New Scientist

WEEKLY September 19–25, 2020

EVIDENCE FOR ALIEN LIFE?

'It's basically either not a big deal, or we just found Venusians and that's incredible'

An extraordinary discovery in the atmosphere of Venus

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Vol 247 No 3300
Infographic: Stef Bayley

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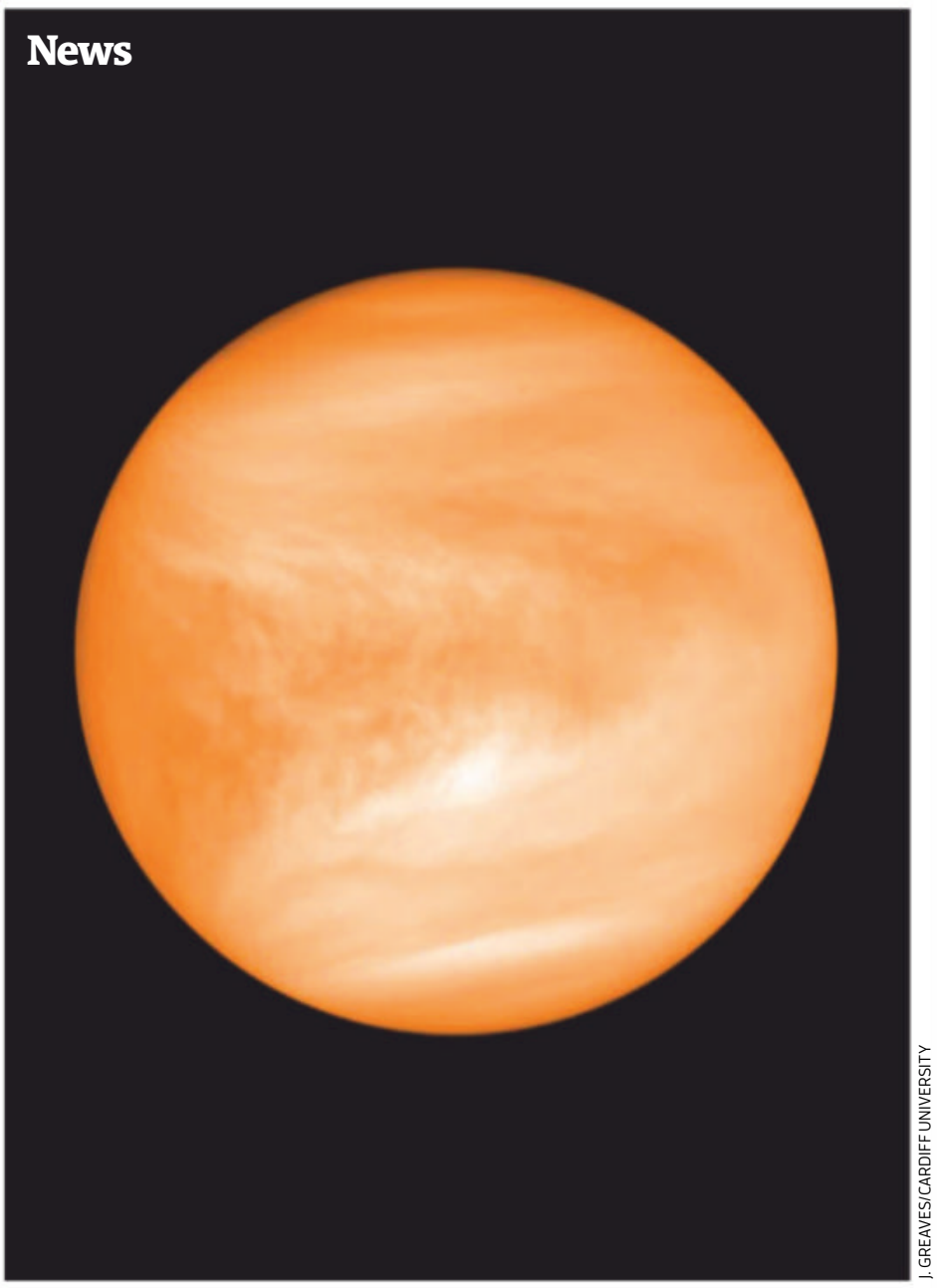

