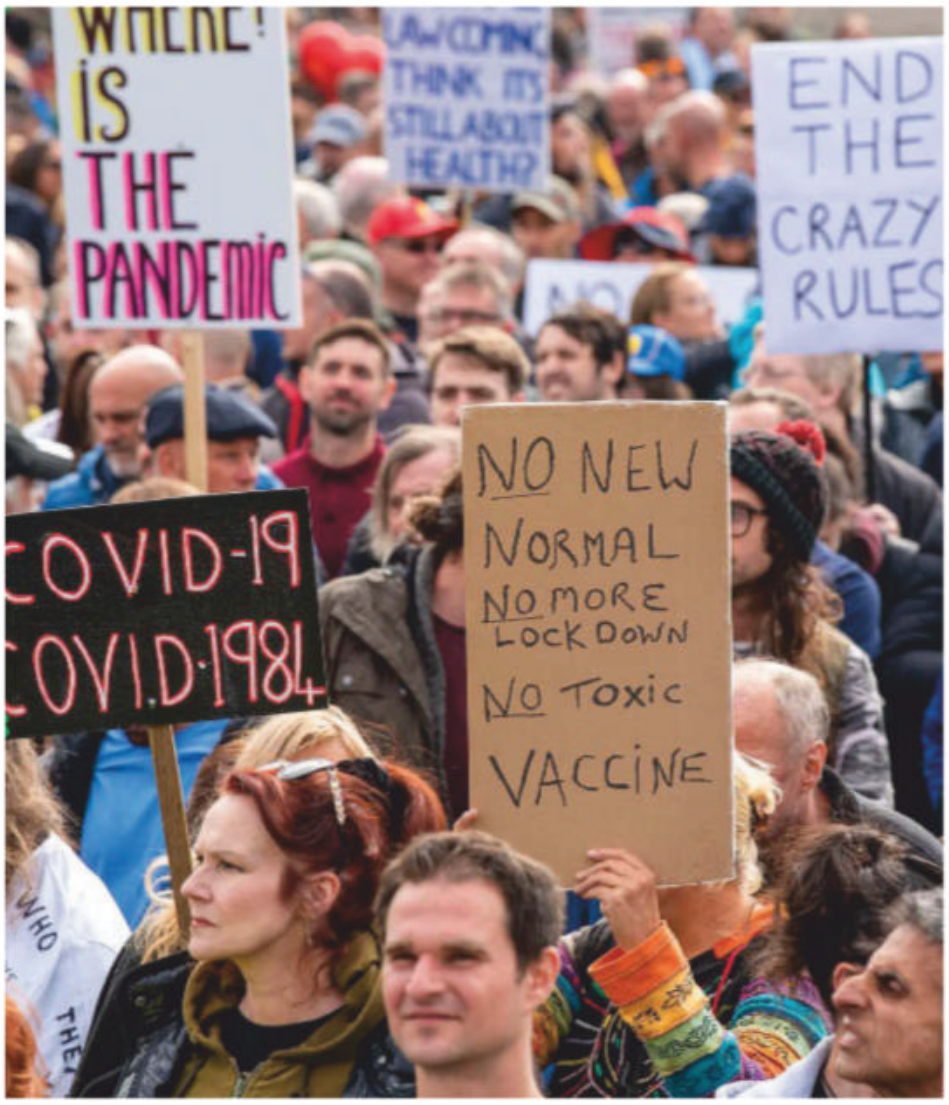
Should we let the virus rip?

A small minority are against lockdowns, but the evidence doesn't support the idea

Jessica Hamzelou

CORONAVIRUS cases are rising again across the UK. Without urgent action, they could reach 50,000 per day by mid-October, health officials have warned. Many scientists are now calling for further measures, such as a short-term national lockdown to limit the virus's spread (see page 8). But others point out that restrictions cause their own harms, including impacts on other health services, economic hardship and a significant toll on mental health.

Thousands of people attended a London protest last weekend against lockdown and related measures. Similar protests have taken place around the UK and the world. Meanwhile, a group of scientists have signed an open letter essentially arguing that the virus should be left to let rip through young and healthy populations.



DAVE RUSHEN/SOPA IMAGES/LIGHTROCKET VIA GETTY IMAGES

Anti-lockdown protesters in London on 26 September

Devastating impact

The open letter, by Sunetra Gupta at the University of Oxford and 31 of her colleagues, argues that lockdown and other restrictions have had a devastating impact on the wider delivery of healthcare. Cancer Research UK estimates that around 350,000 fewer people with suspected cancer symptoms were referred for a diagnosis between April and August, for example.

However, others argue that the overwhelming of health services that occurred in the UK in April wasn't solely because of the coronavirus epidemic, but was also due to years of underfunding of the National Health Service, which is often stretched beyond capacity during winter.

The authors of the letter rightly point out that the pandemic has significantly worsened mental health, although anxiety and depression appeared to be rising before lockdowns came into effect. But their further points have come under fire from other scientists.

Gupta and her co-authors argue that young people should be given age-specific advice on their individual level of risk because they are much less likely to die from covid-19. Older and vulnerable people should be shielded, while young and healthy people continue to live much as they used to. "The main concern is the destructive effect of lockdown and restrictions," says Gupta.

Although the letter doesn't mention the term "herd immunity", this is what the writers consider the way forward, says Gupta. Allowing the virus to spread through a low-risk group is the quickest way to develop immunity in the population at large and will eventually provide protection for older and more vulnerable people, she says. Without restrictions, this could be achieved in around three months, says Gupta. "I've been arguing that we build up immunity in people who aren't at risk."

> "Most believe that herd immunity is far from having been reached even in hard-hit regions"

Most scientists strongly disagree with this approach, though, arguing that it would still lead to a large number of deaths as well as putting more individuals at risk of "long covid", in which people continue to experience ill effects long after the virus has left their system. "There's a huge amount of evidence this is not going to work," says Stephen Griffin at the University of Leeds, UK. For a start, most scientists believe that herd immunity is far from having been reached even in regions hard hit by the virus.

While the threshold for herd immunity is debated, estimates suggest that about 60 to 70 per cent of people would need to be immune to the coronavirus to stop its spread. But studies suggest that only 10 to 20 per cent of people in London and Madrid, for example, have antibodies to it.

Gupta and others argue that this might already be enough for herd immunity, but they represent a minority among scientists. They also point out that, even without antibodies from being exposed to the coronavirus, some individuals will have immune responses that protect them from it. But it is unclear how many will have such responses and how effective they might be. "We don't even know if herd immunity is possible," says Christina Pagel at University College London.

The ethics and practicalities of shielding a significant chunk of the population are also a concern. "Those people need to be cared for, have families and are working," says Griffin. "It's not feasible."

So how do we curb a second spike in infections? Sticking with measures like social distancing, hand washing, mask wearing and avoiding indoor and crowded places can help. Controlling the spread of the virus doesn't have to involve lockdowns, says Pagel. "It's about suppression through test and trace," she says. "Countries that do that can open everything." ■

New Scientist
Debate

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Astrochemistry

Can we verify life on Venus?

The hunt for alien life on Venus must start in labs on Earth to rule out other sources of the mysterious molecule we have seen, says **Leah Crane**

POSSIBLE signs of life have been glimpsed in Venus's atmosphere, but there is a significant amount of work required to confirm this unexpected finding before we can dive deeper into what it means.

On 14 September, a team announced that it had seen what appears to be phosphine gas in the Venusian atmosphere. On Earth, phosphine is only produced by living organisms or in industrial processes, and the researchers couldn't identify any way to make as much of the gas as they spotted on Venus through any known non-biological process. Phosphine is expected to be destroyed quickly in conditions like those in Venus's atmosphere, so something must be replenishing it.

"The conditions in Venus's clouds are difficult to work with in the lab. They are either toxic or corrosive"

"Everyone is deeply excited, but at the same time we've got like a hundred things we've got to do," says Jason Dittmann at the Massachusetts Institute of Technology (MIT). "It's going to be really exciting over the next few years while we puzzle this one out."

First, we need to confirm that the team really did see phosphine. The group found it using a process called spectroscopy, which can identify certain compounds by the way they absorb light at particular wavelengths, leaving dark lines in the spectrum of any light that has passed through gas. Phosphine is expected to produce thousands of these absorption lines, but the team only caught one with the two telescopes they used.

Phosphine was the best match for that line, but it will be important to confirm it with observations of other absorption lines of phosphine at different wavelengths, says Clara Sousa-Silva at MIT, who is part of the discovery team. She and several of her colleagues had observations scheduled with other telescopes to confirm phosphine on Venus, but they have been delayed because of observatory closures caused by the covid-19 pandemic.

"Maybe it's phosphine, and if it's phosphine, maybe it's life," says Sousa-Silva. If her team confirms the finding, figuring out if that phosphine came from life will be a much more arduous endeavour.

Thousands of experiments

One problem is our fundamental lack of understanding of both phosphine and Venus, which makes it hard to even say that finding phosphine there is totally unexpected. "Your ability to decide whether or not the presence of a molecule is weird is 100 per cent determined by how good your model is, and your model is only as good as the information you put into it," says Sarah Hörst at Johns Hopkins University in Maryland.

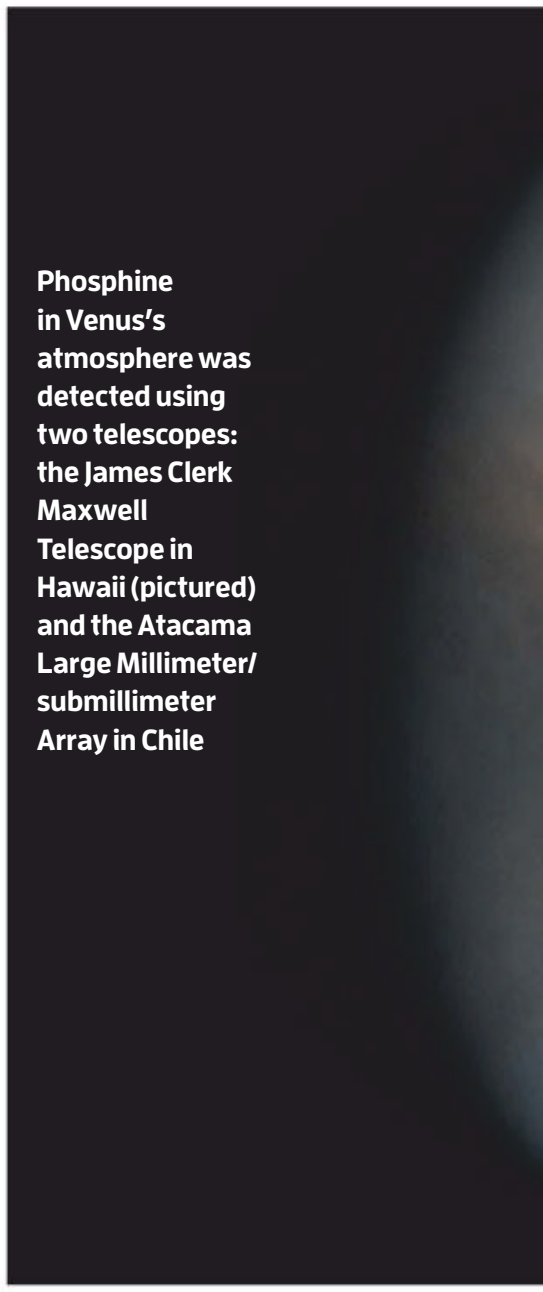
Right now, our models of both the Venusian atmosphere and the behaviour of phosphine are chock-full of educated guesses, says Sousa-Silva. To replace those guesses with reliable information, we need to study Venus's atmosphere in a lab setting. That is easier said than done.

"This work requires very specialised equipment, it takes a lot of time and a lot of the conditions in the Venus atmosphere are extremely difficult to work with in the lab, as are the materials, either because they are very toxic or very corrosive," says Hörst. Phosphine in particular is toxic for any organism that depends on oxygen, including humans.

To understand how phosphine might be produced, we need to not only overcome those issues, but also do an enormous number of experiments. We have to study how every type of molecule in the Venusian atmosphere interacts with every other molecule there, and how they interact with every wavelength of light. We must also study those interactions at every temperature and pressure in the atmosphere, which ranges from about 467°C and 9.3 megapascals at the planet's surface down to the cold vacuum of space at the atmosphere's top. And we also need to know how the atmosphere interacts with the planet's surface.

It could be that any one of these interactions produces phosphine. Or maybe it doesn't, but we have to check to be sure. "It's completely overwhelming," says Hörst.

Without all those experiments, we can't definitively rule out non-



Phosphine in Venus's atmosphere was detected using two telescopes: the James Clerk Maxwell Telescope in Hawaii (pictured) and the Atacama Large Millimeter/submillimeter Array in Chile

What else could make phosphine?

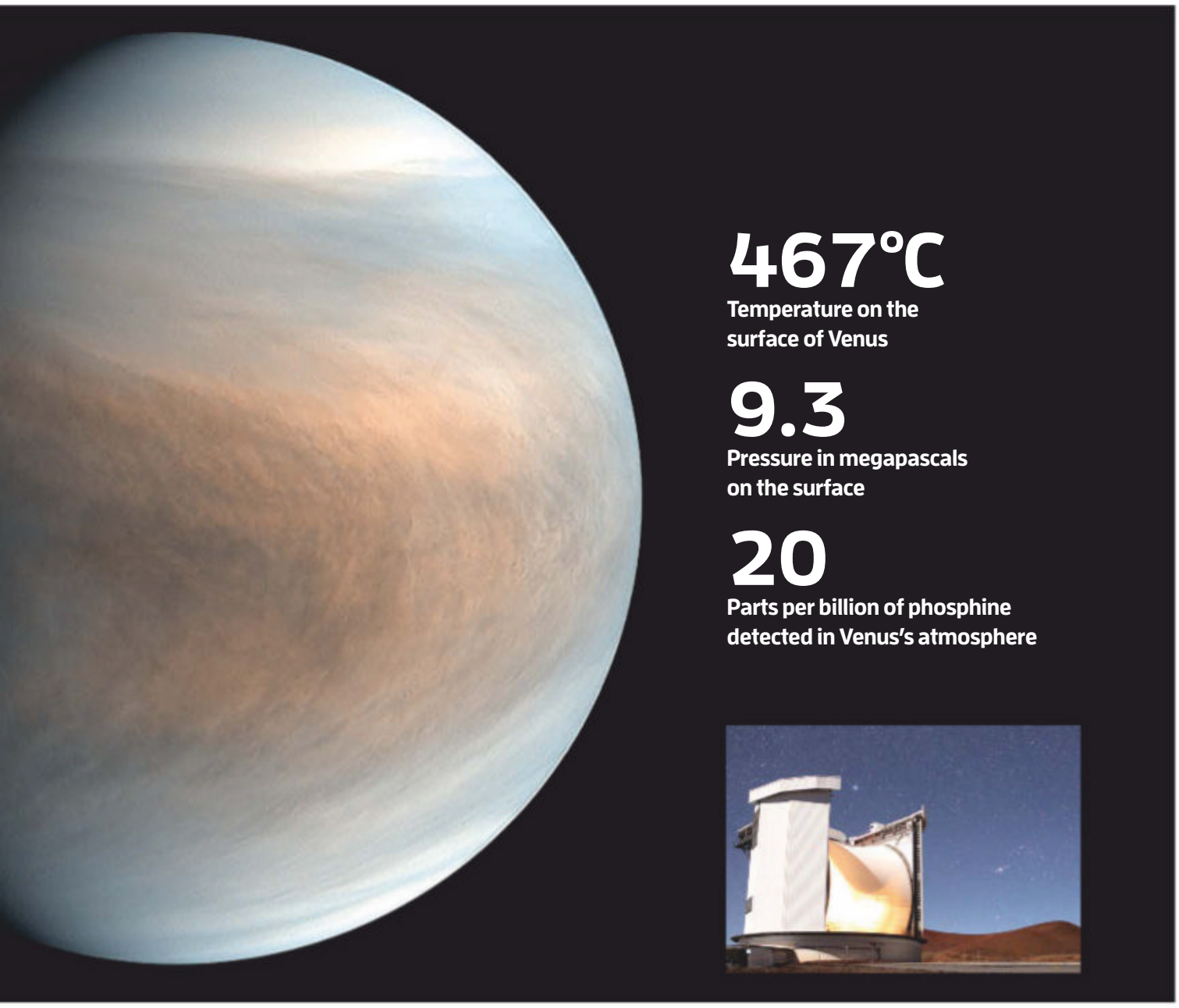
To be sure that the phosphine gas discovered in Venus's atmosphere was a potential sign of life, the team that spotted it searched for other processes that could be behind it. These would need to maintain phosphine levels of around 20 parts per billion in the atmosphere despite its continuous destruction.

None of the reactions between chemicals that we know exist on Venus is likely to produce phosphine. It can be made in interactions between these chemicals and light, but the amount of phosphine produced is too low by a factor of at least 10,000.

Lightning striking compounds containing phosphorus could make trace amounts of phosphine – less than one part per trillion. And meteorites carrying phosphine, or the ingredients to make it, could account for only 10 times less than lightning.

Volcanism could produce phosphine, but Venus would have to be at least 200 times more volcanic than Earth to blow enough phosphine into the air to account for the observations, and readings suggest that it isn't.

Even the most exotic processes could produce only tiny amounts of phosphine, so either Venus has unexpected chemical processes, or the phosphine is produced by something alive.



467°C
Temperature on the surface of Venus

9.3
Pressure in megapascals on the surface

20
Parts per billion of phosphine detected in Venus's atmosphere

L-R JAXA/ISAS/AKATSUKI PROJECT TEAM; WILL MONTGOMERIE/EAO/JCMT

biological sources of phosphine on Venus. The original team used what we currently know to rule out non-biological phosphine sources (see "What else could make phosphine?", left), but the chances are still fairly high that there are chemical interactions on Venus that we simply don't yet understand, says Sousa-Silva.

If we don't get a handle on how those interactions ought to work, it will only make it more difficult to design a spacecraft to observe them on Venus. "I am not immune to being excited about a shiny machine going to the Venus clouds and having a space robot taking samples, but even if we get a probe there and we sample it, the analysis of that sample will only be as good as our fundamental knowledge of how these gases behave," says Sousa-Silva. "It's not as shiny, but it is important."

"Microbes could be chomping volcanic ash and spitting out phosphine as a waste product"

Ideally, lab experiments and direct observations of Venus should go hand in hand, providing accurate models with which to compare atmospheric measurements. To sort out whether the phosphine came from life, we need the right combination of experiments, theoretical modelling and observations.

"Maybe this is just weird chemistry, fine – that's still a compelling reason to go and sample this stuff, get instruments in orbit to look at how phosphine changes over time, get probes into the atmosphere to sample it and figure out where it came from," says Paul Byrne at North Carolina State University.

What does life look like?

There are several spacecraft in development to visit Venus in the coming decades (see "We're heading for Venus", page 14), none of which has hunting for life as a prime directive. "The search for life on Venus is still sort of a taboo topic, it's still considered fringe. So typically, planned missions would not state that their main goal is to search for signs of life or life itself," says Sara Seager at MIT. "Hopefully with this news, those missions can tailor their instruments to look for signs of life."

Even if the missions can change their science goals to hunt for life, we don't know what Venusian life would look like. There are still heated arguments about what constitutes a living organism on Earth, let alone on a planet with different chemistry, where life could be thoroughly unfamiliar.

"It's actually a lot more challenging to find life than abiotic processes, because what does life mean?" says Seager. "You can imagine taking a microscope to Venus, but there are a lot of other cell-like particles there." Non-biological particles could masquerade as living microbes, or vice versa.

If the planned missions to Venus can't look directly for living organisms, we will have to rely instead on other clues that could point to life indirectly. For example, the BepiColombo spacecraft is about to swing past Venus on its way to Mercury – it will look for phosphine, but also for compounds that could indicate if Venus has active volcanoes.

"Current volcanism would make it more likely that it is life because that's a way to get the trace metals that you need for life into the atmosphere," says BepiColombo team member David Rothery at the Open University, UK. "The microbes could be chomping this volcanic ash and spitting out phosphine as a waste product."

We don't know enough about volcanism on Venus to discount it as a potential mechanism to produce phosphine directly, according to a paper published after the discovery was announced (arxiv.org/abs/2009.11904). The authors suggest that if Venus is volcanically active today, it could theoretically produce enough phosphine to account for the measurements.

The bottom line is that understanding the possibility of life on Venus requires first understanding Venus itself – a monumental task that we are only just beginning to tackle. ■

Space exploration

We're heading for Venus

Confirming potential signs of life on Venus may require a trip there, and several missions are already in the works, finds **Jonathan O'Callaghan**

AFTER decades of neglect, our closest planetary neighbour is suddenly the flavour of the month. On 14 September, scientists said they had found phosphine on Venus, a potential signature of life. Will this discovery usher in a new era of Venus exploration, like that of Mars before it?