J. GREAVES/CARDIFF UNIVERSITY

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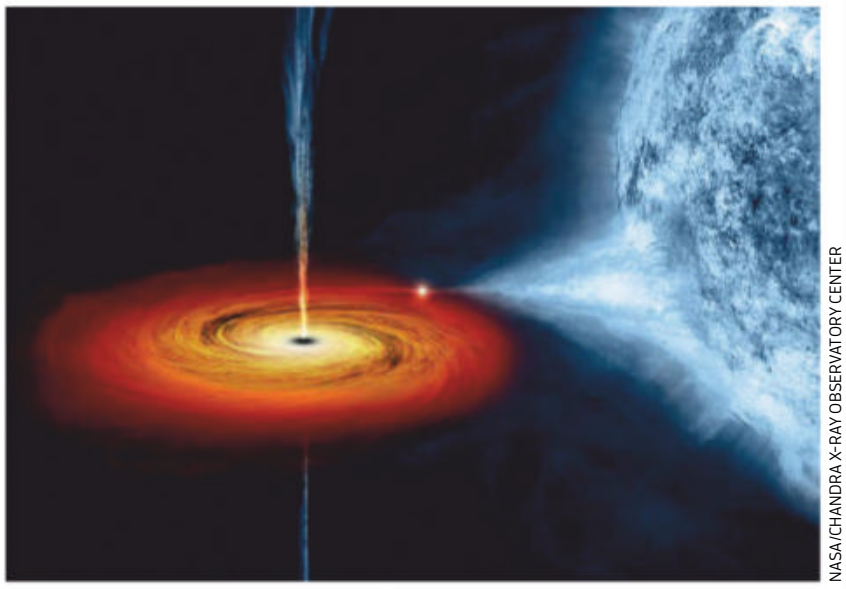

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Dark secrets There is still much to be discovered about black holes

Good bacteria Sam Wong explains how to tend your microbiome

Virtual events

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Our free newsletter sends you on a weekly voyage across the universe and beyond. This week: are there really signs of life on Venus?

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Online

Video

The microorganisms that live inside us are every bit as vital as our heart, our lungs and even our brain – and a healthy diet can give them a boost. Science with Sam explains all.

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A note from the editor

Each year, in our Christmas edition, we talk about what to expect in science in the 12 months ahead. So back in December 2019, what did we see in our crystal ball for 2020?

Here is that list: a giant leap in our knowledge of early humans, crunch time for anti-ageing, a crucial year for the climate, mounting fears over foreign interference and misinformation online, pioneering treatments for old enemies like cancer and steps forward on plastics and human health.

You may notice something rather large missing from that list – which is why crystal-ball-gazing is quite definitely not a science.

Nine months on, because of that missing item, the way in which *New Scientist* is produced has changed dramatically. Since 12 March, all of our products, including this magazine, have been created almost exclusively from people's homes. The journalism we produce has, of course, had to change very quickly, with a significant number of our writers now devoted to reporting on and analysing the pandemic.

"The journalism we produce at *New Scientist* has changed very quickly because of the pandemic"

On Thursday 24 September, between 6 and 7pm BST, I will be hosting a live digital event that will be free for all subscribers. On my panel will be Graham Lawton and Adam Vaughan, two of our key writers on covid-19, as well as co-head of features Cat de Lange, who now runs all of our coronavirus coverage. We will be talking about everything from the tsunami of bad – and good – science that has hit us, the challenges of trying to get journalism right in these times and what lies ahead for all of us over the next year or two. There will also be a chance for all of you to put your questions to us.

Do please come and join in! Go to newscientist.com/subsevent for more information and feel free to send me any questions in advance via editor@newscientist.com.

Emily Wilson
New Scientist editor

New Scientist Newsletter

Health Check

Get the most essential health, diet and fitness news in your inbox every week

Hundreds of new studies about our physical and mental well-being are published every week, but the results can be conflicting and confusing. Our weekly newsletter gives you the health and fitness news you can really trust – which, amid the coronavirus pandemic, is more important now than ever.