The Red Planet was thrust into the limelight in 1996 when scientists said they had discovered evidence for fossilised life in a Martian meteorite called ALH84001 found in Antarctica. "If this discovery is confirmed, it will surely be one of the most stunning insights into our universe that science has ever uncovered," said President Bill Clinton at the time, in an address at the White House.

The announcement ushered in an era of Mars exploration that continues even now. In 1997, NASA sent its first rover to Mars, followed by a dozen other missions. The European Space Agency (ESA) has sent spacecraft too, as have India, Russia, the United Arab Emirates and China.

Today, scientists are less sure about ALH84001 as evidence for life. And while we now think that Mars was once habitable, current prospects for life there are slim. So Mars has started to lose its shine. The phosphine discovery has many wondering if we might see history repeat.

If phosphine is really present on Venus, and we can't work out a non-biological source in Venus's clouds, we could see a new rush to look for life, this time on our solar system's hottest planet.

"We invested billions of dollars in looking for life on Mars because of that discovery," says Sanjay Limaye at the University of Wisconsin-Madison. "So I wouldn't be surprised at all if we see a similar trajectory here from this initial finding."

NEWSCOM/ALAMY

In 2010, Japan sent the Akatsuki probe to study Venus's atmosphere

We know phosphine can be produced on Earth by anaerobic life, which requires no oxygen. Its supposed discovery 50 kilometres above the surface of Venus is in a region where conditions mimic those on Earth, and thus could be habitable – potentially to airborne microbes riding on droplets.

> **"This is about answering arguably the largest question about humanity: are we alone?"**

Until this announcement, phosphine hadn't been on many people's radar as a biomarker. "There are 16,367 molecules associated with life, by our latest count," says Clara Sousa-Silva at the Massachusetts Institute of Technology, a co-author on the phosphine discovery paper who has led much of the work on phosphine as a biomarker. "No one was looking for phosphine."

When Sousa-Silva was alerted to the presence of phosphine on Venus, however, she and her colleagues worked to find a possible source. After exhausting all options, they concluded it must either be produced on Venus by an unknown chemical process, or life.

Finding out will be a cautious process. First, scientists are working to confirm the presence of phosphine with independent observations from telescopes on Earth (see "Can we verify life on Venus?", page 12).

Several spacecraft are also due to fly past Venus in the coming months, including Europe and Japan's BepiColombo spacecraft en route to Mercury, which could look for phosphine in the Venusian atmosphere this month.

"There's definitely a limit of what we can do," says Jörn Helbert at the German Aerospace Centre, part of the BepiColombo team. "But it will not stop us from looking."

Into toxic skies

Beyond these near-term follow-ups, the next step would be sending dedicated missions to Venus to probe the phosphine in more detail. The three-month journey to get to Venus is about half the time needed to reach Mars.

"Venus is the easiest planet to get to," says Colin Wilson at the University of Oxford, who worked on ESA's Venus Express mission in 2006 and is part of a new mission proposal to Venus for ESA, EnVision. "Sending a spacecraft to orbit Venus is not that different from sending a spacecraft to orbit Mars. What is very different is landing on the surface."

EnVision, which would launch in 2032, is one of a number of proposed missions to Venus that were already on the table before the phosphine discovery. India also hopes to launch a mission this decade, while Russia has long talked of going back to Venus.

Japan's Akatsuki spacecraft is currently orbiting Venus, but its instruments lack the capabilities to look for phosphine.

EnVision, meanwhile, is a radar mission designed to study

the surface of Venus, not its atmosphere.

NASA is considering two new missions to Venus: DAVINCI+ and VERITAS. The former would include an atmospheric probe that could paint a broader picture of the Venusian atmosphere and gather some useful information.

2023

The year a Rocket Lab probe is pegged to launch towards Venus

"DAVINCI+ could provide the missing pieces critical to investigating where the phosphine is coming from," says NASA's Jim Garvin, the principal investigator on the mission proposal. He says the mission's chemical analysis of the planet could also tell us if Venus ever was, or still is, habitable.

Outside these national efforts, California-based aerospace company Rocket Lab says it plans to launch a small atmospheric probe to Venus as soon as 2023, to look for evidence of phosphine. The mission, which includes scientists involved in the phosphine discovery, would reach the Venusian atmosphere years before any other spacecraft.

"This is about answering arguably the largest question about humanity, and that is: are we alone?" says Peter Beck, CEO of Rocket Lab.

Another private venture, the Breakthrough Initiatives, is funding studies of potential life on Venus with a view to possibly developing a mission of its own. "We're hoping something comes out of this that's scientifically justifiable and affordable," says executive director Pete Worden.

Such ventures raise issues with regards to planetary protection. Mark McCaughrean at ESA says companies must ensure their missions don't contaminate Venus with Earth microbes. "There is no legal mechanism to prevent them from launching if they haven't followed planetary protection [guidelines]," he says.

To look for life itself on Venus, a dedicated mission that could sample the atmosphere would be needed, perhaps a machine that could float on a balloon, something done before by the Soviet Union.

"You'd have a pump that pulls in cloud particles onto filter paper, and you look at that filter paper using a microscope," says Wilson, part of a team that proposed such a mission in August 2020 called the Venus Flagship Mission. "That is the technique which has been proposed to look for biomolecules."

Eventually, we might want to get a sample back from the Venusian atmosphere, which poses further difficulties.

"You're going to have to have a full-scale launch vehicle dropped into Venus's atmosphere, and then launched back out of Venus orbit and brought home," says Dave Clements at Imperial College London. "That's quite a complicated mission. I don't think that's going to happen any time soon," he says.

In the nearer term, there are plausible routes to follow up the phosphine finding, and even if a biological source turns out to be unlikely – like with a certain Martian meteorite – the prospect of an era of Venus exploration spurred on by the discovery has many supporters, life or no life.

"If we still haven't sent anything to Venus in four or five years, or even considered sending anything, it will have been a waste," says Paul Byrne, a planetary scientist at North Carolina State University. ■

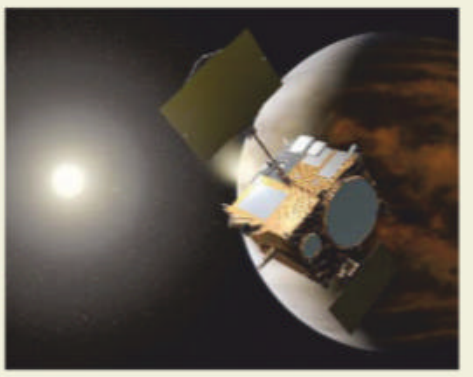
Missions to Venus

US space agency NASA might not have sent a dedicated mission to Venus since its Magellan spacecraft in 1989, but other nations have shown more interest.

In the 1970s and 1980s, the Soviet Union led much of the exploration of Venus. The country sent multiple probes and landers as part of its Venera programme, having had a mostly unsuccessful run of Mars missions in the 1960s.

In total, the Soviet Union performed 10 landings on Venus, returning stunning images from the ground, and is still the only state ever to operate a craft on the surface of the planet.

In 1985, the Soviet Union also deployed two balloons into the Venusian atmosphere, called Vega 1 and 2, the first and only missions of their kind to date. They floated at an altitude of about 54 kilometres and travelled on the Venusian wind for days. Unfortunately, neither had a camera to take images.



JAXA

NASA also sent two missions to our gas-shrouded neighbour in 1978: Pioneer Venus 1, which included an orbiter and a probe, and Pioneer Venus 2, a sister ship with four probes.

More recently, in 2006, the European Space Agency's Venus Express spacecraft became the first to orbit Venus in more than a decade, operating until 2014. It was followed by Japan's Akatsuki spacecraft (pictured launching, opposite) in 2015, which continues to operate today.

SCIENCE HISTORY IMAGES/ALAMY

The BepiColombo spacecraft when it was under construction

Microbiome

Paleo diet may cause you to biologically age

Michael Le Page

A NEW way of calculating our biological age based on gut bacteria has thrown up some surprising results. Among other things, it suggests that people following the paleo diet are nearly two years "older" on average than people who aren't.

"It is striking," says Guruduth Banavar at Viome, a Californian company that sells tests that measure gut bacteria. "In our population, people on a paleo diet were younger, but their biological age is actually older."

In the past decade, many groups have developed ways to estimate people's age based on biomarkers, such as the length of structures called telomeres on the ends of chromosomes. These biological ages are thought to show whether people are ageing slower or faster than normal, though it has yet to be shown that they can accurately predict life expectancy.

Several groups have been trying to estimate age by using machine learning to analyse microbiome data. Viome's approach involves looking at which genes are active in gut bacteria, not simply which genes are present, as other groups do, says Banavar.

Its findings are based on 90,000 stool samples from customers analysed by the firm, making it by far the largest such study to date. Having so many samples has allowed the firm's researchers to look at how various lifestyle factors affect biological age as estimated by their method. For example, they could examine the effects of the paleo diet, in which people eat as our Palaeolithic ancestors are supposed to have done.

"For the paleo diet, the finding is quite strong," says team member Hal Tily. "It's unambiguous that something is going on."

However, this could be because people with poor health are more likely to try the paleo diet, rather than this being a result of the diet itself, cautions Cara Frankenfeld at George Mason University in Virginia. "We can't identify whether something about a person's health made them decide to change their diet or whether the diet preceded and influenced the biological age," she says.

The team also found that people on the low-carb, high-fat ketogenic diet had biological ages nearly two years older on average, but this finding isn't as robust as the paleo diet one, says Tily. Women who reported drinking more than a unit of alcohol a day, and men who say they drink more than two units a day, were nearly a year older on average. People who say they eat organic food were around half a year older (bioRxiv, doi.org/d97t).

The paleo diet is supposedly that of early hunter-gatherers

Vegetarians fared best, being around a year-and-a-half younger biologically than non-vegetarians on average. This finding isn't surprising given all the evidence that a vegetarian diet is beneficial, says Banavar, but he stills thinks it is significant.

"This is the first time that anybody has shown through biological ageing modelling that this effect is true at a population level," he says. Vegans were also younger biologically, but not quite as much as vegetarians.

"From a machine-learning perspective, the methods look sound," says James Cole at University College London, who has estimated biological age from brain scans. However, Cole says the microbiome method is much less accurate at estimating actual ages than other techniques. ■

XSANDRA/GETTY IMAGES

Climate change

Extreme weather events could make evolution backfire

Michael Le Page

EVOLUTION normally helps organisms positively adapt to changing circumstances, but climate change may turn that on its head. A model of how some species could rapidly evolve in response to increasingly extreme events, such as storms, has found that mutations could actually drive some populations to extinction.

This is because traits that help the animals or plants that survive extreme events can be a hindrance in normal situations. "By the next generation, the environment has already gone back to normal," says Kelsey Lyberger at the University of California, Davis. "You never get to benefit from the change."

"Lizards on the Caribbean island of Dominica evolved a superstrong grip after Hurricane Maria in 2017"

It is already clear that extreme events fuelled by global warming, such as more extensive wildfires, can drive vulnerable populations to extinction. Those extreme events can also produce rapid evolution. Lizards on the Caribbean island of Dominica evolved a superstrong grip after category 5 Hurricane Maria in 2017 –probably because only lizards that managed to cling onto branches survived.

Such observations inspired Lyberger and her colleagues to create a mathematical model comparing the effects of environmental changes of different durations (bioRxiv, doi.org/d97h). The results suggest that brief changes, such as storms, can reduce the fitness of survivors in normal conditions to such an extent that their numbers decline rather than recover. The size of the effect depends on how extreme an event is, how often such events happen and how much genetic variation there is in a population. ■

Exoplanets

First planet outside our galaxy?

Astronomers may have spotted a world 28 million light years away

Leah Crane

IN A galaxy far, far away, a huge planet may be orbiting a binary star system. If this world is real, it would be the most distant ever spotted – the first planet to be found in another galaxy.

A team of researchers led by Rosanne Di Stefano at the Harvard-Smithsonian Center for Astrophysics in Massachusetts spotted this potential planet, now named M51-ULS-1b. It resides in a galaxy called M51, known as the Whirlpool galaxy, which is 28 million light years away. The researchers found the planet by hunting through data from 2624 observations made by the Chandra X-ray Observatory space telescope.

They scanned the data for signs of transits, which occur when a planet blocks out the light of a star or other bright object it passes. To eliminate the chance that changes in light levels were merely due to fluctuations in the bright objects themselves, the researchers looked for cases in which all the light was blocked out. They found one possible exoplanet (arxiv.org/abs/2009.08987).

NASA/HUBBLE

The Whirlpool galaxy may host the first extragalactic world ever spotted

"It's exciting, but not unexpected," says Angelle Tanner at Mississippi State University. "There's absolutely no reason to think there wouldn't be planets in other galaxies."

The planet appears to be in a system where a star orbits a black hole or neutron star. The team says the best explanation for the transit is a planet, but this isn't certain.

"It's sticky that there's only one transit," says Matthew Kenworthy at Leiden University in the Netherlands. "The gold standard is three transits equally spaced from one another because then you know it repeats", which indicates that the planet is in orbit, he says.

We have never seen a planet in a system like this, says Tanner, so we don't have much in our own galaxy to compare it with. "I'm cautiously optimistic, but I would not be surprised if it ended up being something else," she says. "It could be something that just passed in front of this system, never returning again."

The Chandra measurements indicate that if the planet is real, it is probably a gas giant a bit smaller than Saturn, orbiting tens of astronomical units (AU) from the centre of the binary system. The distance between Earth and the sun is 1 AU, so that puts the planet at least as far from the system it orbits as Saturn is from the sun.

That is potentially a problem for confirming that the planet exists, says Kenworthy. "If it's more than a few AU out, then it's going to be decades before it comes around and causes a transit again," he says. "I can't think of a good way how I'd confirm this."

There have been few other planet candidates outside our galaxy, with none ever confirmed. If we determine that this planet exists, it will be our first glimpse of a world outside the Milky Way and confirmation that our galaxy isn't special in its ability to host planets. "It gives us a little bit more of a feeling that maybe we're not alone in the universe," says Tanner. ■

Animals

Fairy shrimp can live in the hottest place on Earth

TINY freshwater shrimp have been found in the world's hottest desert, where their eggs can lay dormant for years between rare downpours.

In 2006, satellite measurements recorded ground temperatures in Iran's Lut desert reaching 70.7°C, a world record. Since then, the desert's surface has surpassed 80°C. The intense heat and relative dearth of knowledge about the region's flora and fauna spurred scientists to make a series of expeditions to the Lut to survey biodiversity there.

Hossein Rajaei at the State Museum of Natural History Stuttgart in Germany was on one of these excursions in early 2017. As he was cooling off in a temporary pool left behind by a recent, rare deluge, he spotted something moving in the water. He grabbed a net and scooped up a swarm of freshwater crustaceans, each smaller than the nail of a pinky finger and with a battery of feathery legs.

Martin Schwentner at the Natural History Museum Vienna in Austria helped him identify the crustaceans as a type of fairy shrimp. These animals live in temporary water sources in the world's arid places and survive on algae. Between floods, their eggs can survive in the soil in a form of stasis.

"These eggs can stay dormant in the sediment for decades, maybe longer," says Schwentner.

They found that this was a previously undescribed species and have named it *Phallocryptus fahimii* (*Zoology in the Middle East*, doi.org/d93r).

"The shrimp eggs can stay dormant in the sediment for decades, maybe even longer"

"There doesn't seem to be any permanent water or groundwater in this region of Iran, which begs the question: where have these [fairy shrimp] come from, evolutionarily?" says Michelle Guzik at the University of Adelaide in Australia, who wasn't involved in the research.

For Rajaei and Schwentner, the next step is determining if the new crustacean is widespread or if it is endemic to the Lut and thus needs special protection. ■

Jake Buehler

Health

Blood test can tell if you are susceptible to the placebo effect

Jessica Hamzelou

THE proteins in your blood could reveal whether or not you will experience the placebo effect.

A sugar pill or sham treatment can often make people feel better, but the reasons why have long been a mystery. Karin Meissner at the Ludwig Maximilian University of Munich in Germany and her colleagues looked for clues in blood.

They induced nausea in 100 volunteers on two separate days by asking them to sit in a booth with moving black and white lines. On the second day, 10 of them were given transcutaneous electrical nerve stimulation (TENS), in which a pressure point on the wrist was stimulated with electrodes placed on the skin. Sixty volunteers were given a sham TENS treatment that provided little or no electrical stimulation. The remaining volunteers had no treatment at all.

All the volunteers gave a blood sample before and after the nausea-inducing experience, and each was asked to rate their level of nausea. Among the group who received the sham treatment, those who felt that their nausea fell by at least 50 per cent on the second day were judged to have shown the placebo effect.

There were 74 blood proteins that seem to be linked to the placebo effect (*PLoS One*, doi.org/d92r). The levels of these proteins could predict who is likely to respond to a placebo, the team says. This might also help explain how the placebo effect works. Some of the proteins are known to play a role in controlling inflammation in the body, which is involved in a range of disorders, as well as pain.

If the finding is replicated, it could shape the way disorders are treated. It might be possible for people who are more likely to experience a placebo response to be given milder drugs at lower doses, says Luana Colloca at the University of Maryland School of Nursing. ▮

Analysis Climate change

China's surprising ambition

President Xi Jinping has announced that China wants to be carbon neutral by 2060. It is a welcome bright spot this year, says **Adam Vaughan**

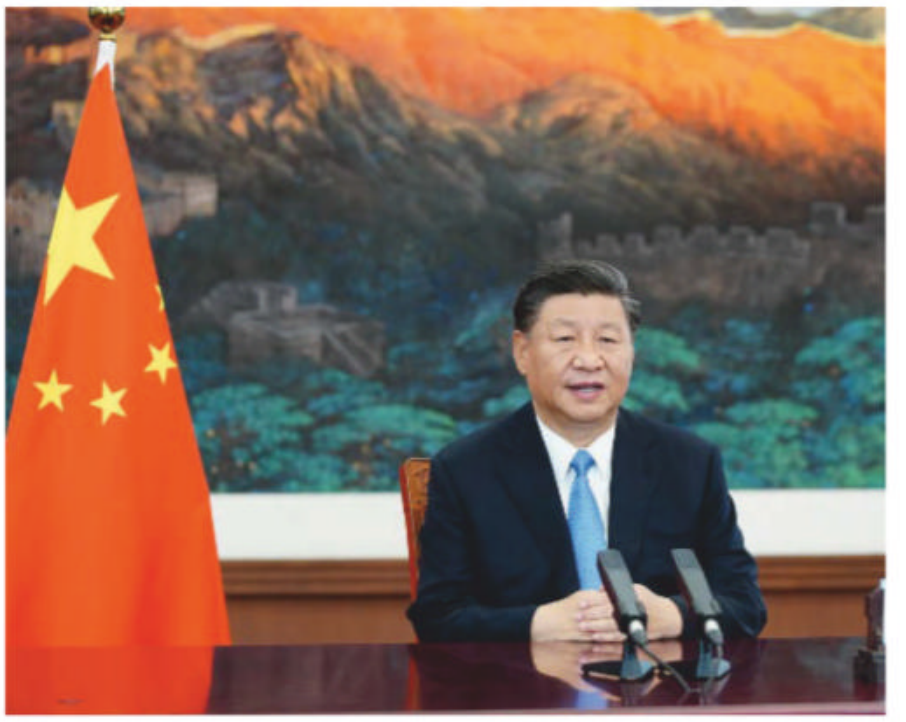
UNTIL now, 2020 has been a bad year for action on climate change, with a major UN climate summit postponed due to the coronavirus pandemic and only 13 countries putting forward a stronger carbon pledge, as required by 2015's Paris agreement. Now, China's president Xi Jinping has promised that the country will "achieve carbon neutrality before 2060". It is a shining bright spot and significant for two big reasons.

First is sheer size. China overtook the US as the world's biggest emitter of carbon dioxide 14 years ago, and now emits more than 10 billion tonnes of CO_2 a year, meaning it accounts for about 28 per cent of global emissions. That is more than the US and India combined, or almost twice the European Union. Crucially, while emissions in the EU and the US are already falling, in China they are still growing.

Second is geopolitics. The US has been largely absent from international climate negotiations for the past four years of the Donald Trump administration, emboldening other countries that are regressive on climate change. Now, China is cementing its role as a climate leader and sending a signal to other governments, businesses and investors.

> **"China is cementing its role as a climate leader and sending a signal to other governments"**

Declaring a long-term climate goal before the US is a big deal. It shows that China sees political and economic gain in leading the industries of the future, from battery manufacturing for electric vehicles to making solar panels and wind turbines. Xi's move also makes Trump's claim on the same day – that China is responsible for "rampant pollution" – ring hollow.



JU PENG/XINHUA/PA IMAGES

Chinese president Xi Jinping addresses the UN on 22 September

There was other notable news in Xi's speech to the UN general assembly last week. One was to "aim to have CO_2 emissions peak before 2030", a modest tweak on its previous plans for a peak "around 2030". That is good news, but analysis last year suggested the country was already on track to peak before 2030, as its economy shifts from industry to services.

The Chinese president also promised a stronger carbon reduction plan (an enhanced version of a nationally determined contribution, or NDC, in UN jargon). All countries that signed up to the Paris agreement have to submit one this year. The EU last week signalled it will submit a new NDC before the year is out, and the UK is expected to announce one on 12 December, the five-year anniversary of the Paris deal being reached.

Those three alone would mark an important shift in ambition for the NDCs this year because, until now, only 13 enhanced plans have been submitted, none from major economies.

It isn't all good news though, because we don't know what Xi means by "carbon neutrality". Will it be the same as the UK's law to hit net zero by 2050, which allows any emissions to be balanced out by carbon removal. Will it allow the goal to be met by offsetting Chinese farming and heavy industry's emissions by planting forests in South America and Africa? Is it only CO_2 emissions or all greenhouse gas emissions?

You may also have noticed that 2060 is later than the "around 2050" net-zero deadline set by the UN's climate science panel, which aims to give us a chance of holding warming to 1.5°C.

Still, none of those buts undo the importance of Xi's announcement. The move was welcomed and described as significant by the likes of the UN's climate chief and the US's former top climate envoy as well as Greenpeace, respected think thanks and the UK minister hosting next year's climate summit. ▮

DAVID ANDERSON/ALAMY

Animal behaviour

Young bats accept reality of climate change faster

YOUTHFUL male bats are the first of their species to adjust to the reality of a warming world, with older generations being slower to adapt.

The noctule bat (*Nyctalus noctula*), a common European species, usually migrates more than 1500 kilometres between its northern summer roosts and its southern winter hibernation grounds. Now that is changing one generation at a time, says Kseniia Kravchenko at the Leibniz Institute for Zoo and Wildlife Research in Berlin, Germany.

The bats have a short lifespan, averaging three years, and a high reproductive rate, leading to rapid generation turnover.

Kravchenko and her team studied nearly 3400 noctule bats in a newly colonised winter roost in Ukraine. They identified the bats' summer locations by looking for hydrogen isotopes in the bats' fur, which originate in the food and water consumed by the animals. Having followed the bats' journeys over 12 years, the team determined that young males settled first in new winter colonies further north. Later, young females and eventually older adults join them in staying closer year-round to their northern summer homes, rather than hibernating further south (*Biology Letters*, doi.org/d96t).

"This bat species seems capable of adjusting rapidly to the high pace of climate change, which is good," says Kravchenko. "But what about the other species of bats that have longer generation times and don't migrate? Global warming might be more difficult for them to cope with." **Christa Lesté-Lasserre**

Computing

Powerful carbon-based computers

MICROCHIPS containing ribbons of carbon just a few atoms wide could let us build powerful computers while also reducing their power consumption.

Felix Fischer at the University of California, Berkeley, and his team have developed a way of turning graphene nanoribbons – ribbons of carbon that are only a few atoms wide – into conductors, which could be used to connect carbon-based transistors.

There have been many efforts to develop transistors based on carbon because it has good electrical properties, but a key challenge has been making wires out of carbon to transport electrons between transistors.

"Just like the traditional silicon-based architectures we are using today, any carbon-based transistor technology still requires some form of interconnects that allow for the communication between individual transistors or other circuit components," says Fischer.

His team built nanoribbons by creating smaller graphene building blocks and connecting them together (*Science*, DOI: 10.1126/science.aay3588). Graphene, a two-dimensional form of carbon, is known for its exotic properties.

The next step will be to build circuits containing graphene nanoribbons and see if they can outperform the most advanced silicon-based semiconductor technologies. If successful, Fischer says they could one day be integrated into everyday devices, such as smartphones.

"Think about the possible impact of a mobile phone with comparable performance to the fastest desktop computers, but with a power consumption that requires you only to charge it every other month," says Fischer. **Layal Liverpool**

Robotics

Curly the robot beats athletes at curling

A ROBOT has beaten top-ranked humans at the sport of curling. Klaus-Robert Müller at the Technical University of Berlin in Germany and his colleagues built the artificial-intelligence-powered robot, called Curly, to master the sport.

In curling, players slide stones along ice towards a target. People compete in two teams of four, with most players taking turns turn to "throw" a stone or to use brooms to sweep the ice in front of a moving stone. Points are awarded for stones closest to the centre of the target and a team wins by accumulating the highest score.

WON ET AL., SCI ROBOT.5,EABB97

Curly (pictured) won three out of four matches against top-ranked South Korean women's curling teams and the country's reserve national wheelchair curling team (*Science Robotics*, doi.org/d96x). The robot throws stones, but doesn't sweep.

Mounted on wheels, the robot has a crane-like neck with a video camera to assess the position of stones and a gripper that can rotate and release stones.

Curly's reinforcement learning algorithm AI takes into account the position of other stones and the state of the ice when deciding its next moves. Once the game began, Curly continuously learned how to improve on its previous moves, based on the errors that arose from its preceding throws. **Donna Lu**

Really brief

CHRISTIAN IRIAN

Why frogs can have such big eyes

The size of a frog's eyes compared with its body scales depending on its environment, according to a study of thousands of specimens representing 220 frog species. Tree frogs have the biggest eyes and frogs from murky waters have small eyes (*Proceedings of the Royal Society B*, doi.org/d97n).

Birdsong got deeper during lockdown

As covid-19 restrictions went into place and there was less human noise in urban areas, birds changed their tunes. A study in San Francisco shows that white-crowned sparrows started singing in lower pitches, making their songs travel further and sound more appealing to mates (*Science*, doi.org/d97p).

Microbot puts neuron in its place

Tiny robots steered by magnetic fields have moved brain cells to create a neural circuit, which could help us to study brain disorders. The robots are made of a polymer coated in nickel and titanium, and have grooves that neurons can grow along (*Science Advances*, DOI: 10.1126/sciadv.abb5696).

Renewable energy

Energy harvested from gentle breezes

A SMALL device can harvest energy from the breeze generated as you walk and could potentially be used to power your gadgets.

Ya Yang at the Chinese Academy of Sciences in Beijing and his colleagues have developed a device that takes advantage of the triboelectric effect, which occurs when materials become electrically charged as they rub together.

The team used an 8-centimetre-long tube containing two thin films, each made up of a layer of plastic on top of a layer of silver that acts as an electrode. The two films flutter in response to winds as slow as 1.6 metres per second. The wind speed required for most wind turbines to generate power is 3 metres per second.

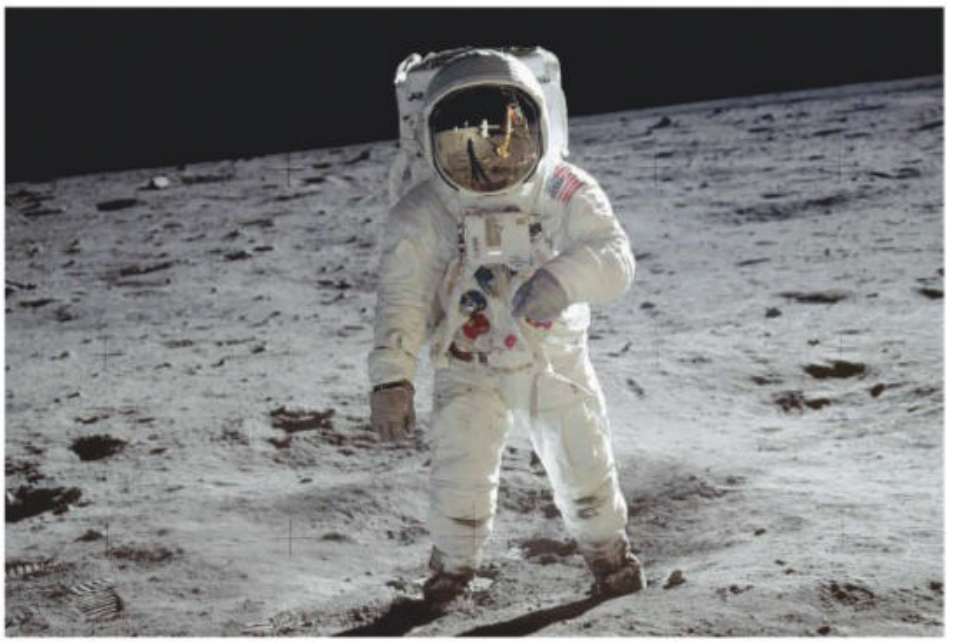
As they brush against each other, the films generate an electric current, which is transmitted through the silver electrodes to drive a tiny generator in the device.

Yang and his team put the device on a volunteer's arm and found that the airflow generated by swinging the arm when walking was enough to generate power (*Cell Reports Physical Science*, doi.org/d96v).

Yang's device can produce 2.5 milliwatts of power, enough for 100 tiny LED lights, a thermometer or a pressure sensor.

"Such wind energy harvesters can be used to power wireless sensors deployed in open space where breezes are available," says Dibin Zhu at the University of Exeter, UK. They could also power wireless sensors put in heating and air conditioning ducts for air quality monitoring, he says. **LL**

Space



NASA

Radiation levels on the moon may make lunar living harder

ASTRONAUTS on the moon would face nearly three times as much radiation exposure as those on the International Space Station (ISS), which could make long-term missions riskier than thought.

"Once you've survived being on the moon and come back to Earth, radiation damage is what stays with you for the rest of your life," says Robert Wimmer-Schweingruber at the University of Kiel in Germany.

Wimmer-Schweingruber and his colleagues analysed data from China's Chang'e 4 lander, which became the first spacecraft to land on the far side of the moon last year. Levels of radiation exposure on the moon were between 200 and 1000 times higher than on Earth's surface and some 2.6 times higher than those astronauts on the ISS experience (*Science Advances*, DOI: 10.1126/sciadv.aaz1334).

"There is still uncertainty on whether this increased level of exposure to heavy-charged particle radiation will have significant short and long-term impacts on human health," says Jeff Chancellor at Louisiana State University.

"If you wanted to live on the surface of the moon, you'd want to dig down pretty deep or cover yourself with a lot of lunar dirt," says Wimmer-Schweingruber. LL

Marine biology

Whale breaks record for the longest dive

A CUVIER'S beaked whale has made the longest recorded dive by any mammal, lasting 3 hours and 42 minutes. The previous record was just 2 hours and 43 minutes.

"It's pretty amazing," says Nicola Quick at Duke University in North Carolina, part of the team that revealed the dive.

The record for humans holding their breath underwater is 24 minutes, and that is while floating motionless. By contrast, whales are active during dives. "They are hunting down there, and moving and echolocating," says Quick.

The 23 species of beaked whale dive deeper and stay under longer than any other mammal. They routinely reach depths of 1000 metres or more, and hold their breath for around an hour.

The latest record-breaking dive was made in September 2017. The same individual made another dive lasting 2 hours and 53 minutes (*Journal of Experimental Biology*, doi.org/d96w). Why it stayed under so long isn't clear. Perhaps it found many squid to suck up, says Quick.

The record-setting dive wasn't particularly deep, though, she says. The record for the deepest dive remains 2992 metres.

Michael Le Page

Signal Boost

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

Humanity First is a multi-sector NGO, responding when disasters strike as well as working on development projects. From installing water wells, providing agricultural support and running medical camps to building schools and hospitals, we strive to bring sustainable provision, access to healthcare and opportunity for a better future to all people, regardless of race, religion or creed.

We have been at the forefront of fighting covid 19 globally with trained volunteers including medical professionals and disaster responders.

GLOBAL COVID RESPONSE

So far in the fight against covid 19 our 3487 unpaid volunteers across the world have:

- Distributed 185,140 PPE items
- Supported 148 hospitals
- Donated 2190 units of blood
- Provided over 10 million meals
- Worked 726,700 volunteer hours
- Served 650,492 beneficiaries

UK RESPONSE

- In the UK, we support communities up and down the country, including our new Foodbank in Mirfield, Yorkshire.
- We partner with International Health Partners (IHP) to donate and deliver essential PPE to our brave frontline NHS workers in the UK.
- Our national support line helps to signpost people to services relating to the Coronavirus (Covid-19) pandemic

THOUGHT LEADERSHIP

At the same time, we have pushed on Thought Leadership with our Webinars including on:

- *Humanitarian Ethics in Covid* by Dr Hugo Slim formerly of ICRC and now at Oxford.
- *Mental Well Being & the Covid Crisis* by Professor Jeremy Howick, Director of the Oxford Empathy Programme, University of Oxford
- *The Global Economy & Covid* by Professor Atif Mian, Princeton University
- *Cancer Care in the Covid era* by Royal Marsden Cancer experts.

WHAT NOW?

The covid-19 crisis has hit many charities financially with a massive dip in donations. More than 53% of charities have reported a drop in donations, however most have reported a spike in demand for their services. Despite the different streams of funding made available by the UK government, many charities are still struggling.

Humanity First's huge volunteer base ensures great efficiency and our pound or dollar goes much further. All our management team here do not take a salary for their services.

Want to help?

We need the support of our donors to continue to carry out the work we do. Help us reach out to many more people here in the UK and abroad by donating to our Coronavirus Emergency Appeal. For more information visit: hfuk.org

Comment

Fighting for the birds

Our feathered friends are struggling. Standing up for them in court may be the best bet to avert an avian apocalypse, says **James Thornton**

BIRDS are vital. They are landscape creators, habitat regulators and pollinators, as well as treasured wildlife. But they are under threat everywhere in the world and, without protection, their future could be very grim indeed.

Migratory birds are a case in point. Their arrival and departure dates have fascinated people for millennia. What is evident is that a typical migratory bird relies on many different locations throughout its annual cycle for food, rest and breeding. This is crucial for survival. Our activity increasingly intersects with migration paths, with impacts ranging from landscape changes to noise, light and air pollution.

More than 90 per cent of migratory birds are inadequately protected on their journeys around the world. Most such species have declined in past decades, as a result of the likes of habitat loss and hunting. These birds and their habitats need safeguarding and taking legal action may be our best hope of doing this. My colleagues at the environmental law charity ClientEarth and I are currently involved in a case that shows why.

The Tagus estuary in Portugal is one of the world's most important wetlands and more than 300,000 birds regularly winter there, including waterfowl, ducks, waders, flamingos and gulls. While the Portuguese government recognises this is the country's most important wetland, it also plans to build a new airport right on top of it called Montijo airport.

MICHELLE D'URBANO

While this will destroy part of the wetland, the problem goes beyond the footprint of the airport. In order to reduce the possibility of collisions between flocks of birds and aircraft, you have to scare birds away from a much wider area. In 2003, the UK government discounted the possibility of an airport at Cliffe in Kent partly for this reason.

We believe the project in Portugal fails to comply with both EU and national environmental laws that safeguard protected sites against development that risks serious harm to ecological health. So we are teaming up with SPEA, a Portuguese bird protection organisation, and other NGOs to take the government to court. We don't take such action lightly and only use it as a last resort when all other elements of environmental governance have failed.

We are bringing this case to protect bird species from around the world that depend on this unique habitat for survival and to raise the voices of all who stand with us. We will argue that the airport would not only impact migratory birds that winter in the estuary, but also those that use the Tagus as a migratory stopover before travelling beyond Portugal. Additionally, increased air travel will affect Portugal's ability to meet its obligations under the Paris climate agreement, while the wetlands themselves are important carbon sinks and vital to climate adaptation and mitigation.

A victory would mean the safeguarding of a vast, vulnerable protected area and a future in which the birds that use it can thrill our descendants. The first challenge has been submitted to the courts and we currently await the legal response to it from the Portuguese authorities.

In the past decade, we have helped to stop illegal logging of the Bialowieza Forest in Poland, taken the UK government to court and won three times over illegal levels of air pollution, won a world-first climate risk case over the construction of Europe's last coal-fired power station in Poland and helped to launch a climate justice case against the Australian government for failing to mitigate the effects of global warming in the Torres Strait.

Failure to protect ecologically important sites will cause irreversible losses to wildlife and damage to our climate. Environmental thinking should never be an afterthought. ■

James Thornton is CEO of ClientEarth. He tweets @JamesThorntonCE

#FactsMatter

A loaded term The word "monoculture" is often used to signify all things bad about agriculture, but if you dive in to what it really means, you may be surprised, writes **James Wong**

James Wong is a botanist and science writer, with a particular interest in food crops, conservation and the environment. Trained at the Royal Botanic Gardens, Kew, he shares his tiny London flat with more than 500 houseplants. You can follow him on Twitter and Instagram @botanygeek

James's week

What I'm reading
Mountains of scripts, while filming a new BBC series.

What I'm watching
Extinction: The Facts. *David Attenborough on amazing form, as always.*

What I'm working on
The usual mix of research for columns, radio and TV. I really need more of a life.

This column appears monthly. Up next week: Chanda Prescod-Weinstein

AS SOMEONE who spends far too much time reading academic journals and far too little talking to real people, I find it fascinating how different the actual meaning of scientific terms can be to how they are often used in popular culture. It is like the Alanis Morissette interpretation of "ironic" compared with, well, what the word actually means. Ironically, kind of ironic, you might say.

Of all the terms with colourful interpretations that I see used in conversations, in the media and online, perhaps the most common is "monoculture", especially in the field of environmentalism. Far from this just being the boring pedantry of a science geek, as a passionate conservationist, I think it is crucial that we know what this word actually means if we are to avoid environmental own goals. So here we go...

Monoculture is often used as a quick internet byword for "bad" when it comes to food and sustainability. Immediately bound up in narratives on the overuse of pesticides, fertilisers, water and land, the frequency with which biodiversity loss, depleted soils and industrial agriculture are used in the same sentence might lead you to think that they are synonyms for monoculture.

It can also be used as a sort of tribal label, too. If you follow social media skirmishes between carnivore and vegan diet activists – though it is probably best not to – you will find that monoculture is a word used by both sides to discredit opposing dietary views. Yet surprisingly, mixed into all of this are environmentalists using the term to actively push for changes that can be seen as being in direct opposition to their stated aims.

So what is monoculture in reality? Agriculturally, it just means an area composed of a single crop, rather than a mix of them. Instead of being a modern, industrial spectre, it is a practice that is as old as agriculture itself, and not without good reason. Focusing on just one species makes everything from sowing to harvesting easier and more efficient for the farmer, allowing much higher yields of crops from a given area of land.

This efficiency can often extend down to resources like fertilisers and pest control measures, meaning farmers can – theoretically, at least – use agrochemicals at the minimum levels they need to be effective. Yes, biodiversity in these fields is lower, but the higher yields and lower resources needed mean that significantly more mouths can be fed from far less land, leaving more space for nature elsewhere.