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Clare Wilson

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Episode 34 out Friday 18 September

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Episode 33
The healthy-eating revolution, China's cosmic ambitions, Russia's pursuit of gene-editing technology and the world's greatest mammal

Episode 32
Billionaire plan to geoengineer the planet, how the moon affects your health and Neuralink's telepathic pigs

Episode 31
Widening the search for alien life on habitable planets, why unconscious bias training might not work and the microbiome of cancer tumours

Episode 30
Redefining time, why mindfulness can cause problems and secrets of super-resilient tardigrades

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

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A heavy toll

As the pandemic reaches a million deaths, we must remain immune to indifference

MOST people still don't have any level of immunity to the virus behind covid-19. But there is a growing risk that some of us are becoming immune to the enormous numbers that this pandemic is throwing out on a weekly basis.

As *New Scientist* went to press, the world was on track to exceed a million deaths from covid-19 within days (see page 10). That is a number that we shouldn't allow ourselves to become blasé about.

Early in the pandemic, US President Donald Trump suggested covid-19 wasn't as bad as the flu. He was wrong. In a bad year, the flu kills up to 650,000 people globally. Covid-19 has killed far more, with three months of the year still to go – and won't stop when *Auld Lang Syne* is sung, or even when the first effective vaccine is manufactured. And covid-19 has killed those people not under normal circumstances, but in the face of a global lockdown the like of which we couldn't even imagine a year ago.

Overwhelmingly, those who have died were aged 65 and over, but on average, they would have had more than a decade of life left had it not been for covid-19. The disease's long tail, meanwhile, means the impact on younger people has still to be fully understood.

"The world is on track to soon exceed a million deaths from covid-19. It is a number we shouldn't become blasé about"

Most concerning is the fact that 1 million is an underestimate: it only counts those covid-19 deaths that we have detected. Many people will have died from the illness untested and so may not be included in official death tolls (see page 11).

The best approach will be to look at data on excess deaths – those above the long-term average for any given period – although in the world's poorest places, a lack of baseline records means we may never fully know the true toll.

When people grumble about the UK's new "rule of six" or rail against countries such as Israel adopting a second national lockdown during religious holidays, we should take a minute to remember that at least a million people – a million individuals – have died from this disease. We owe it to them to stay immune to indifference. ▮

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New Scientist
Newsletter

Fix the Planet

Overwhelmed by climate change? You're not alone

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Adam Vaughan

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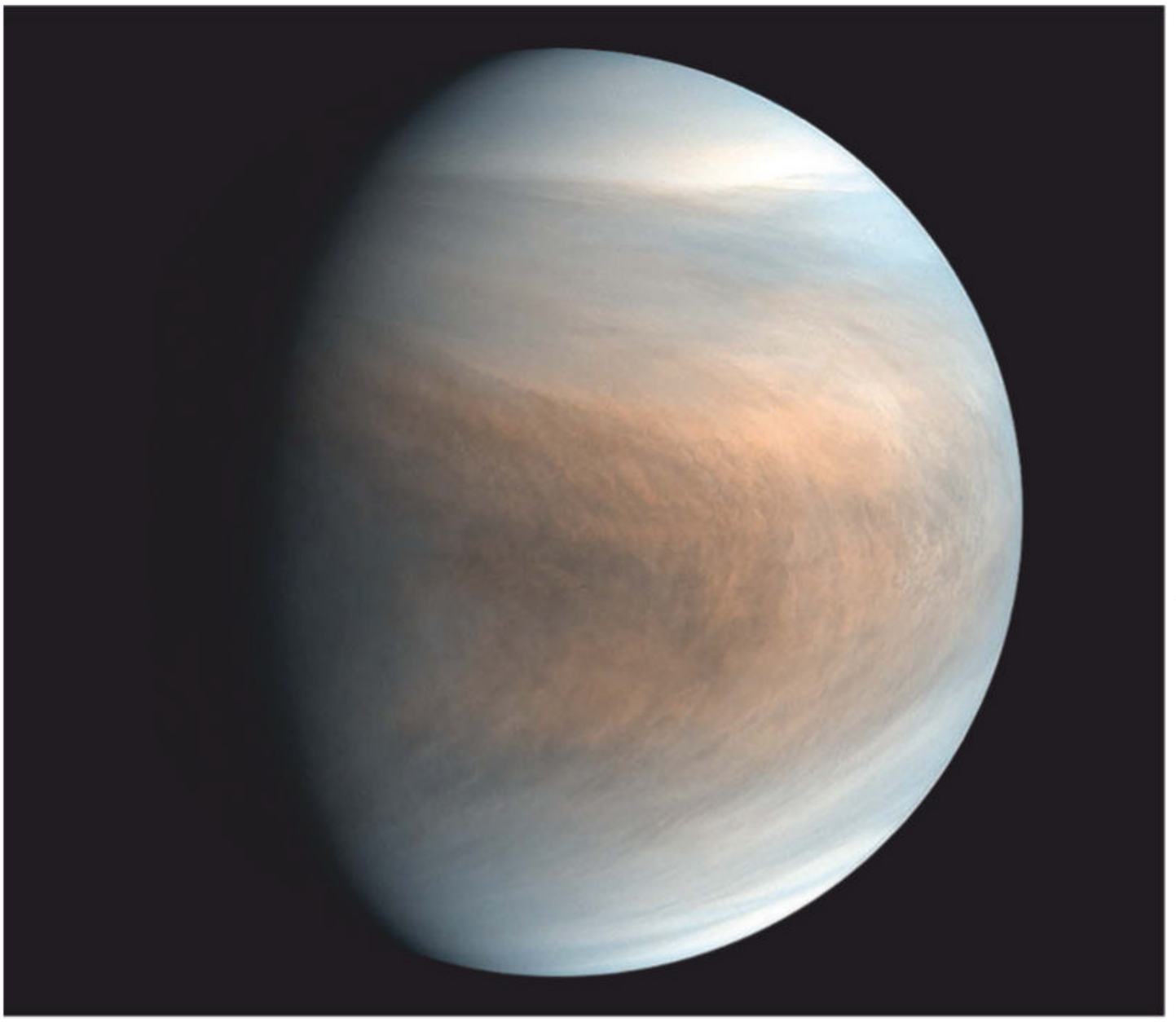

JAXA/ISAS/AKATSUKI PROJECT TEAM

There may be life swirling around in the Venusian atmosphere

Astrobiology

Signs of life on Venus?

The atmosphere of our sister planet contains a gas that hints at an extraordinary discovery, says **Leah Crane**

THE clouds of Venus may contain life. Some 50 to 60 kilometres above the planet's surface, there are small quantities of phosphine gas, a substance that is present in Earth's atmosphere because it is produced by microbes and by human technological processes. There are no known non-biological mechanisms for making this amount of gas on Venus, so it may be being produced by alien microbes.

Jane Greaves at Cardiff University, UK, led a team of astronomers who looked at Venus using the James Clerk Maxwell Telescope in Hawaii and the Atacama Large Millimeter/submillimeter Array in Chile. The data from both telescopes showed signs of phosphine gas in the Venusian clouds, which was completely unexpected.

"Phosphine in that environment is a weird thing to observe. It doesn't belong there," says David Grinspoon at the Planetary Science Institute in Arizona, who wasn't involved in this research. "It would get destroyed – there has to be a source." Somehow, the phosphine has to be continuously replenished.

The only way phosphine is made on Earth is in laboratories or by microbes. It also exists deep inside giant planets, but its formation requires conditions that don't exist on Venus.

The researchers tested a variety of ways to produce phosphine on Venus, from atmospheric chemistry to volcanism to delivery by meteorite, but they couldn't account for the amount of phosphine observed in the data.

"We thought of every process that could produce phosphine, and none of them produced phosphine in anywhere near the amounts that we found it," says team member Clara Sousa-Silva at the Massachusetts Institute of Technology. "We've exhausted the possibilities."

Only two scenarios remain: either there is something going on in Venus's clouds that we don't understand, or whatever is producing all that phosphine is alive (*Nature Astronomy*, DOI: 10.1038/s41550-020-1174-4).