> **"Instead of a modern, industrial spectre, monoculture is a farming practice that is as old as agriculture itself"**

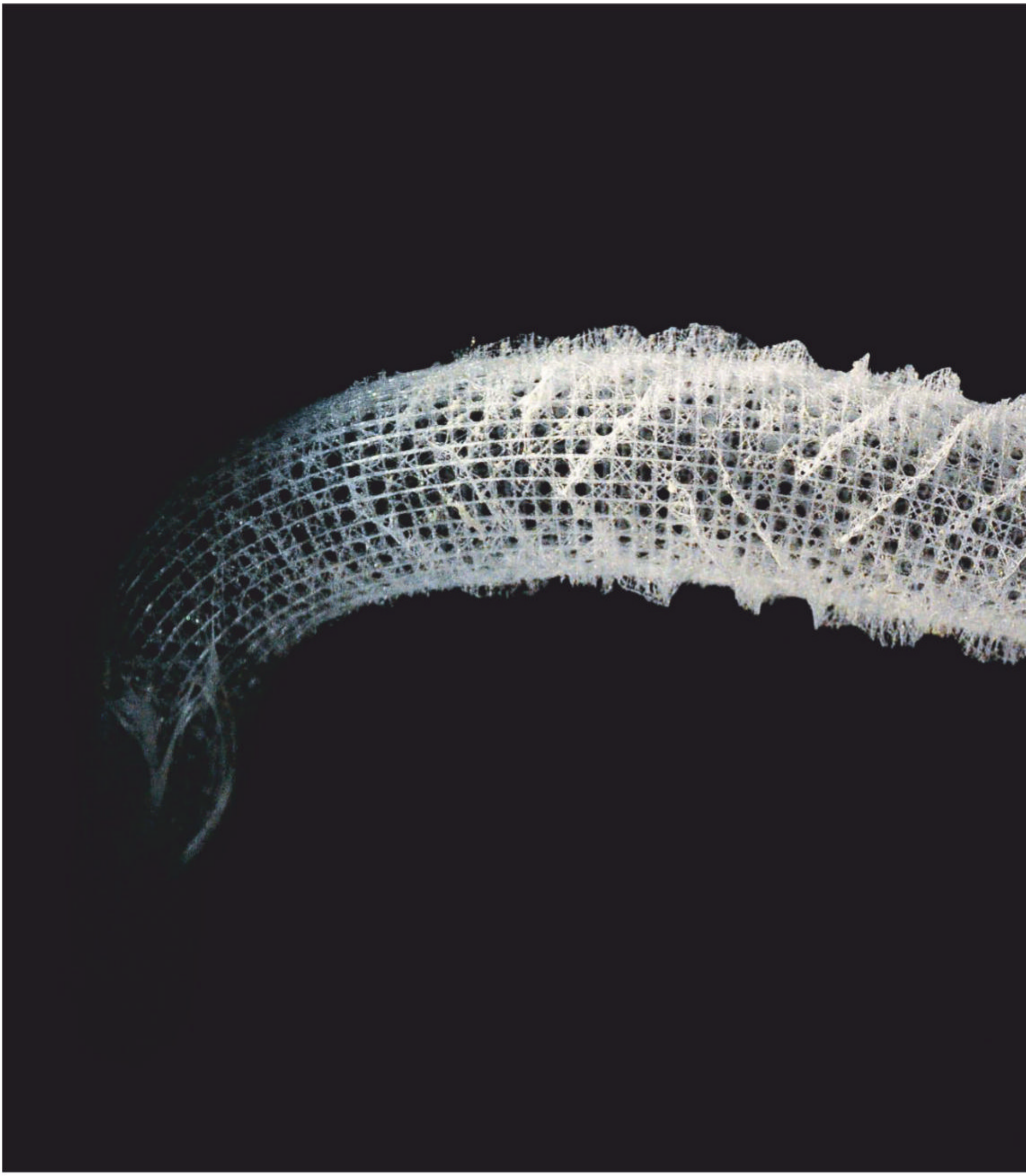
Outside of the world of theory, though, things get more complex. Putting all your agricultural eggs in one basket can leave farming systems and the societies built on them at perilous risk from external shocks, such as new pests and diseases. The knock-on effect can ironically mean more resources are used in a system that originally may have required less of them. This is before we even mention that just because technological efficiencies mean more land could be left to nature, it doesn't mean political or economic decisions will let this actually happen. Humans are tricky like that.

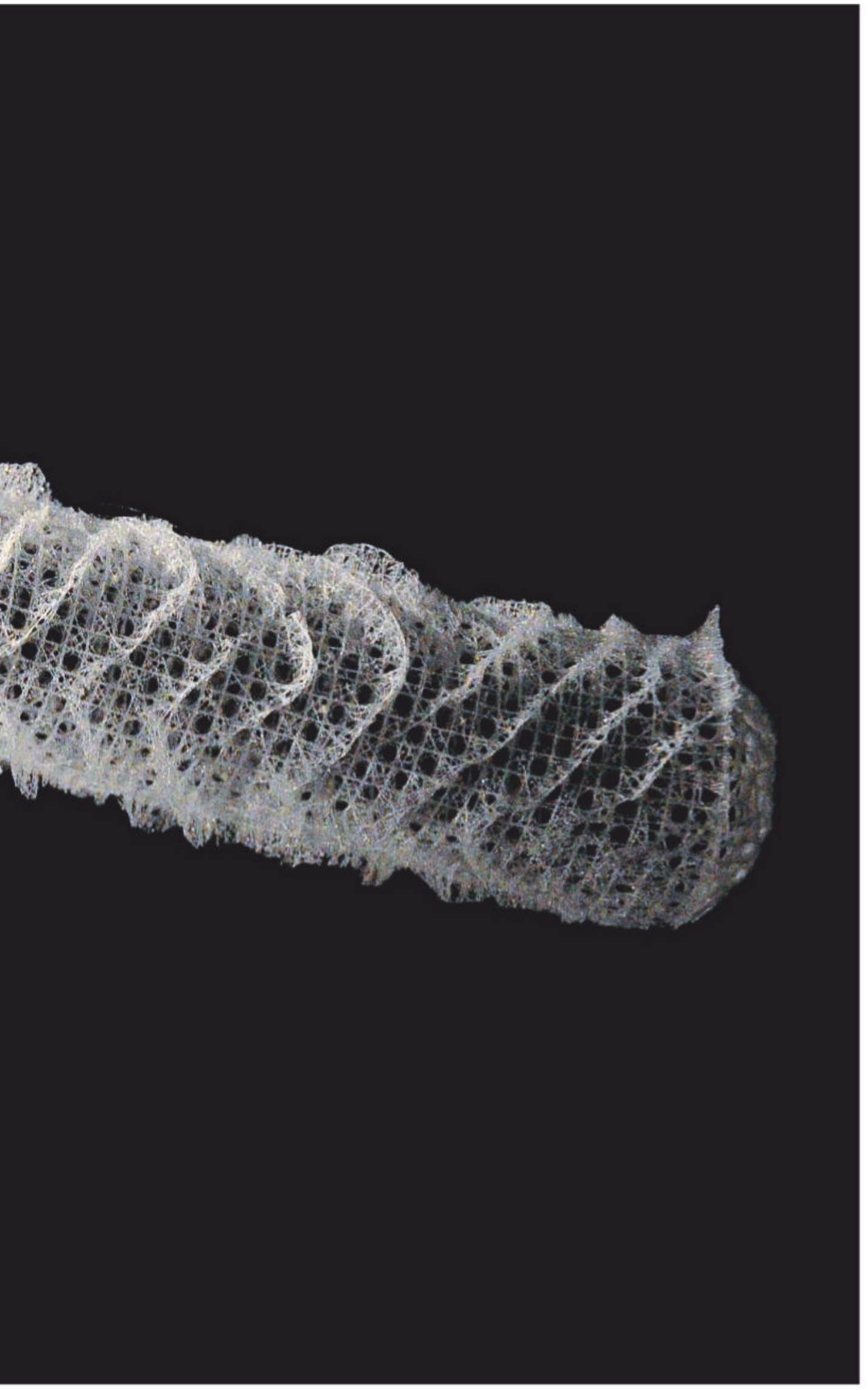
If this wasn't complex enough, there is significant leeway in how to interpret the scientific definition of monoculture in the first place. Technically, vast human-engineered grasslands dedicated solely to cattle production are monocultures. However, proponents of these will argue that the pasture the cows eat means they aren't. On the flip side, it is easy to say that never-ending sugar beet fields aren't true monocultures, as these are grown on rotation, with crops like carrots or potatoes planted on alternate years.

Even the size of the plot makes a difference. You could easily describe the land of a small farm growing just one thing as a monoculture (and perceive it as "bad"), but not that of a larger farm growing mixed crops (thus thinking of it as "good"), even if the size of land dedicated to each crop was larger than the smaller farm in its entirety.

So where does that leave us? Well, if you are looking for a neat label to use as a byword for "bad", monoculture's context-dependant definition and its mixture of benefits and drawbacks mean there is plenty of scope to use it to support your existing beliefs. It can be neatly deployed to back pretty much any foodie position, even contradictory ones and those that may actually go against the environmental goals you seek. But is that what being a conservationist is about?

If we really care about the environment, we should care about evidence. And in our beautifully complex world, there are very few absolutes. So let's look at the full picture of what is in front of us on a case-by-case basis, even if it is hard, and not just (mis)use words like monoculture because it is easy. ■





Sponge power

Image courtesy of
Matheus Fernandes/Harvard SEAS

THIS extraordinary, intricate marine sponge that lives deep in the Pacific Ocean could inspire even stronger, yet lightweight materials for use in anything from skyscrapers and bridges to spacecraft.

The Venus's flower basket (*Euplectella aspergillum*) is classed as a glass sponge because the lattice skeleton that supports its tubular body is made of silica. The skeleton's chessboard-like geometry, formed from diagonal struts fused to an underlying grid, is mimicked in architectural design to achieve things like evenly spreading loads across a bridge or shelf.

Yet even though the technique has been used for centuries, researchers knew that it didn't reach the full potential of *E. aspergillum*'s design as it wastes material, requires a lot of maintenance and can't support extremely heavy loads.

Last week, researchers at Harvard University showed that the diagonal reinforcement of the sponge's lattice design allows it to take on heavier loads, boosting its structural strength by more than 20 per cent (*Nature Materials*, doi.org/d97g).

The discovery adds to a growing appreciation of the superiority of certain biological materials, such as fungi and bamboo, over artificial ones. Some sea sponges have previously proved useful in other ways, too, by inspiring a cheaper way to make solar cells.

Gege Li

Editor's pick

Maybe Venusians are just Martians, like us

19 September, p 7

From Dudley Miles, London, UK

You report that life in Venusian clouds "could upend our ideas about what life can be and how it arises". However, we know that Martian rocks have travelled to Earth and a lesser quantity have travelled from Earth to Mars. There will have been a similar exchange between the two planets and Venus. Life on Venus, if it exists, may originate elsewhere.

As astrobiologists have pointed out, life on a moon of an outer planet would be more significant, as transfer from Earth or Mars could be rare, so it would almost certainly have an independent origin.

Should we jump the gun on vaccination?

Letters, 19 September

From River Axe-the-Tax, Manchester, UK

Simon Goodman expresses concern about Russian plans to roll out a coronavirus vaccine without the usual stage III clinical trials, rightly saying that these can help spot harm. Similar concerns have to be raised about Donald Trump's desire for a vaccine to be released before the US election.

But I question whether standard safety procedures are relevant in the current situation. In assessing the consequences of delaying widespread vaccination pending such a trial, we should consider not just the direct medical consequences to those infected, but also the effects of prolonged or repetitive lockdown on mental health and on the social and economic life of the community.

Some birds are seen as less fully fledged than others

5 September, p 36

From Brian Reffin Smith, Berlin, Germany

So many of the questions and answers within Eddy Keming Chen's article "Welcome to the fuzzy-verse" seem, perhaps paradoxically given the article's emphasis on mathematics, to be due to human choice, and hence to become impossibly vague. We can choose to think about things as if they were well defined, or not.

For instance, if you ask people to rate animals according to their "birdness", where 0 is absolutely not a bird and 1 is totally a bird, I suppose a robin or an eagle would score a 1, an elephant a 0. But a penguin might score less than 1 and a bat would probably be more than 0. However, if you ask averagely informed people if a penguin or a bat is a bird, you would get the right answer.

Similarly, I define Chen's contentious "bald" as H-1, where H is the number of hairs on my head.

One bit of science where reproducibility is a cinch

22 August, p 36

From Andrew Glassner, Seattle, Washington, US

Your interview with Stuart Ritchie paints a bleak picture for reproducibility in science. But taking all of science to task like this may be too broad-brushed.

In computer science, particularly in fields such as computer graphics and artificial intelligence, publications are now expected to include a link to a public repository, such as GitHub, providing the complete source code. Reproducibility is a snap: install the code and run it.

For all but the most gargantuan systems, every claim made by the authors can be easily confirmed or demonstrated to be false. This explicit mechanism for easy, objective reproducibility may partly explain the explosive growth of these fields.

Why global greening won't keep climate change at bay

15 August, p 38

From Patrick Davey, Dublin, Ireland

Your article explores how the rate of carbon absorption by forests may alter as the climate changes.

While I was working in Uganda with Mountains of the Moon University, one of our central projects involved growing roses. We were about 300 metres higher than Entebe, where the majority of the flower industry is located, and our roses grew better.

The reason was related to lower night-time temperatures. During the day, photosynthesis generates sugars that store the energy for growth. Photosynthesis rises with temperature, but if temperatures are high at night, much of the sugar formed during the day is used to maintain night-time metabolism and not for growth.

Colder nights reduce the rate of metabolism, leaving the sugars to power growth. Thus it appears that although warmer days may offer some benefits to plants, these are likely to be outweighed by higher night-time temperatures, leading to reduced growth.

The only real option to tackle the damage we are doing to the planet's climate is to reduce our carbon emissions.

Books can store carbon as well as knowledge

Letters, 12 September

From Ro Scott, Cromarty, Ross-shire, UK

With reference to the letter from Eric Kvaalen on the long-term preservation of harvested timber as a carbon store, my favoured domestic carbon store is paper, in the form of books. Around the world, libraries must contain a massive amount of sequestered carbon dioxide, some of it of great antiquity. Barring wars and pyromaniacs, these seem set to persist for the long term.

Perhaps life's origins happened in slow motion

8 August, p 34

From Jim Ainsworth, Kingsland, Herefordshire, UK

As to which came first when life arose – structural integrity, metabolism or reproduction – Michael Marshall explains that it is possible all three happened at once. He adds that metabolism is the trickiest system to account for, since it involves "creating entire sequences of chemical reactions... controlled by battalions of protein enzymes, which can't have existed when life began".

However, we learned in the previous edition that microbes may have existed deep beneath the sea for 100 million years in "minimally active mode", with barely enough energy to power either metabolism or reproduction (1 August, p 13). This suggests that we should maybe cut the first proto-microbes some slack, at least allowing them a few million years in which to get one system going before another is fully functioning.

A simple explanation for weird baby dinosaurs?

5 September, p 20

From Paul Wood, Hamilton, New Zealand

You report that baby titanosaurs had a sharp horn on their snout, something that was absent in any adult fossils, but offer few possible reasons for this difference. Perhaps it was there to help them break out of their egg, just as birds use their beaks to hatch today. ▮

For the record

▮ **Private astronauts going to the International Space Station will be in addition to NASA astronauts, they won't replace them (19 September, p 18).**

Want to get in touch?

Send letters to letters@newscientist.com; see terms at **newscientist.com/letters**

Letters sent to New Scientist, 25 Bedford Street, London WC2E 9ES will be delayed

Children will love the Art issue of AQUILA Magazine!

There is much more to Art than meets the eye. Science shows that Art is good for us all - and children who enjoyed making rainbow window art earlier this year will find this glorious issue of **AQUILA** takes them to the next level!

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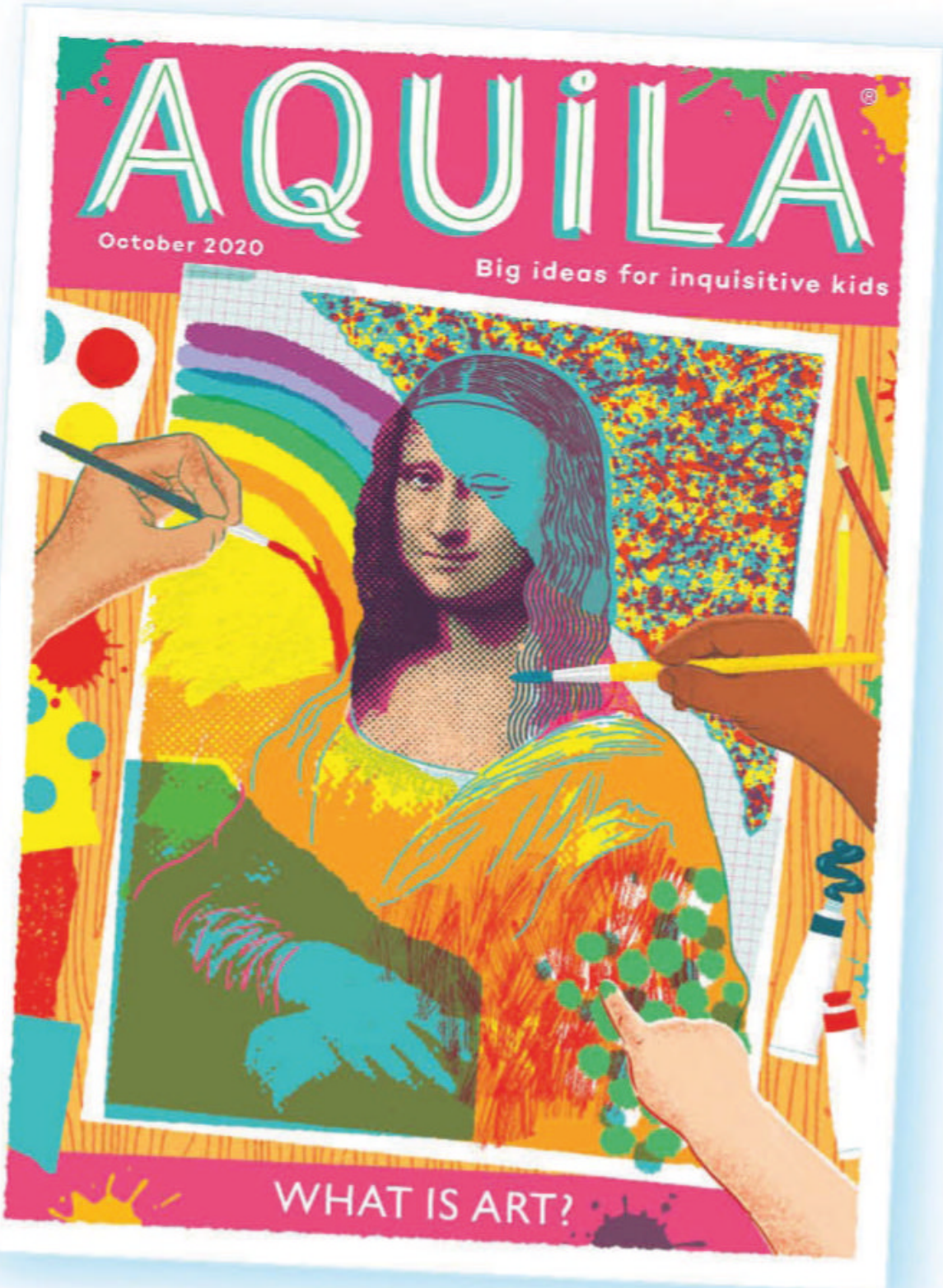

In the October issue: AQUILA reveals the therapeutic effects of drawing on the human brain, and how **Art** together with **Science** can help explain the world around us; we meet some **Animal Artists** and discover that **Graffiti** has been around for at least 2000 years! PLUS: children can doodle with **Geometric Islamic Art**, solve a hilarious **Art Heist Mystery** and take part in **AQUILA's fantastic '31 Days of Art' challenge**!

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New Scientist

A street dog named Laika

Space Dogs follows the story of the stray who was the first living thing to orbit Earth, providing a canine-eye view for the first time, writes **Elle Hunt**

Film

Space Dogs

Elsa Kremser and Levin Peter

Available for streaming on Mubi

A RUSSIAN dog named Laika was the first living creature to orbit Earth. This fact is so well known as to scarcely need stating, but in becoming trivia, the ambition and brutality of the early Soviet space age experiment she was part of have been lost.

Space Dogs, a documentary with a limited streaming release in the UK in September and October, attempts to expand our perspective of this chapter in history to include a dog's-eye view.

Laika died shortly after launch in November 1957, her body circling the Earth in Sputnik 2 "like some cosmic flotsam", says actor Aleksei Serebryako, who contributes the film's occasional narration in Russian.

The craft she perished in burnt up as expected on re-entering the atmosphere in April 1958, though according to legend, Laika's ghost returned to Earth.

This new take on her story combines archive material from the Soviet era with footage of modern-day strays in Moscow to invoke what Laika's life might have been like before she was forcibly recruited into the test programme.

Directed by Elsa Kremser and Levin Peter, the documentary is light on narrative and exposition, instead presenting, sometimes whimsically, the street dogs as Laika's descendants, dreaming of the space exploration that was ultimately her doom.

At times, the camera quietly accompanies the dogs as they chew parked cars, forge alliances, see off threats and otherwise roam the city with apparent purpose. This dream-like atmosphere is punctured by sudden bursts of high energy and aggression, true to the life of a stray.

The film mirrors this with footage of the experiments on the space dogs that came after Laika, conducted in part as a result of her perceived "success".

Indeed, the Soviet Union publicly maintained she was alive for several days after her flight and died humanely as planned. Only in 2002 did new research establish that she had perished just hours after launch.

Peter and Kremser have said they sought to show the "bitterness" in the relationship between dogs and humans. The film's canine take does cast a new light on these scenes from the lab, showing dogs strapped into a centrifuge or draped in wires, visibly trembling.

But *Space Dogs* is essayistic in scope to the point of obscuring facts, such as in its assertion about its canine subjects that "after weeks in stifling darkness, only a few dogs returned to Earth alive".

In attempting to create an exhaustive list of orbital and suborbital flights of the Soviet space dog programme, *Animals in Space* authors Colin Burgess and Chris Dubbs were thwarted by incomplete and inconsistent record-keeping.

> **"The film invokes what Laika's life might have been like before she was forced into the space race"**

Their best estimate was that dogs were launched into space 71 times from 1951 to 1966 and there were 17 deaths.

Of the dozens of dogs that the USSR sent into space, only Laika's death was a certainty. The first to orbit Earth and return alive were Strelka and Belka in 1960, with Strelka's puppies later presented as proof that it was possible for living things to thrive after a stint in orbit.

It was certainly a crude public relations ploy – but the presentation in *Space Dogs* of Strelka's mating as a sinister plot to produce the "first cosmic children" demonstrates the film-makers' readiness to deploy their creative licence.

If the aim was to show how the space dogs were mistreated or reveal Russia's embrace of Laika as a self-serving source of national pride, more structure and facts would have been effective.

Instead, *Space Dogs* adds to the mythology – though, of the reductive and the romantic interpretations of Laika's story, it may come the closest of any to offering a canine perspective. ■

Elle Hunt is a freelance writer based in London

RAUMZEITFILM

The unwanted mutts of Moscow paved the way for the first cosmonauts

The power of drones

Drones are waging a stealth war on how we see society and rewriting how we think about war and peace, finds **Simon Ings**

Book

The Drone Age: How drone technology will change war and peace
Michael J. Boyle
Oxford University Press

AGEFOTOSTOCK/ALAMY

The US Air Force operates military drones such as this MQ-1 Predator

MACHINES are only as good as the people who use them. They are neutral – just a faster, more efficient way of doing something that we always intended to do. That is the argument wielded by defenders of technology, anyway.

Michael Boyle, a political scientist at Rutgers University in New Jersey, isn't buying it. From commerce to warfare, spy craft to disaster relief, our menu of choices "has been altered or constrained by drone technology itself", he writes at the end of this concise, comprehensive overview of the world the drone made.

Boyle manages to be nuanced and terrifying at the same time. At one moment, he is pointing out the formidable obstacles in the way of launching a major drone attack. In the next, he is explaining why political assassinations by drone are just around the corner. Turn a page setting out the moral, operational and legal constraints keenly felt by upstanding US military drone pilots, and you are confronted by shadowy handlers in government, who operate with virtually no oversight.

Though grounded in just the right level of technical detail, *The Drone Age* describes not so much the machines but the kind of thinking they have encouraged: an approach that no longer distinguishes between peace and war. In some ways, this is a good thing. Assuming war is inevitable, what isn't to welcome about a style of warfare that involves working through a kill list rather than cutting swathes through the enemy's population?

Well, two things. For US readers, there is the way a few careful drone strikes proliferated under President Barack Obama (and even more so under Donald Trump) into a global counterinsurgency air platform. And peacetime living is affected for all of us, too. "It is hard to feel like a human... when reduced to a pixelated dot under the gaze of a drone," Boyle writes. If information gathered on us expands, but not the understanding or sympathy for us, where is the positive for society?

Boyle brings proper philosophical thinking to our relationship with technology. He is indebted to French philosopher Jacques Ellul, whose book *The Technological Society* (published in English in 1964) transformed our thinking. Ellul argued that in applying technology to a problem, we adopt a mode of thinking that emphasises efficiency and instrumental rationality, but also dehumanises the problem.

Applying this to drones, Boyle writes: "Instead of asking why we are using aircraft for a task in the first place, we tend to debate instead whether the drone is better than the manned alternative."

The UN has been known to fly unarmed surveillance drones low to the ground to deter rebels. If you adopt the thinking that Ellul described, this must be good: it means hostiles have been scattered efficiently and safely. In reality, there is no reason to suppose that violence has been avoided, only redistributed. Remember how al-Qaeda, decimated by drones, reinvented itself as an online brand.

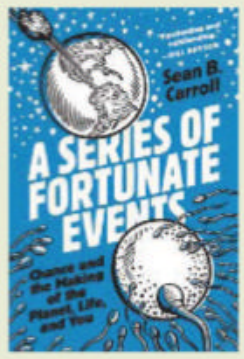
Boyle warns us that drones vary so substantially that "they hardly look like the same technology". And yet *The Drone Age* keeps this heterogeneous flock together well enough to give it historical and intellectual coherence.

The book is just as valuable on surveillance, the rise of information warfare and the way that the best intentions can turn the world we knew on its head. But, ultimately, if you read only one book about drones, this should be it. ▮

Don't miss

Watch

Connected, in cinemas from 9 October, finds the Mitchell family trying to bond one last time, but the electronic devices they brought with them on their road trip have other ideas, in this animated take on the technological singularity.



Read

A Series of Fortunate Events occupy biologist Sean B. Carroll's attention as he sets about explaining the role of chance in the evolution of our planet, our environment and us. Life might have turned out differently – but was it always bound to appear?

Listen

The Microscopists gather to discuss their work, their discoveries and their beloved equipment with host Peter O'Toole in this lively and revealing new podcast from Bitesize Bio and Zeiss Microscopy.

SONY PICTURES ANIMATION

The TV column

Living on another planet *Raised by Wolves* is an original and visually stunning new science-fiction series, produced by Ridley Scott. Set on a recently discovered exoplanet, it has echoes of *Prometheus*, *Alien* and *Dune*, says **Emily Wilson**

Emily Wilson is the editor of *New Scientist*. You can follow her on Twitter @emilyhwilson or email her at editor@newscientist.com

COCO VAN OPPENS

Mother (Amanda Collin) is an android raising children on Kepler-22b

This review contains zero spoilers other than the basic premise and setting.

THE blockbuster new science-fiction series from HBO Max, *Raised by Wolves*, is set on a real exoplanet: Kepler-22b.

Discovered in 2011 by the Kepler Space Telescope, Kepler-22b was the first exoplanet to be found in the habitable zone of its star. In reality, we don't know much about what it would be like to stand – or perhaps swim or float – on whatever this world can boast for a surface. Yet you would think you would probably need a spacesuit on arrival, right?

Such things aren't a concern in *Raised by Wolves*, an original work by US screenwriter Aaron Guzikowski. Not that that is a criticism – this is an ambitious and visually stunning piece of science fiction and I, for one, am prepared to forgive the odd missing space helmet, and even the occasional plot wobble.

Here, Kepler-22b is sandy and windy, with rocky outcrops and air that is OK to breathe. It is warm enough by day and you can even grow things outside, just about, but the night leaves behind drifts of snow.

It actually looks very much like the moon the crew head to in the film *Prometheus* – which isn't that surprising when you learn that the first two episodes of *Raised by Wolves* were also directed by Ridley Scott and that he is an executive producer on the show.

> **"The look of the androids is quite arresting, with their rubbery bodysuits and Joan of Arc helmets"**

Much of its visual style actually feels very like that of *Prometheus*, and there are many other echoes of Scott's *Alien* sequence here, right down to the thin, white liquid that serves as blood for the androids.

Ah yes, the androids! Two such beings, Mother and Father, have left war-torn Earth to raise a new generation of human children on Kepler-22b. The look of the robots is quite arresting, with their strange, rubbery bodysuits and Joan of Arc helmets.

Mother, played by Amanda Collin, is particularly captivating. She seems to feel emotion and to have real softness, as she cares for the tiny infants that she and Father (Abubakar Salim) rear up from a precious cargo of embryos they brought to the Kepler-22 system. But there is steel in Mother too, telegraphing all that is to come.

There are other hints of darkness right from the start. The planet has strange tunnels going straight down into its depths, allegedly dug long ago by mysterious, ancient serpents, into which people and things tend to disappear. It is all very *Dune*, mixed up with a bit of *Pitch Black*, David Twohy's cult sci-fi flick.

The tiny, unconventional family isn't alone in having chosen Kepler-22b for refuge. An "ark" ship is heading their way, carrying a very different bunch of colonists on board (one of whom is played by the very charismatic Travis Fimmel, aka Ragnar Lothbrok in the TV show *Vikings*).

What is wonderful about a fresh show that isn't based on any source material is that you have no idea what is going to happen, so I won't ruin it for you by veering too close to the plot. Suffice to say, things are going to get a great deal more complicated as the 10-episode first season unfurls.

Actually, the show was immediately judged a hit in the US, so much so that season two has already been commissioned. Annoyingly, the first batch of episodes isn't yet available in all regions. Fingers crossed that this will be sorted out soon. ▮

TV

Raised by Wolves
Aaron Guzikowski
HBO Max

Emily also recommends...

Films

Pitch Black
David Twohy
This sci-fi horror, released in 2000, is so incredibly clever in its use of light and sound on a strange, alien planet. It has been endlessly copied, of course, but it is a bona fide, bone-dry classic.

Aliens
James Cameron
So old now – 1986! – but still so nutritious. Alien *is obviously posher, cleverer, more original, blah blah blah, but this sequel is my personal favourite. I have watched it a dozen times and I still find so much to enjoy in it.*

Is anybody out there?

News from Venus has raised fresh hopes of finding alien life right next door – but that is the easy bit. What are the chances we will find intelligent life elsewhere in the universe, asks **Dan Falk**

EARTH makes life look easy. Our home planet is teeming with some 9 million species, including at least one smart enough to contemplate intelligent life existing elsewhere in the universe. We love to think it is out there – that we aren't a one-off, alone in an unimaginably vast cosmos.

A string of discoveries has boosted the idea that extraterrestrial life might be abundant. The growing catalogue of exoplanets, many orbiting within the "habitable zone" of their host stars, points to seemingly ample real estate on which life might be found. Closer to home, subsurface oceans on icy moons in the outer solar system hint that some life-friendly conditions might be commonplace. And then there is last month's discovery of phosphine in the poisonous atmosphere of Venus (see page 12), which suggests life might flourish even in seemingly hostile places.

With all that in mind, it is easy to imagine that intelligent life has evolved on at least one planet around one of the 100 billion or so stars in our galaxy. So easy, in fact, that we tend to assume, given the vastness of the visible universe, that there must be other technological civilisations out there. Yet we haven't heard from them. Why?

In the absence of evidence from deep space, some astronomers have recently returned their focus to Earth – and the only example of intelligent life we have – for a fresh look at the question. What they found meshes with what biologists have been whispering for a while: that anyone expecting to hear from an alien civilisation should settle in for a long wait.

A famous formula

For all its lack of success, the search for extraterrestrial intelligence (SETI) has never lacked for optimism. For decades, SETI researchers have swept the skies with radio telescopes in the hope of finding messages from another technological civilisation. But the truth is that we have no idea if there is anybody out there.

To estimate the number of intelligent civilisations capable of transmitting or receiving radio signals within the Milky Way, we often fall back on a formula drawn up by astronomer Frank Drake in 1961. The Drake equation multiplies seven variables, starting with the rate of star formation in the galaxy, the fraction of those stars with orbiting planets and the fraction of those planets that are habitable. Thanks largely to the Kepler space telescope, which discovered thousands of exoplanets before it retired in 2018, we now know that pretty much all stars host planets, many of which could harbour life. That means we can use solid numbers for several of the Drake equation's terms.

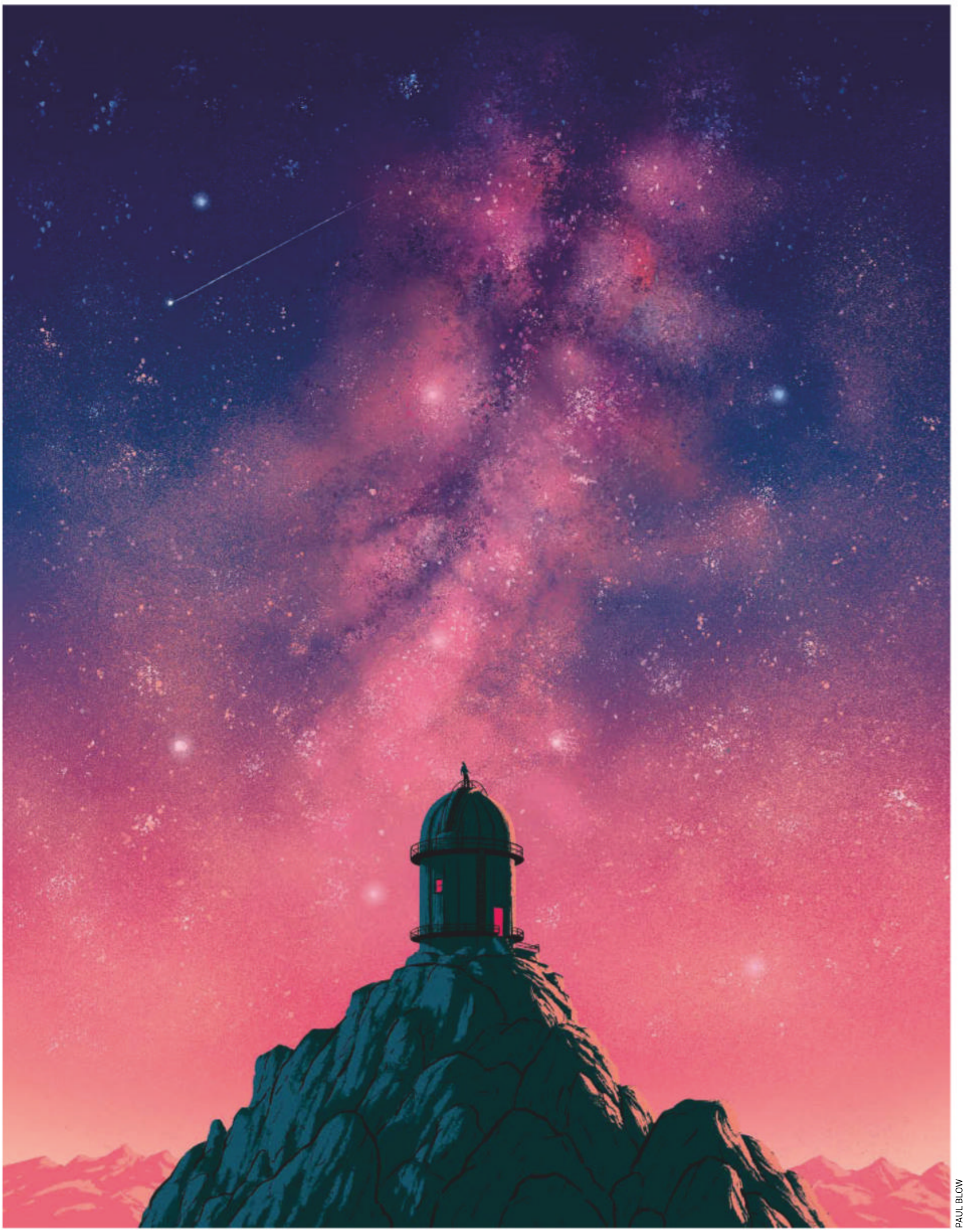
But the calculation also contains other biological variables. Here, we can do little more than guess. What is the probability that, given a habitable world, life gets started on it? And if life does arise, what are the chances that it becomes intelligent?

As things stand, these terms in the Drake equation are so poorly known that the calculation as a whole can end up spitting out numbers that suggest we are alone in the galaxy or instead that our civilisation is one of millions. It all depends on what you put in.

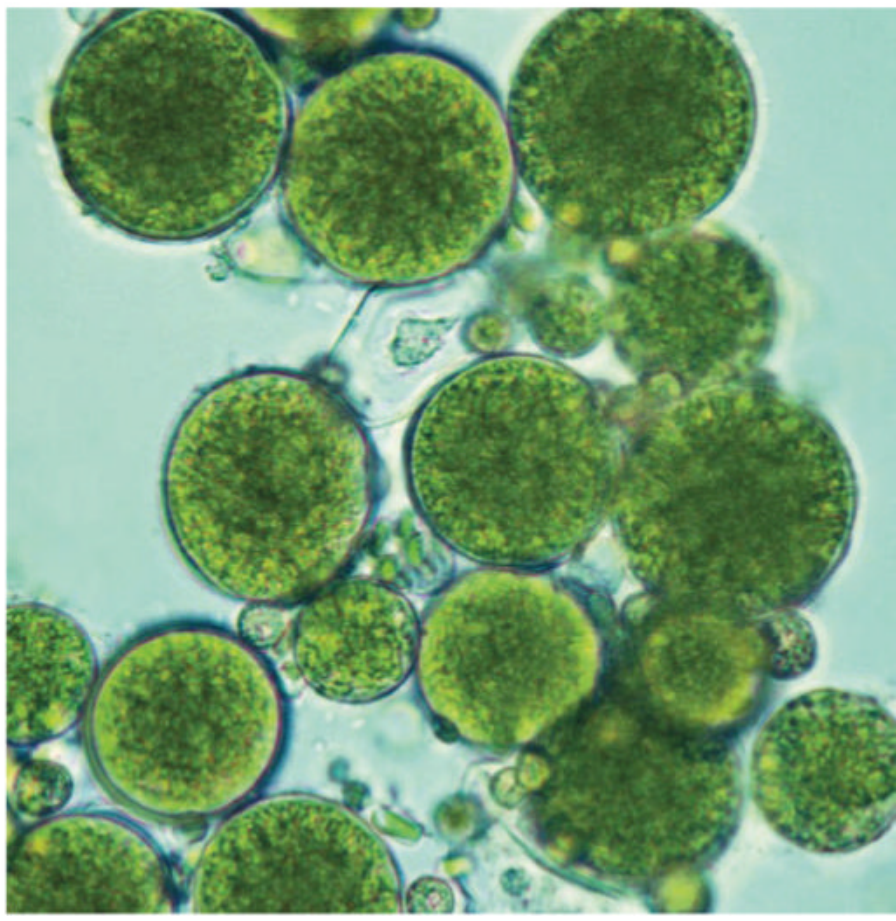
A conventional approach to narrowing down these probabilities would involve doing some statistics. You observe a large sample of Earth-like planets over billions of years to see how frequently life arises and how often any life that does emerge becomes intelligent. The trouble is that we have a sample size of one – Earth – and a grand total of two data points concerning it. We know that life appeared on our planet fairly quickly after it was formed some 4.5 billion years ago – within the first 300 to 900 million years – while intelligence is a much more recent development.

But there is another way to approach probabilities, and it could change how we think about the odds of finding alien civilisations we could communicate with.

Bayesian statistics takes its name from 18th-century mathematician Thomas Bayes. He came up with a way to calculate the probability of a future event based on what ›



PAUL BLOW



The jump from simple to complex life may have been a complete fluke

has come before by constantly updating the odds as new information becomes available. Roughly put, probability depends not only on the data you have, but also on your prior assumptions. So Bayesian statistics provides a clever way to calculate probabilities from limited data.

Prior beliefs, or "priors", are crucial. In this case, they involve our beliefs about how quickly life appeared on Earth after its formation and how quickly intelligence followed. Once we select values for these priors, we can draw conclusions about the relative likelihood of these processes playing out again – either on Earth, if we turned back the clock, or on other similar planets.

In 2012, David S. Spiegel and Edwin Turner, both then at the Institute for Advanced Study in Princeton, New Jersey, were the first to apply a Bayesian approach to life's early appearance on Earth. They relied on so-called uniform priors: if you divide our planet's history into uniform chunks (each spanning 100 million years, say), you can then assert that life is equally likely to get started in any one of those chunks. But they described their results as "inconclusive". The early appearance of life on Earth hinted at its emergence being relatively common, but they were unable to draw a stronger conclusion.

Now, David Kipping, an astronomer at Columbia University in New York, has found a way to perform the calculation independently of the choice of priors, promising a more robust result. Roughly speaking, this boils down to betting that the probability of life appearing on a habitable planet and the probability of life evolving to become intelligent both ought to be either close to 0 (meaning it would never happen) or to 1 (meaning it would always happen), but not some arbitrary value in between. "It would be really odd if 50 per cent of Earth-like planets, with the exact same conditions as Earth, ended up with life on them and 50 per cent didn't," says Kipping. "You'd expect that either they pretty much all do or they pretty much all don't."

This produces four general scenarios that Kipping argues are more probable than all the others: life and intelligence are both rare; life and intelligence are both common; life is rare, but almost always gives rise to intelligence; or life is common, but rarely gives rise to intelligence.

Into this framework, he inserted the numbers. Just as there is some uncertainty about when life first got established, so the question of when intelligence appeared is open to debate. Did it arise with tool-using hominins a few million years ago or with the advance of modern science a mere 400 years ago? Drake himself saw the key moment as the development of radio technology, which happened little more than a century ago. In fact, Kipping points out that the date you take hardly matters: a few million years over a multibillion-year timescale makes little difference to the final result.

Uncommon intelligence

Crunching the numbers, Kipping found that the "life is common, but rarely gives rise to intelligence" scenario is about nine times more likely than the "life and intelligence are both rare" scenario. Remarkably, he also found that the "life is common" conclusion follows no matter what priors you take. Ultimately, Kipping concluded that the pair of intelligence-is-rare scenarios are favoured by three to two over the pair of intelligence-is-common ones.

"To me, that's so close to 50:50 that it's not worth getting too hung up on," he says. "It's a very 'soft' preference." Yet it does tell us something. Given a limited amount of data and some sophisticated maths, our expectations for finding intelligence beyond Earth are nudged "very gently toward a pessimistic view", says Kipping. "My bet is that life is common, but intelligent life may be rare."

This may be a minority position for astronomers, but it is something that biologists have been suggesting for some time: that we may have been overestimating the likelihood of life taking hold on habitable planets and the chance that life, once it appears, gives rise to intelligence.