"It's basically either not a big deal, or we just found Venusians and that's incredible," says Sousa-Silva. "The fact that it's even a possibility is really breathtaking to me."

"It's basically either not a big deal, or we just found Venusians and that's incredible"

The idea of life floating about in the Venusian clouds isn't entirely out of the blue. The surface may be crushingly dense and hot, but among the clouds it is relatively temperate. "For decades, people have argued that Venus may be habitable," says Paul Byrne at North Carolina State University. "Before it was just a conjecture, a place where biology could in theory be possible, but now we have this phosphine."

Greaves and her colleagues are now working on confirming the observations of phosphine with far more detailed measurements, but to be sure where it is coming from we will probably have to send a spacecraft to Venus to take a closer look.

"You want to get into the atmosphere and sample it to see what's there," says Byrne.

If those samples have life in them, even if it is tiny microbes, the planet next door could upend our ideas about what life can be and how it arises. ▮

Still have questions? See our readers' Q&A on page 8

Q&A

The Venusian enigma

This week's news from Venus left many of our readers with questions. Here our resident space expert, **Leah Crane**, tries to answer some of them

A TEAM of researchers has used two of the biggest telescopes on Earth, including the ALMA telescope in Chile (pictured right), to find signs of phosphine gas on Venus – a compound that is produced on our planet only by industrial processes and microbes – and raised many questions about whether we have just found alien life.

ESO/C. MALIN

How hot is Venus? Would any life there burn up?
There are a lot of different environments on Venus because of its thick atmosphere. The surface is absolutely miserable, with temperatures reaching 470°C and pressures 90 times that at sea level on Earth. But it is pretty temperate where the phosphine was found, at 50 to 60 kilometres above ground level, so the atmosphere could be conducive to life.

Why would the phosphine gas stay at this altitude?
The clouds of Venus aren't shifting and ephemeral like Earth's clouds. They are thick, their motions are driven by convection and the gas could just be floating around like plankton in Earth's ocean.

Do we know that this phosphine gas cannot be produced by anything other than biological processes?
It is impossible to prove a negative, so unless we can show definitively that this phosphine was produced by life, there will always be a chance that it was produced by a non-biological chemical process. But the team tested all the processes we know that could happen on Venus, and none made enough gas to account for the amount they have detected.

How big would an organism have to be to create what was found?
Not big at all. On Earth, phosphine is produced by microbes, so you might expect microbes to be able to make it on Venus too. If there is life there, it could be fairly simple.

Could it be that an organism made this gas in the past and is now extinct?
The exciting thing is that this isn't really an option. The researchers calculated that the lifetime of phosphine on Venus should be less than 1000 years before it is destroyed, so something must be continually replenishing it for it to exist in the concentrations we see.

If the organisms that may have produced it are now extinct, they must have been around until pretty recently. Given planetary timescales, it would be shockingly unlucky for them to have died out just as we became capable of finding them.

Any chance it could be tardigrades in Venus's atmosphere?
Although they can endure extreme temperatures, the microscopic, eight-legged Earth animals called tardigrades (also known as water bears) aren't known to produce phosphine, so if there is life on Venus it is probably something else.

Would this be an indication that there was life on the surface at one point?
It isn't an indication that there is life on the surface now, but if there is life in the atmosphere now, it could have interesting consequences for our understanding of what may have been on the surface back when it was – maybe – not so hot there.

50-60km
The altitude at which researchers detected phosphine gas on Venus

Could the phosphine have come from microbes carried by the Soviet Venera spacecraft, which visited Venus in the 1970s?
That isn't likely. The researchers found a large amount of phosphine, and the Venera landers were pretty small, so it is unlikely they carried enough microbes to seed this much of the gas.

What capabilities would a spacecraft need to investigate possible life on Venus?
You would want to be able to sample the atmosphere and chemically analyse it. A spacecraft would need to be able to look for life, which can show itself in patterns of materials consumed and released, but also to examine the atmosphere more generally in case the phosphine isn't biologically produced.

Could we use an atmospheric balloon to search for signs of life on Venus?
The hot, dense atmosphere makes it hard to send spacecraft to Venus, but several have made it down to the surface before they burned up. There have been a couple of balloons sent to Venus. It isn't impossible, it is just a tough engineering problem.