Matthew Cobb, a biologist at the University of Manchester, UK, has argued that people have been too eager to assume that life has some sort of tendency towards increasing complexity – never mind intelligence. In a chapter he contributed to the 2017 book *Aliens: The world's leading scientists on the search for extraterrestrial life*, Cobb points out that there are myriad hurdles to get from simple life forms to intelligence, any one of which might never be cleared if Earth's history played out again.

The jump from simple organisms to multicellular eukaryotic organisms

L-R ED RESCHKE; HANS STRAND; MARCO BOTTIGELLI/GETTY IMAGES

consisting of complex, membrane-bound cells with a central nucleus, for example, may have been a complete fluke. It required two simple cells to bump into one another in a particular way, one absorbing the other – an event of "mind-boggling improbability", says Cobb. Similarly unlikely, he thinks, is the development of culture and intelligence. He notes that it is easy to imagine an alternate Earth in which, say, the scientific revolution never happens. All of which suggests we should exercise caution, if not outright pessimism, when it comes to estimating the chances that intelligence and ultimately technological civilisations evolved elsewhere.

But wait. What if evolution, even though it has no preferred "direction", nonetheless converges on certain useful characteristics – like intelligence, for instance? Wouldn't that boost the odds? After all, evolution has found multiple pathways leading to animals with eyes and wings. So perhaps evolution isn't quite as haphazard as it first seems. One might imagine that intelligence is at least as advantageous as seeing or flying. Might we then expect intelligence to appear often, wherever life has taken hold?

Cobb isn't convinced. "Human intelligence had a selective advantage for us," he says. "But there's no tendency in animal life for increased intelligence." Take fish. They first appeared about 450 million years ago, but we wouldn't describe them as intelligent life. "They're pretty smart – but they're fish," says Cobb. In the end, he leans towards a position similar to Kipping's: while various sorts of primitive life might be commonplace, intelligence may be much rarer.

"We may have overestimated the chance that life, once it appears, evolves intelligence"

Charles Lineweaver, an astrobiologist at the Australian National University in Canberra, goes further. He believes that when we define intelligence as some sort of generic quality, we are being disingenuous. What we really mean, he says, is human-like intelligence. That is a problem because such intelligence is a species-specific attribute of *Homo sapiens*. "And as soon as you take that term 'species-specific' seriously, there's no chance in hell that you should expect to find [intelligence] elsewhere," he says.

Of course, none of this proves that we are alone in the cosmos. Space is, after all, awfully large. With at least 100 billion planets in the Milky Way and trillions beyond, we still might expect a few technological civilisations to have cropped up over the aeons, in spite of the biological hurdles. But where making contact is concerned, we have to consider whether those civilisations have mastered radio technology, as well as the final term in the Drake equation: the length of time such civilisations last.

In June 2020, just a few weeks after Kipping's study was published, Tom ›

SETH SHOSTAK/SETI INSTITUTE

The Allen Telescope Array in California listens for messages from alien civilisations

Westby and Christopher Conselice at the University of Nottingham, UK, used a modified version of the Drake equation to estimate that there are at least 36 civilisations in our galaxy. They arrived at this figure by assuming that, given a planet hospitable to life, intelligent life typically appears after about 5 billion years, because that is how it played out here on Earth. Then they expressed this as a fraction of the length of time for which those hospitable conditions persist – roughly, the lifetime of the host star. They also assumed that once an intelligent civilisation arises, it lasts for at least 100 years. If they typically last longer than this, the pair's estimate for the number of civilisations in the Milky Way would increase.

All of which sounds distinctly optimistic, but the result was greeted with scepticism from many in the field. That is partly because in Westby and Conselice's estimation, the number of civilisations in the galaxy could be anything from four to 211. "The error bars are too huge to really mean anything," says Angelle Tanner, an astronomer at Mississippi State University. Another concern is that the analysis amounts to plugging best-guess numbers into the Drake equation, something astronomers have been doing for decades.

Long-distance call

But suppose there really are 35 other civilisations in the Milky Way. In that case, the average distance between them works out to about 17,000 light years, the pair conclude, putting a damper on any hopes we might have for back-and-forth communication. "It would take 17,000 years for any signal to reach us," says Conselice. "And even if we're able to understand it, any signal we send back would take another 17,000 years – and then another 17,000 years for them to reply. If there are thinking things out there, we're probably never going to make contact with them."

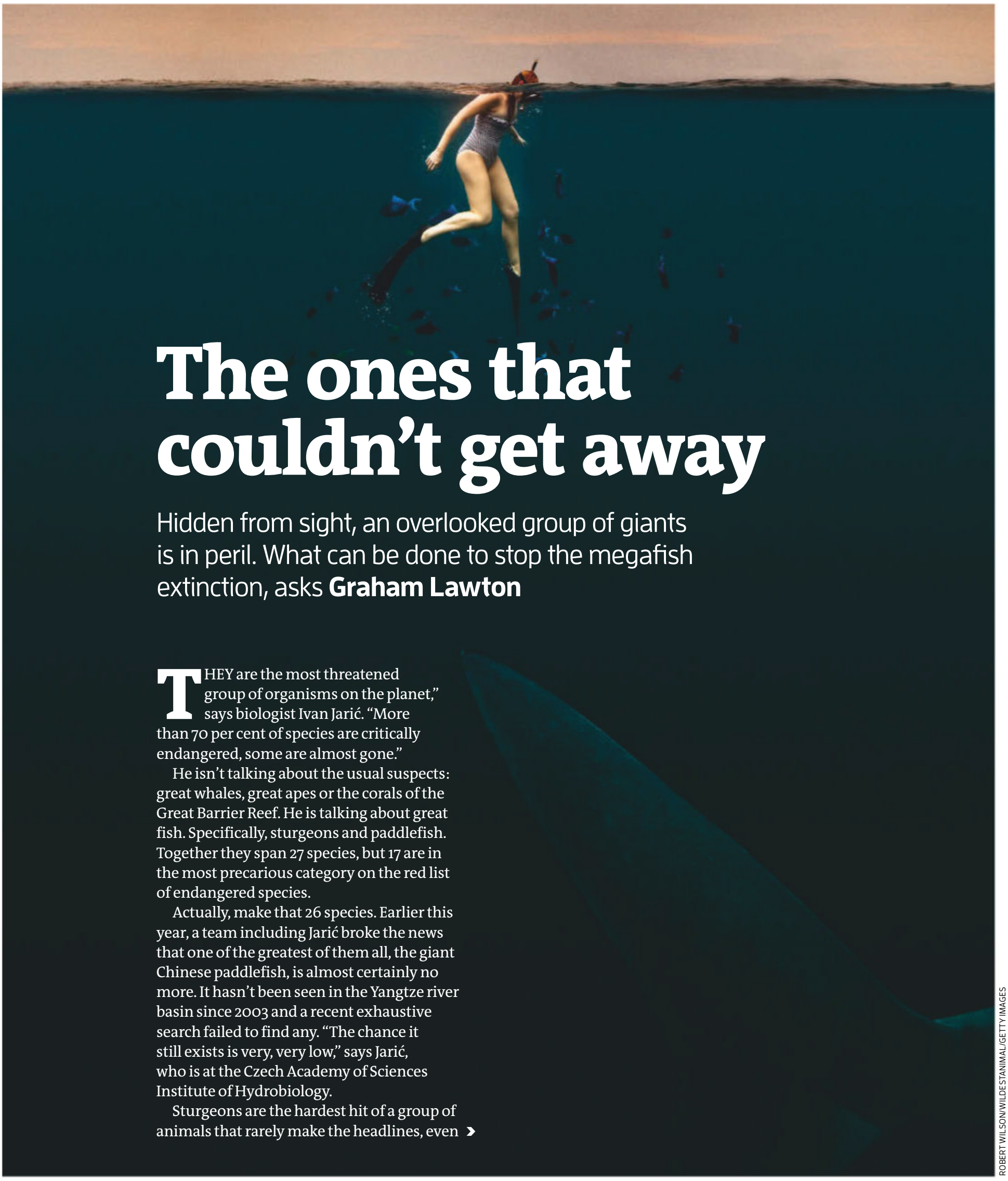
The idea that we will is perhaps conditioned. "I think there's a degree of cultural preprogramming from shows like *Star Trek* and *Star Wars* that have definitely geared us up to that expectation," says Kipping. Humans are also inherently social animals, he adds. Collectively, we yearn to reach out to some other species that is our intellectual equal. So when we ask if such creatures are out there, somewhere, "I think we're biased toward wanting the answer to be 'yes'", he says.

"If there are thinking things out there, we are probably never going to make contact"

In any case, even the sceptics believe that SETI, which is gradually moving from the fringes to be recognised as a branch of mainstream science, is a worthwhile pursuit. You don't make discoveries by calculating probabilities, so reckoning the chances of success shouldn't deter astronomers here from searching for messages sent by their counterparts on other planets. What's more, the sheer scale of the implications were the SETI project to succeed compel us to keep looking even in the face of long odds – and who knows what else we might discover along the way.

It remains to be seen what we might find on Venus, but perhaps the new hints of life there provide fresh support for a line that Lineweaver likes to quote, from the late biologist J. B. S. Haldane: "The Universe is not only queerer than we suppose, but queerer than we can suppose." ▮

Dan Falk (@danfalk) is a science journalist based in Toronto. His books include *The Science of Shakespeare* and *In Search of Time*



The ones that couldn't get away

Hidden from sight, an overlooked group of giants is in peril. What can be done to stop the megafish extinction, asks **Graham Lawton**

THEY are the most threatened group of organisms on the planet," says biologist Ivan Jarić. "More than 70 per cent of species are critically endangered, some are almost gone."

He isn't talking about the usual suspects: great whales, great apes or the corals of the Great Barrier Reef. He is talking about great fish. Specifically, sturgeons and paddlefish. Together they span 27 species, but 17 are in the most precarious category on the red list of endangered species.

Actually, make that 26 species. Earlier this year, a team including Jarić broke the news that one of the greatest of them all, the giant Chinese paddlefish, is almost certainly no more. It hasn't been seen in the Yangtze river basin since 2003 and a recent exhaustive search failed to find any. "The chance it still exists is very, very low," says Jarić, who is at the Czech Academy of Sciences Institute of Hydrobiology.

Sturgeons are the hardest hit of a group of animals that rarely make the headlines, even ›

ROBERT WILSON/WILDESTANIMAL/GETTY IMAGES

"The river megafauna are hidden below the surface of human perception"

in conservation biology circles, but this group is declining faster than any other. They are collectively known as "freshwater megafauna" – monster fish such as sturgeons, giant catfish, river sharks and rays, along with river dolphins, porpoises, seals, manatees, crocodiles, alligators, snakes, turtles and salamanders.

All told, there are more than 200 species of freshwater megafauna; most are in deep water and some are probably already doomed to extinction. Yet they are largely overlooked by efforts to save the world's biodiversity. "It really is a neglected area," says Sonja Jähnig a the Leibniz-Institute of Freshwater Ecology and Inland Fisheries in Berlin, Germany.

The Chinese giant paddlefish (*Psephurus gladius*) would never have made it onto a list of the world's most beautiful endangered species. But its demise has turned it into a poster child for the dire conservation status of the world's last remaining pool of megafauna.

We are used to thinking of megafaunal extinction as something that happened many thousands of years ago, as humans spread around the world and, probably not coincidentally, ran into the last mammoths, ground sloths, giant flightless birds and many more. Some terrestrial megabeasts survived, but in the past 50,000 years about two-thirds of these species have vanished. One place where they survived was in freshwater, probably for the same reason that we ignore them today. "They are hidden below the surface of human perception," says Jähnig.

But if we looked, we would be amazed. There are 206 living freshwater megafaunal species – defined as those that can exceed 30 kilograms, about the size of an adult golden retriever. Three-quarters of the world's major river basins are home to at least one, with the Amazon, Congo in Africa, Orinoco in South America, Mekong in South-East Asia and Ganges-Brahmaputra basins especially rich in them.

Many can grow much bigger than the 30 kg lower limit for this oversized club. In 1931, a Chinese biologist claimed that paddlefish in the Yangtze near Nanjing, China, could reach 7 metres in length, although the largest recorded in more recent decades before they vanished are only about half that. That is still a very big animal (see "The river giants", left). The largest freshwater fish in the world is the beluga sturgeon (*Huso huso*), which is can reach 7 metres and 1.5 tonnes. A small adult whale shark is about the same size.

Final swimmer

The Chinese paddlefish was one of two remaining species of an ancient lineage of fish (*Polyodontidae*) that evolved in the Jurassic and survived the extinction of the dinosaurs. The last one swimming is now the American paddlefish (*Polyodon spathula*), which is found in small numbers in the Mississippi river basin.

Its Chinese cousin had been in trouble for years before finally gasping its last. They were once common, with around 25 tonnes caught every year for food. But a survey of the Yangtze river in Sichuan province in the summers of 1974 and 1975 found that large specimens were already rare, a fact that was attributed to overfishing.

In 1981, the huge Gezhouba hydroelectric dam was built across the Yangtze, preventing paddlefish from migrating upstream to their ancestral spawning grounds. This seems to have been the last straw for a species already under pressure from overfishing, habitat destruction, shipping and pollution. The last live specimen – a 3.6-metre-long female – was unexpectedly caught in 2003 near Yibin in

The river giants

Many rivers around the world were once home to megafish longer than 2 metres, but they are now a rarity. Here are some of the biggest:

Beluga

Status: Critically endangered

This sturgeon is the world's largest freshwater fish, found in the Black, Azov, Caspian, and Adriatic seas and their tributaries. The largest was over 7 metres, but the average is around 2 metres

Giant Chinese paddlefish

Status: Extinct

Once common in the Yangtze river, China, this fish grows up to 3.6 metres and possibly even double that length

Pirarucu

Status: Recovering from overexploitation

This air-breathing fish from the Amazon river can grow larger than 3 metres

SHUTTERSTOCK/NATALIA BELAY

IMAGEBROKER/ALAMY

The Chinese paddlefish (top) is thought to be extinct, but the American paddlefish (below) is still swimming

central China. A rescue programme was launched in 2005, but didn't work, and an extensive survey of the entire Yangtze basin in 2017 and 2018 failed to locate a single one of these fish. "Given that there hasn't been a reliable sighting for so long, there's not much hope," says extinction biologist Dave Roberts of the University of Kent, UK. In all likelihood, the last one actually died between 2005 and 2010 and the species was functionally extinct – that is, unable to reproduce – by 1993. There are no specimens in captivity and hence no prospect of a comeback. The scientists who broke the news described the extinction as a "reprehensible and irreparable loss".

It isn't the only large animal to have disappeared from the Yangtze in living memory. The baiji, aka the Yangtze river dolphin (*Lipotes vexillifer*), hasn't been sighted since 2002 and is almost certainly extinct too.

Others are going the same way. The paddlefish's close relative, the Chinese sturgeon (*Acipenser sinensis*), is on the critical list, as are the Chinese alligator (*Alligator sinensis*), Chinese giant salamander (*Andrias davidianus*) and the Yangtze giant softshell turtle (*Rafetus swinhoei*).

Smaller fish are also in trouble. There are 474 known species of fish in the Yangtze; the paddlefish survey failed to find 140 of them. Most of these are probably highly endangered, according to the team from the Chinese Academy of Fishery Sciences which carried out the survey.

The annihilation of the Yangtze biosphere is entirely down to human activity. Since the 1950s, the 6300-kilometre river – the longest in Asia – has undergone explosive development. A third of China's population, some 400 million people, live close to what is now the world's busiest river; there are more than 40 cities beside it including the vast metropolises of Chongqing, Wuhan, Nanjing and Shanghai. Until the Gezhouba dam opened in 1981, it was free-flowing; other dams including the immense Three Gorges have since been added and several more are planned or under construction.

And there is more to come. In 2016, the government unveiled the Yangtze River Economic Belt to promote further development. In the face of this immense pressure, the paddlefish survey scientists recently warned that the Yangtze aquatic ecosystem is in danger of collapse.

The Yangtze is just a drop in a very large freshwater ocean. All over the world, freshwater ecosystems and their megafauna are in trouble. According to a paper Jähnig co-authored in 2019, "They are among the most threatened ecosystems globally".

Some river systems are in even worse shape than the Yangtze. On a measure of threat to biodiversity, the Yangtze scores 0.822. Worst of all is the Danube (0.912), closely followed by the Mississippi (0.900), Shatt al-Arab (0.898) and the Orange (0.858). ›

Caviar catastrophe

Sturgeon – long-lived fish with a shark-like fin on their back – used to be common across Eurasia and North America, but demand for their roe in the form of caviar has reduced them to a few diminished and often unsustainable populations. Between 1985 and 2005, the sturgeon population in the Caspian Sea – the source of 90 per cent of the world's wild caviar – collapsed. Even today, sturgeon poaching is big business, even though there are hardly any fish left.

"Poachers face high punishments, but the money they can earn is a big motivation," says Ivan Jarić at the Czech Academy of Sciences Institute of Hydrobiology. "They can get rich from a single catch." One beluga sturgeon can supply 60 kilograms of caviar worth €30,000 to the poacher. And as sturgeon species get rarer, the price spirals ever upwards. These fish are now farmed for caviar, but connoisseurs say it is an inferior product. "Illegal fishing is very profitable and hard to control," says Jarić.

According to another recent assessment, even though rivers and lakes (excluding wetlands) cover just 1 per cent of Earth's surface, they harbour around a third of all vertebrates and half of fish species. Freshwater vertebrates are declining faster than their terrestrial and marine cousins.

Despite this, freshwater ecosystems are neglected in conservation policy. They really ought to be seen as a separate – and uniquely vulnerable – category alongside terrestrial and marine ecosystems, but are usually just lumped in with the former. "If you look at how freshwaters are represented in conservation frameworks, they lack their own goals," says Jähnig. Freshwater biologists were planning to lobby the 2020 UN biodiversity conference in China for better recognition, but the meeting has been postponed until at least 2021 because of the covid-19 pandemic.

The animals bearing the brunt of this neglect are the 80 or so species of really big fish – not just sturgeons, but also giant catfish and carp, electric eels, lungfish, freshwater rays, river sharks and more. Since 1970, their populations have declined by 94 per cent on average. Most of them are endangered; some are probably doomed.

Vital yet vulnerable

These aren't just aesthetic losses. Ecologists regard megafauna as disproportionately important for biosphere functioning. Large animals, for example, eat and excrete a lot and so are vital for the nutrient cycling that other, smaller species rely on.

Big fish are especially vulnerable for a number of reasons, says Jähnig. "They reproduce really late [in life] so they need to have the right conditions for a long time; some need 10 or 15 years to mature. They have relatively few offspring, and they require a big habitat. Many are migratory, so they wander up and down stream and that means if there is a barrier like a dam, they get into trouble."

"There are multiple threats," agrees Jarić. "Damming, pollution and big pressure from the human population." That includes being hunted for food. Overfishing helped

JUAN MANUEL BORRERO/NATUREPL.COM

to see off the Chinese paddlefish, and has reduced megafish populations in the Mekong – the most heavily fished river system in the world – to "close to zero", says Jähnig. In this part of Asia, species in the firing line include the Mekong giant catfish (*Pangasianodon gigas*), giant Siamese carp (*Catlocarpio siamensis*) and shark catfish (*Pangasius sanitwongsei*).

Overfishing has also been the scourge of sturgeons (see "Caviar catastrophe", left). But despite this generally gloomy picture, there are glimmers of hope. The near-certain extinct status of the Chinese paddlefish, on top of the earlier loss of the river dolphin there and the generally rotten state of the Yangtze, seems to have focused the minds of the Chinese government, says Jarić, who works closely with freshwater biologists in the country.

"The paddlefish was a wake-up call in China," says Jarić. After this, he says, there was a meeting between researchers working on fish in the Yangtze, the International Union for Conservation of Nature, conservation group WWF and the government to develop some new actions.

MARK CARWARDINE/NATUREPL.COM

In the Amazon, the pirarucu (left) is making a dramatic comeback, but the Yangtze river dolphin (below) is now almost certainly extinct

"There seems to be a will to protect the Yangtze's fish stocks and ecosystems," he says. "So there could be positive effects from this." One immediate action was a moratorium on fishing in 332 designated areas, which will be extended to the whole river and all of its tributaries next year. That is a start, says Jarić, but fishing bans don't always work and can make matters worse. "If there is not good control, people just switch to illegal fishing, and then there's even less control."

And fishing bans don't address the bigger issue of dams. New ones usually have fish gates to allow migratory species to swim freely up and down stream, but they rarely work as well as advertised, says Jarić. "Even if they are constructed, they are usually not as efficient as we want, some migration occurs through them, but not as much as is needed."

Dams remain an issue for river animals worldwide. A recent assessment of the world's longest rivers found that only 37 per cent of those over 1000 kilometres are completely free-flowing. These are restricted to the Amazon and Congo basins and remote regions of the Arctic. "It's pretty unrealistic to say don't build any dams," says Jähnig. "But if we really want to build them – which is really a questionable thing, they have so many negative effects – can we move them to a certain part where maybe biodiversity won't be that much affected?"

Despite these obstacles, efforts to save the megafish are under way. In Europe, for example, sturgeon restoration projects are gathering momentum. The last remaining wild population of the European sturgeon – which 150 years ago was common in every major river system connected to the North Atlantic, including those in the UK – is clinging on in the Gironde river in France. Ditto the Adriatic sturgeon in the Po in Italy. Captive breeding programmes are attempting to restore those populations to healthier numbers, while programmes are also under way to reintroduce European and Baltic sturgeons to rivers in Poland and Germany. Whether these can succeed isn't clear, says Jarić. "We don't know if they can establish stable populations, the rivers are still heavily fished, polluted and degraded."

In the Americas, the picture is brighter. "The Amazon river basin is reasonably fine still," says Jähnig. On the Juruá river, which feeds into the Amazon in Brazil, sustainable fishing projects have even allowed the pirarucu, an air-breathing megafish, to make a comeback.

In North America, strict conservation measures have allowed other species to turn the corner. The Alabama sturgeon is probably lost and gone forever, but the lake and Atlantic sturgeons are showing signs of recovery. "None of them are really doing well," says Jarić. "They are still critically endangered, but many populations have a positive trend."

In the Mississippi, meanwhile, another critically endangered megafish seems to have dodged extinction and has a shot at recovery. The US river is even more degraded than the Yangtze, but somehow its own weird fish, the American paddlefish, is doing relatively well. The loss of its Chinese cousin remains a reprehensible and irreparable loss. But maybe after 50,000 years of big animal extinctions at the hands of one uniquely destructive megafauna, we are finally learning to look after the giants that remain. ▮

"The animals bearing the brunt of this neglect are the 80 or so species of really big fish"

Graham Lawton is staff writer at *New Scientist*

Reasons to be cheerful

If you think the world is going to hell in a handcart, then **Ruby Wax** has got news for you. The comedian and mental health advocate tells Clare Wilson why it is more important than ever to focus on the positives

ROCIO MONTOYA

RUBY WAX is on a serious mission to improve people's mental health. The American-British TV star, comedian, author and mental health advocate found fame in the 1980s TV sitcom *Girls on Top* and went on to deploy her comic persona of a brash, overconfident American in multiple comedy interview shows. Yet it is her experience with depression and stress that has shaped much of her more recent career. Her encounter with major depression 15 years ago led her to earn a master's degree in mindfulness-based cognitive therapy at the University of Oxford, an experience she incorporated into a stage show. For this, as well as her writing about depression and mindfulness, she was awarded an OBE, one of the highest civilian honours in the UK.

Wax has also set up community groups where, before lockdown, people could meet up and chat; these have now moved online. In her fifth and latest book, *And Now for the Good News... To the future with love*, Wax goes on a whirlwind world tour to meet innovators in schools, businesses and communities whose work she believes shows things are looking up.

Clare Wilson: Now seems an odd time for a book about optimism. Why did you write it?
Ruby Wax: We were besieged by bad news, even before covid. We were going on a drip feed, from one disaster to another, and we were getting addicted to it – at least, I was. I couldn't wait for more bad news, and you could gossip about it. But where you pay your attention defines your reality. Your brain is shaped by what you look at. So I said, let's move the lens, let's break the habit.

How did you do that?
I went on a global hunt, to try to see the innovators, the people that are going to change the world. I also wanted to change my life – to see where I could live, what I could do, because I like reinvention. I did find some places I would like to live some of the time and people who I'd like to be around.

The old model is we live in these dystopian islands of concrete. You live on the 87th floor, and if something terrible happens, you don't know your neighbours. It's built to isolate. But there are these places called intentional communities, where people share resources and responsibilities, like Findhorn in Scotland. I've just been there. It's a community, there are little roads between the houses. People smile when they see you, even though they don't know you. There's a community room where you can eat with other people, although it's not open now because of covid. I like the idea that everybody's got your back – this is how humans were built, to have each other's backs.

But we can't all live in villages...
Well look at Copenhagen. They've got the most developed cycle network in Europe and the streets are designed to encourage people to spend more time in public spaces. These people seem a little happier. There are real ›

fat cycle lanes, I cycled everywhere and I felt really safe. The shops weren't all franchises: you can get original, olden-days shops that there's only one of. Not where it's just one shop after another that you've seen a thousand times. It's a really interesting hipster neighbourhood, it has just been reinvented.

All we hear about the environment is doom and gloom, but there are these little islands of optimism. The most impressive business I went to visit is a US store called Patagonia, which makes sustainable clothing. I have a jacket from them made out of plastic bottles. When you buy something from them, they say "don't ever buy this from us again" because if it tears or wears out, you send it back. You can return an item within a hundred years of buying it. Wow! They share their profits with their employees and they give money away to environmental groups. They do really good work in their local community, they hand out food, they put money back into it. And they have the happiest employees I've ever seen.

"All we hear about the environment is doom and gloom, but there are little islands of optimism"

SHUTTERSTOCK/OLGAGOROVENKO

That sounds great, but can individual firms change the world?

The book is about the green shoots. If we pay attention to them, they might grow into a brighter future.

There are schools where they're teaching kids in a whole new way, for instance. At a primary academy chain in the UK called Reach2, it's about working as a team, teaching empathy. I went to one of these schools and saw the children learn techniques to self-regulate when their stress gets too extreme. When people are in high alarm, they can't focus on anything. They have a zen den – the children go in when they feel out of control. The school gives them tools to lower their stress.

You have studied and written about mindfulness meditation – what made you want to try it?

I had a major depression about 15 years ago. Shrinks are great, but I got sick of repeating my stories constantly. So I looked it up, I researched scientific papers. Mindfulness and cognitive therapy had the most empirical evidence – for depression or people who were just generally frazzled. I ended up doing a master of studies degree at Oxford in mindfulness-based cognitive therapy. My book, *A Mindfulness Guide for the Frazzled*, was based on the work of my professor, Mark Williams, who was one of the co-founders of mindfulness-based cognitive therapy. He gave me his blessing, but I did it my way. I gave mindfulness exercises for while you're taking care of your kids, while you're going to the office, how to deal with somebody shouting at you. Mine was more practical.

How does mindfulness meditation work?

It's a way of relating to your thoughts in a different way. You befriend them, you understand them. I have habits of thinking, theme songs that come up like old recordings. Suddenly, I'll think: "She thinks I'm an idiot." It's very much like how doing sit-ups strengthens your stomach muscles and you get a six-pack. There are areas in your brain that can get buffer, just like an athlete. With mindfulness, it gives muscle to the area in your brain that allows you to pay attention. Now, when I do have a spark of anger, it doesn't stay with me. I won't keep regurgitating it because I'm so addicted to my rage, which I used to be. You know, when something happens and you call your friends and go: "Guess what he did?" [Breaking that habit] doesn't happen overnight, though, you've got to work at this thing.

Do you still practise mindfulness?

Yes, every day for about 45 minutes. And then before a show, when I get the heart-pounding and I'm nervous, to get myself level. And if I start to lose my lines during the show, because my muscle is pretty exercised I'm able to think clearer and my lines come back.

Wow. Can it really work fast enough to be used on stage?

Oh yes. When you're scared, your memory goes down and you get even more nervous. I can tell when I'm starting to lose it. I look at the audience and I can feel their fear because they hate it. I'll stand and I'll focus with my feet on the ground. You have to send the focus

Copenhagen has more than 400 kilometres of cycle paths separated from both roads and pedestrian routes

to something physical because that means your mind isn't carrying on with endless ruminations: "Oh, god, I fucked up, I'm never going to get my lines." You need to go to a physical sensation – it could be your breath, it could be your feet on the ground or listening to sound. If you didn't practise this, you wouldn't be able to do it.

What do you think about recent research that found mindfulness can make a small proportion of people worse?
It could be detrimental for some people. It's just my opinion, but if you're having a breakdown I don't think you should go there. If you're in trouble, if you're totally traumatised – you don't want to look into your mind if something is seriously wrong. I think you have to sit it out, get medication, see somebody.

Tell me about your community work promoting mental health.
I run a community called Frazzled Cafe, where we meet each night. I wanted to create a meeting place where small groups of people could speak honestly without the fear of appearing weak. Originally, the meetings were cafes in actual places, like Marks & Spencer cafes. We would have from 12 to 15 people and a facilitator. Now we do it through Zoom and it doesn't matter where you are. You could be in Los Angeles or you could be in Dubai. I run a meeting that has a real structure to it and there are rules, so it isn't a free-for-all, and it lasts an hour. Other hosts are trained too, so meetings go on any time in the day. People can go on the Frazzled Cafe website and say "I want a meeting at 3 o'clock", and there's somebody who can host it. But I do 5.30 in the evening.

So it is like group therapy?
No, we don't do therapy. It's from the guts. I open and close with mindfulness, just to settle everybody. And then somebody starts. They might say – and I always say – "What's the weather condition in your mind?" It's almost like you're passing the talking stick.

Why do you think it helps people?
We steady each other because we feel empathy and that's as good as meditation or yoga. I do it every day. I cannot change the world. It's not for people who are seriously mentally ill. We don't deal with that, we give you places to go. This is really just a chat room. There are people of different ethnicities, different ages. It's a melting pot of people being honest with each other. There are so many complaints about technology destroying us, but who knew that Zoom would form communities like it has?

What else makes you optimistic right now?
I think millennials have the potential to be the salvation for us all. They are concerned because my generation has ripped them off. They have Greta Thunberg and it's cool to be in Extinction Rebellion. They don't take bullshit. It's an interesting phenomenon, that kids are really taking the reins. They're faced with climate change like my generation was faced with Vietnam. You fight for what's in front of your eyes. ■

Clare Wilson is a biomedical reporter at *New Scientist* and author of the Health Check newsletter

Fellowships for Postdoctoral Scholars

WOODS HOLE **OCEANOGRAPHIC** INSTITUTION

Scholarships are available to new or recent doctoral graduates in diverse areas of research
Applications will be accepted from doctoral recipients with research interests associated with the following:

Departments - Applicants who wish to conduct research on topics of general interest to one or more of the departments are encouraged to apply. Interdepartmental research, including with the Marine Policy Center, is also encouraged. The Departments are:

- **Applied Ocean Physics & Engineering**
- **Biology**
- **Geology & Geophysics**
- **Marine Chemistry & Geochemistry**
- **Physical Oceanography**

A joint USGS/WHOI award will be given to a postdoc whose research is in an area of common interest between USGS and WHOI Scientific Staff. The individual will interact with both USGS and WHOI based advisors on their research.

The Center for Marine and Environmental Radioactivity (CMER) will award a fellowship for research on natural and human-made radioactive substances in the environment including the study of their sources and fate or use as tracers of ocean processes.

The National Ocean Sciences Accelerator Mass Spectrometry Facility (NOSAMS) will award a fellowship in the development and implementation of new techniques in marine science radiocarbon studies.

The Ocean Bottom Seismic Instrument Center (OBSIC) will award a postdoctoral fellowship for research on the earth's internal structure and earthquake processes using seafloor seismic measurements.

The Ocean Twilight Zone (OTZ) project will award a fellowship for research on twilight zone (100-1000 m) ecosystems and processes, including biomass, biodiversity, life histories and behavior, trophic interactions, links to the global carbon cycle, and ways to engage scientists with stakeholders.

Recipients of awards are selected competitively, with primary emphasis placed on research promise. Scholarships are awarded for 18-month appointments with a stipend of $62,250 per year, a health and welfare allowance and a modest research budget. Recipients are encouraged to pursue their own research interest in association with resident Scientific and Senior Technical Staff. Communication with potential WHOI advisors prior to submitting an application is encouraged. Completed applications must be received by October 15, 2020 for the 2021/2022 appointments. Awards will be announced in December. Recipients of awards can initiate their study and research period at the Institution any time after January 1, 2021 and before December 1, 2021.

Further information about the Scholarships and application forms as well as links to the individual Departments and their research themes may be obtained through the Academic Programs section of the WHOI web pages at:

www.whoi.edu/postdoctoral

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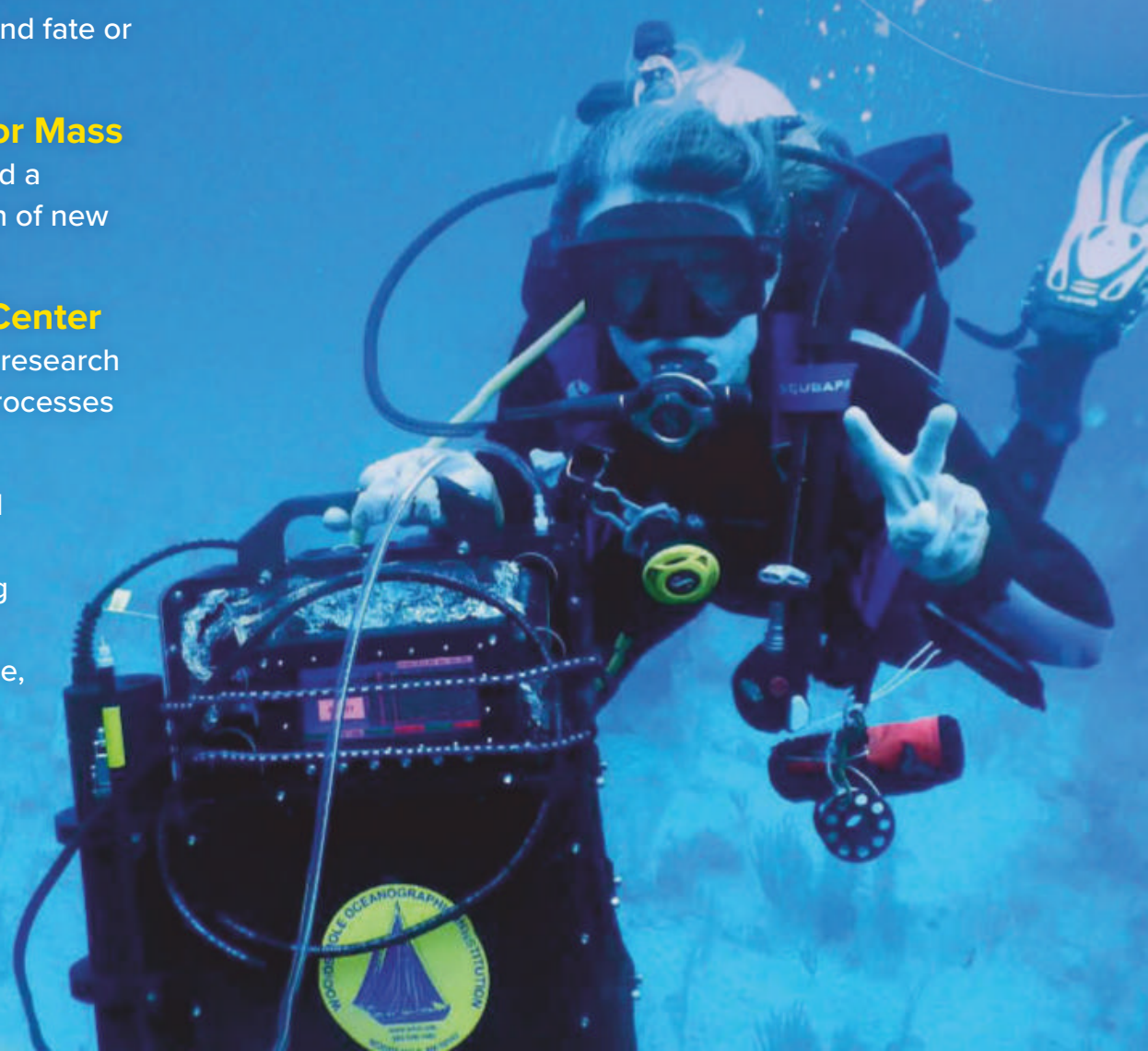


The back pages

Citizen science

Put your computer to work

Millions of people are helping scientists understand the new coronavirus without leaving their homes, finds **Layal Liverpool**

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

What you need

A computer with internet access
Folding@home's freely available software

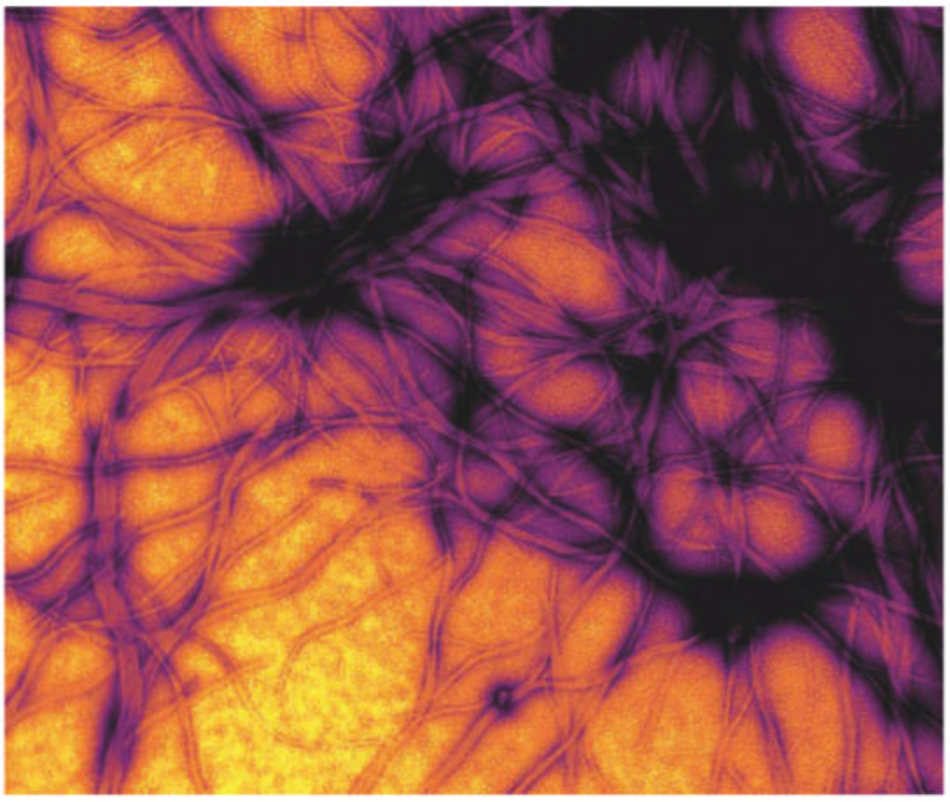
THIS week, instead of folding my laundry, I decided to fold some proteins. I joined more than 4 million citizen scientists around the world and lent my computer power to Folding@home, a project running powerful simulations of proteins to help us understand these large molecules and the role they play in disease.

Proteins are the machines that our bodies use to get things done, and the way they work is dependent on their ability to fold into different shapes. By understanding this at the level of the atoms within the molecule, we can manipulate the process.

To participate in Folding@home, you need a computer with internet access. You then download and install free software from foldingathome.org. When you are ready, click "start folding" to donate your computing power to the project. If you are competitive like me, you can check a leader board to see how many protein simulations you have contributed to compared with other people. You can also form a team and compete as a group.

The work could help us understand conditions that arise when proteins fold incorrectly (see the pictured misfolded prion proteins above), such as Alzheimer's disease, Parkinson's disease and motor neuron disease. It could also inform the development of new drugs that work to prevent proteins from misfolding in the first place.

In light of the pandemic, Folding@home has shifted its focus to proteins related to the coronavirus, including the surface "spike" protein that the virus uses to invade cells. Simulations have already revealed one way in which the spike protein may change shape to avoid the virus being detected by the body's immune system.



NIAID/SCIENCE PHOTO LIBRARY

Analysing all of the possible movements of a protein requires such an enormous amount of computing power that only a few standalone supercomputers are up to the task. Even then, they are pretty slow.

Folding@home's software gets around this by splitting up each protein simulation into tiny fragments, each of which are run on individual devices in the homes of volunteers around the world. These mini-simulations are then combined together to acquire a full picture of how the proteins move. In March this year, Folding@home exceeded 1.5 ExaFLOPS of computing power, which is more than 10 times the power of Summit, the world's fastest public supercomputer.

I haven't made it to the top of the protein-folding leader board yet, but I do have a certificate confirming that I helped power nine protein simulations. I like the idea that I have contributed to research that could improve our understanding of disease, without even leaving my living room. Unfortunately, I am yet to get a certificate for folding laundry. ▮

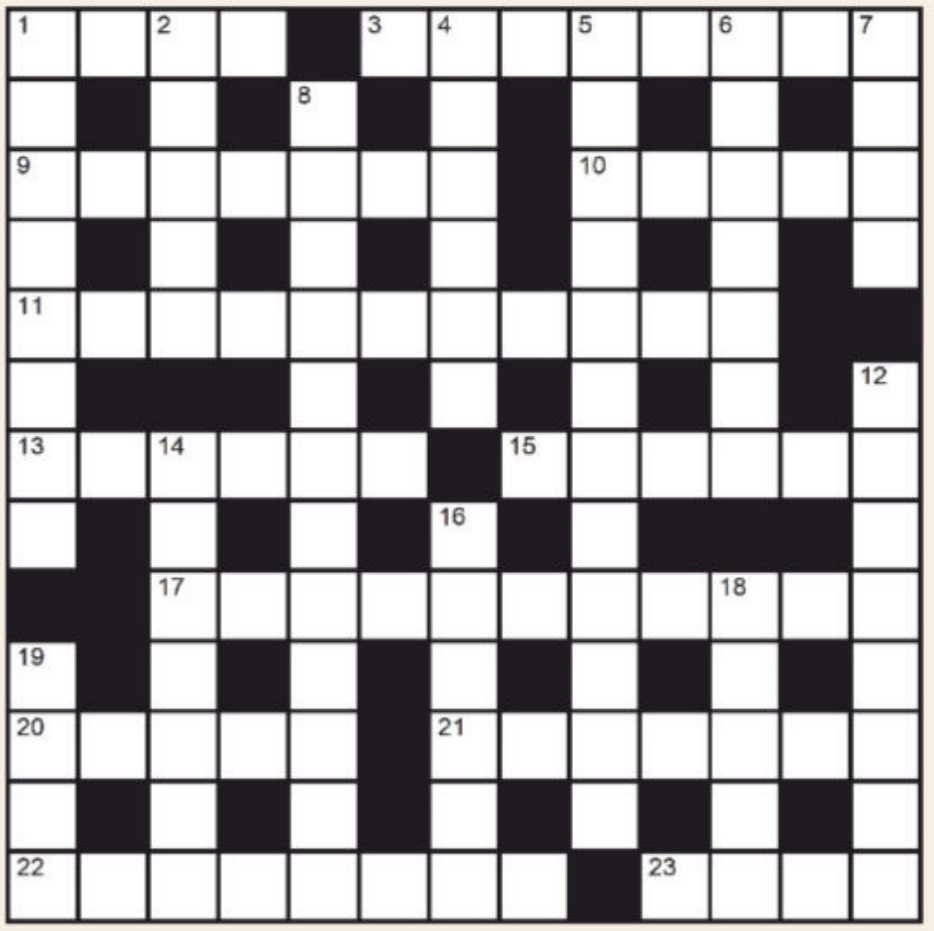
Citizen science will be back again in four weeks' time

Next week

Science of cooking

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

Cryptic crossword #41 *Set by Rasa*



Scribble zone

Answers and the next quick crossword next week

ACROSS

1 Make sound of disapproval at front of unbecoming skirt (4)
3 Widespread fear about odd characters in dreams (8)
9 Returning Pixar rat chef cut protein, for example (7)
10 Father beginning to notice femme fatale (5)
11 In G-suit, Lyra travels region of infinite gravity (11)
13 Greek island ways described on podcast (6)
15 Measure of reflectivity for nimbus without first including bottom section (6)
17 Call "unconventional" Roy's overwhelming desire for cold cuts? (11)
20 Baker's ingredient still includes arsenic (5)
21 Affirm perspiration coats circus's third ring (5, 2)
22 Bemused, I mentioned covering deposit (8)
23 Hang around, more or less keeping time (4)

DOWN

1 Hanging sticky strip at filthy spot infested with roaches, at first (8)
2 Most of presentation on feature of raptors (5)
4 A test of part of the heart (6)
5 Passes around one's gardening tool for spirit plants (12)
6 Deface poem after rejecting Hardy's first proposal (5, 2)
7 Inclination to use jargon (4)
8 Enemy summits reconfigured defence arsenal? (6, 6)
12 Poorly, messily, eviscerate lowly woodlouse (4-4)
14 Source of fruit or vegetable (7)
16 Welcomes as son, surrounded by family (4, 2)
18 Feel bad about dropping original bird (5)
19 Indigo and saffron certainly underlying last bit of red (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #71

1 What other name was originally given to 51 Pegasi b, the first exoplanet orbiting a sun-like star to be discovered?

2 Who referred to mathematics as the "queen of the sciences"?

3 Native to Australia and parts of Indonesia, *Dicaeum hirundinaceum* is a species of bird known for eating what plant?

4 In what year did German pharmacist Friedrich Sertürner first isolate morphine from opium?

5 The turquoise colour of many glacial lakes is caused by what substance?

Answers on page 55

Puzzle
set by Zoe Mensch

#79 Marathon relay

Ruritania is thrilled to be hosting The Continental Games, and the Queen has decreed that two of the country's greatest athletes, Rimsky and Korsakov, will take it in turns to carry the torch on its 26.2-mile journey from the harbour to the stadium. For each leg of the journey, the athlete can choose to run for any distance between 1 and 3 miles before handing over the torch to the other. Of course, Rimsky and Korsakov both privately hope that they will be the one who runs the last leg and hence gets to light the Continental flame. A coin is flipped, and Rimsky correctly calls heads. Should he choose to run the first leg or should he give that honour to Korsakov?

Answer next week

Introducing ATEM Mini

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

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

Create Training and Educational Videos

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

Use Professional Video Effects

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

Live Stream Training and Conferences

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

Monitor all Video Inputs!

With so many cameras, computers and effects, things can get busy fast! The ATEM Mini Pro model features a "multiview" that lets you see all cameras, titles and program, plus streaming and recording status all on a single TV or monitor. There are even tally indicators to show when a camera is on air! Only ATEM Mini is a true professional television studio in a small compact design!

ATEM Mini.....**US$295***
ATEM Mini Pro.....**US$595***
ATEM Software Control.....**Free**

Learn more at www.blackmagicdesign.com

Blackmagicdesign

*SRP is Exclusive of VAT. Prices subject to change.
ATEM Mini for use in training, conferencing and teaching purposes only.

Spilt milk

Why is it that when you heat milk to a point where it boils, the volume increases and it sometimes spills over?

David Muir
Edinburgh, UK
There are two factors that cause milk's unfortunate tendency to boil over. The first is the abundance of surfactants, or foaming agents, within it, such as proteins, phospholipids, glycerides and free fatty acids. These lower the surface tension and stabilise the froth formed when milk boils.

"Clean liquids heated in clean vessels tend to 'superheat'. When these liquids do eventually boil, they do so violently"

The second is the so-called denaturing of milk proteins due to the heating. These altered proteins coagulate with fats in the milk to form a sticky skin called lactoderm. This film dries through surface evaporation and acts as a blanket, trapping the foam and protecting it from the open air, whose dryness would otherwise cause the bubbles to burst. The froth pushes up and over the pot rim, much to the irritation of the negligent cook.

Anna Butcher
Brookton, Western Australia
When milk boils, small bubbles of air form and create a foam that can spill over the side of the pot and make a mess.

This isn't a problem in my kitchen as I have a "milk boiler" that disrupts the formation of large bubbles from small ones, so the foaming doesn't occur and the liquid doesn't boil over. The milk boiler rattles on the bottom of the pot as the liquid reaches boiling point and so also alerts the cook that it has begun to boil.

I have a ceramic milk boiler, made by a company called Bristile, that was my husband's grandmother's. This device works just as well in milk as it does in water when I cook pasta. It was made in Perth, Western Australia, back in the 1930s and has saved many a mess.

The Bristile company now makes roofing tiles as there isn't much demand for milk boilers today. In the past, most farming families in Australia had a cow and there was always so much milk to do something with.

Ron Oren
London, UK
From a chemist's perspective, milk is a mess of proteins and fats in water. Heating the milk disturbs the balance and forces the fats and proteins to form a layer on top. If you let the milk cool down again, that layer will solidify into the skin that most people dislike.

While the milk is boiling, bubbles that rise from the watery phase pick up a thin coat of this layer, which stabilises them so they pile up to form a foam. The foam will keep growing until it runs out of water to create bubbles or fats to coat them. Stirring the boiling milk helps as that breaks up the fatty layer and leaves room for the bubbles to escape.

Simon Goodman
Griesheim, Germany
Liquids boil when the molecules in them move as fast as the average speed of the molecules in the air above them. When heated, gases dissolved in a liquid will come out of solution as bubbles at so-called nucleation centres. These are particles in the liquid or microscopic irregularities on the walls of the heating vessel.

When clean liquids are heated in clean vessels, they tend to "superheat" and go over their boiling point. This "bubbling" can be very dangerous in the laboratory because when these liquids do eventually boil, they do so violently. Inert particles are sometimes added when heating such liquids to avoid this hazard.

PLAINPICTURE/SALLY MUNDY

Do pot plants get lonely when they can't interact with their neighbours?

This week's new questions

Going potty **If plants and trees can communicate via their root system, do they get lonely in pots?** ***Jim Turton****, Bristol, UK*

Groan up **Why do older people groan or say "ohoo" when we sit down, stand up or do pretty much any one-shot physical action? Is it a cultural convention or is there a physiological reason?** ***Adrian Bowyer****, Foxham, Wiltshire, UK*

Contagious cures

Why don't we make disease cures that are themselves infectious?

Tim Stevenson
Great Missenden, Buckinghamshire, UK
We do. They are called bacteriophages and were used medically in the Soviet Union. They are viruses that exclusively attack and live in bacteria. They only failed to become the go-to cure for many bacterial ailments because antibiotics are so easy to mass produce, whereas phages have to be sought out from the smelly places where they dwell, typically sewage.

There is an endless evolutionary struggle between phages and bacteria. This has a good and a bad side. The bad is that a continuous search for new phage cures is needed as bacteria develop stratagems to defeat them. The good is the potentially endless supply of different phage cures to set against our dwindling stock of antibiotics as resistance propagates among bacteria.

However, hopes of a bacteriophage cure that could sweep in on the tails of the current pandemic and stop it are doomed. Covid-19 is caused by a virus. Bacteriophages don't parasitise viruses as these don't have a metabolism to exploit.

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Tom Gauld
for New Scientist

Iain Brassington
University of Manchester, UK
I am in no position to say whether an infectious cure for a disease would be a practical possibility, but let's assume that it would be. There would, however, be a serious ethical and legal concern about any such intervention because it would amount to unconsented medical treatment.

It is a widely accepted principle that people should be able to refuse medical treatment, even if it would be irrational to do so and even if there's a public good to be served by giving it. But with a contagious cure, these people wouldn't even get the chance to refuse, since they would be exposed to the "treatment" simply by standing next to the wrong person at the supermarket.

We do sometimes intervene medically without consent – we vaccinate babies, for example. However, even in that case, there is someone who could refuse on their behalf. There would be no such possibility with infectious cures.

"People would be exposed to the 'treatment' simply by standing next to the wrong person at the supermarket"

Doubly dark

What would it look like if dark matter fell into a black hole? What might you see while it was happening?

Mike Follows
Sutton Coldfield, West Midlands, UK
There would be no discernible difference to the appearance of a black hole. Besides, a small amount of dark matter probably already falls into black holes.

Dark matter doesn't interact electromagnetically – so cannot emit, absorb or scatter light – but it does respond to the force of gravity, so would fall into a black hole in the same way that ordinary matter does. However, while ordinary matter collapses to form a galactic disc, emitting electromagnetic radiation in the process, dark matter stays in the form of a spherical halo around the visible component. This means that it is mainly ordinary matter that falls into a black hole.

Dark matter probably paved the way for black holes to exist by creating the texture of the universe, as well as the location of galaxies. Until the universe was about 300,000 years old, it was too hot for neutral atoms to form. The early universe was composed of plasma (protons and electrons). These charged particles were scattered by photons and this prevented ordinary matter clumping together gravitationally.

Meanwhile, any fluctuations in the density of dark matter were accentuated by gravity, whose fingerprint can be seen today as ripples in the cosmic microwave background radiation. As soon as neutral atoms formed, they could gravitate towards areas where clumps of dark matter built up, leading to the creation of galaxies and the spawning of stars, including black holes. ▮

Answers

Quick quiz #71
Answers

1 Bellerophon, after a hero from Greek mythology known for capturing winged horse Pegasus

2 Carl Friedrich Gauss

3 Mistletoe. It is more commonly known as the mistletoebird or the mistletoe flowerpecker

4 1804

5 Rock flour, or glacial flour. This finely ground rock is produced by erosion. When particles of it are suspended in water, they reflect more blue and green light

Quick Crossword #67 *Answers*

ACROSS 1/4 Planet Earth, **8** Blossom, **9** Camphor, **11** Hydrophobia, **14** Piece, **15** Orbiting, **17** All clear, **19** Ebb, **20** Answerphone, **24** Eurasia, **25** Nitrile, **26** Latex, **27** Edison

DOWN 1 Paley, **2** Absorbency, **3** Ecosphere, **5** Atari, **6** Tape, **7** Cocooned, **10/18** *Tomorrow's World*, **13** Star charts, **14/12** Pale blue dot, **16** Bowerbird, **21** Noise, **22** Nylon, **23** Gaia

#78 Farewell My Blubbery
Solution

The book has 153 pages. You can discover this by trial and error, but algebra offers a shortcut. The number of digits N needed to number a book with 100 pages is 192; with 101 pages it is 195. So, in general, if a book has ABC pages, N = 3(ABC) – 108. Try A = 1, which is the shortest possible book: 3 × (1BC) – 108 = CB1. If 3 × 1BC – 108 ends in 1, then 3 × 1BC ends in 9, so C must be 3. That means ABC = 1B3. The only value of B that works is 5, so there are 153 pages and these will take (as you may easily check) 351 digits to number.

Emperor's virtual clothes

Spurred on by events such as last year's sale of a dress that only exists on the internet for $9500, luxury fashion designer Gucci has announced it is moving into virtual clothing for those who want to look just as fabulous online as offline.

We do, we do. But we urge caution to anyone tempted to clothe themselves only in photons, lest the blurring of our virtual and physical worlds accelerated by lockdown lead to unfortunate incidents when putting the cat out or wandering down to the local shops. We speak from experience. Back in the noughties, tired of the fame and the constant pestering on the street, Feedback was an early adopter of metamaterial invisibility cloaks – until it turned out they only worked when viewed at microwave frequencies. That explanation didn't go down too well at the station.

Still, Feedback is enthused by the possibilities of virtual clothing, such as acting as a digital advertising hoarding on family Zoom chats, or changing colour, chameleon-like, with the tides of conflicting emotions that accompany work calls.

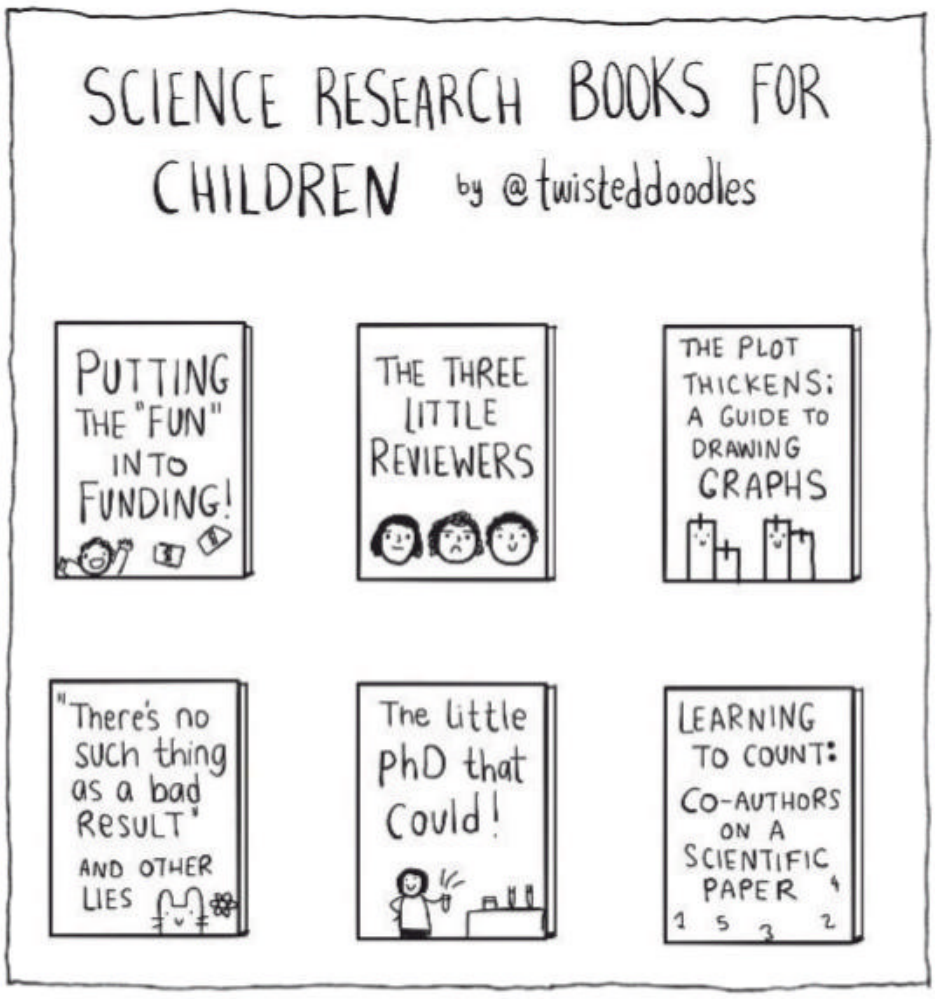
Gucci isn't really our bag. Yet, in common with half of the world, we have rarely seen anyone from the waist down since March, so it should at least be possible to halve the cost of a virtual wardrobe.

Classical fruitloops

Meanwhile, in the world of fruitloopery, quantum physics is so last season. Galen Ives writes in with news of PolarAid, a "revolutionary, easy to use, portable, hand-held body tool that can be used anywhere, at any time".

Feedback thinks there is generally a time and a place for that sort of thing. Yet besides its use to "enhance and encourage male and female sexual health", PolarAid promises benefits in a whole host of other areas, from digestive and bowel health to mental calm (not that those things are entirely unconnected in our experience).

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

Best of all, for those uncomfortable with the turn physics has taken in the past century or so, is that the device – essentially a plastic disc embossed with copper-alloy rings – eschews standard quantum woo entirely. Instead, it operates on classical "scalar wave" principles championed by none other than Nikola Tesla, presumably during the visionary inventor's more-than-a-little-odd period in which he also envisaged beaming death rays across the Atlantic Ocean.

Feedback has previous with scalar waves. One of the best bits of physics that most people miss out, these are essentially electromagnetic waves stripped of direction and left only with magnitude. Lest they feel too naked and point-like, they propagate instead through a mysterious fourth dimension known as time, faster than the speed of light, natch.

But far be it from Feedback to carp. We are too enthralled by our reverie about what would happen if virtual clothing and scalar wave technologies were to merge. Fast fashion forward into the singularity.

A question of degrees

Reviewing the weekly cache of fruitloopery causes Feedback to muse on a near-universally observed law: that the frequency with which anyone mentions their academic qualifications in a given context is generally in inverse proportion to their actual expertise on the subject.

On cue, our inbox bings with the latest missive from the reliably diverting Dr Benny Peiser at the Global Warming Policy Foundation (GWPF), an organisation that exists to convince the world we best not tackle climate change, for fear, Feedback presumes, that we might make a better world by accident. Dr Peiser, whose PhD in cultural studies hangs like an aura around all his communications, is keen to advise us that "Official US Climate Data Reveals No Cause For Alarm".

The basis for the all-clear, it turns out, is a GWPF paper saying there is no cause for alarm. Emphasising that point, "it's hard to find anything in the records of recent weather in the US that should give anyone any cause for alarm", the report's author is quoted as saying.

Feedback sighs. Climate denialism isn't what it used to be. Still, delivered as large chunks of California celebrates black being the new whatever-colour-it-was-before, the line has that ineffable quality of good timing that is central to all good oddball comedy. Climate attribution is, admittedly, a complex and imperfect science. Feedback possesses no relevant qualification in it, which makes it time to fire up the stationery cupboard's photocopier and write our own paper on it. It will also have graphs.

Signs of the times (I)

Smartphone users in California complain of cameras refusing to accept the orange hue of the sky during the recent wildfires, correcting it to blue. As Twitter user Lord Farquaad succinctly put it, "what the hell is the point of living in an ecological disaster if I can't take a picture of it?!?!?".

Signs of the times (II)

London free sheet *The Evening Standard* reports "London virus deaths fall to lowest total on record". Our brief frisson of joy at a potential pandemic turning point is rapidly overtaken by a new fear of the zombie apocalypse. Although, come to think of it, the undead roaming the streets may be a more effective way to enforce lockdowns than many of the methods trialled so far. ▮