Is this a significant enough find that NASA might decide to focus on searching Venus for life, rather than Mars?
NASA has been very focused on Mars for a while, but we are at a point now where there aren't many more planned Mars missions, aside from still-very-theoretical crewed missions. While this news alone probably isn't enough to change NASA's course, it may be time for something new.

Do we have the capability to detect this quantity of phosphine on exoplanets – planets beyond the solar system?
This amount of phosphine – about 20 parts per billion – is right on the edge of what is detectable on planets outside the solar system. That means we probably can't spot it with any confidence at the moment, but if we did find it on an exoplanet it would be extremely exciting as a potential indicator of life. ▮

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Fatalities

One million global deaths

As we approach the grim milestone of a million people killed by covid-19, **Adam Vaughan** examines the toll of the pandemic so far

MICHAEL DANTAS/AFP VIA GETTY IMAGES

A burial taking place in a cemetery in Manaus, Brazil

IT BEGAN on 9 January. In a hospital in Wuhan, China, a 61-year-old man became the first person on the planet confirmed to have died from a new coronavirus. At the time, scientists didn't believe there was strong evidence of transmission between humans.

As this magazine went to press, we are nearing a global death toll of a million people after the virus spread out from Wuhan and exploded around the world. The true count is far higher and won't be established for years, as many killed by the virus weren't tested (see "Can we trust the numbers?", right). What happened?

Within weeks of that first reported death in China, cases appeared in Thailand, Japan and South Korea. The first fatality outside China was confirmed on 2 February in the Philippines. On 11 March, the World Health Organization (WHO) declared a pandemic.

In the months since, virtually no country has gone untouched by covid-19 or the coronavirus that causes it. Only island states, such as Saint Lucia and the Seychelles, and secretive states, including Eritrea, have recorded zero deaths.

Without adjusting for population size, the worst-hit country by far is the US with more than 194,000 deaths, followed by Brazil, India, Mexico and the UK.

At first, the uptick in deaths from covid-19 was gradual. It took two months for the death toll to surpass the 774 killed in the 2003 SARS epidemic, which was caused by another coronavirus. Then things accelerated (see graph, right). The disease took three-and-a-half months to kill 200,000 people. The next 200,000 deaths occurred in just under two months, and the following 200,000 took a similar amount of time. By late August, it had taken only around one month for another 200,000 people to die.

"The fastest growth has been over that period at the end of July and most of August. Now we're seeing a slight slowing in that death rate," says Hannah Ritchie at Our World in Data, which has been tracking data on the pandemic since the outbreak started.

Every day for the past few weeks, 5000 to 6000 people have died globally from an illness that

0.6%
The proportion of deaths that have been in low-income countries

50%
The proportion of global deaths so far that have been in the Americas

650,000
The upper estimate for global influenza deaths each year

nobody had heard of a year ago. Those figures have been stable for the past month, but there is no guarantee that will continue.

"A slow burn can still be very terrible in the long run," says Jennifer Dowd at the University of Oxford. "It's still a wildfire that you want to extinguish. Most of the world is still susceptible so there's plenty of kindling. I think it's going to vary, like a wildfire would, over time and space."

The focus of the pandemic has shifted around the globe in the past nine months. Even as deaths emerged around the world in February, the vast majority remained in China. It took severe restrictions on movement for the country's fatalities to peter out in March.

"It's a wildfire you want to extinguish. Most of the world is still susceptible so there's plenty of kindling"

Iran was next. In mid-February, the country announced the first confirmed covid-19 deaths in the Middle East, though subsequent data leaks revealed that the first death was recorded in January.

Then deaths began to rise in Europe. Italy was first, followed by Spain and the UK, where newspapers dedicated front pages to the first few individuals to die before the numbers became too great to record each life in detail.

"People were asking how bad is this compared to flu? Then week 10 [the week beginning 2 March], 11, 12, 13, we could see this wasn't just the flu, this was huge," says Lasse Vestergaard at EuroMOMO, which was set up after the 2009 to 2010 swine flu pandemic as an early-warning system for future pandemics, by monitoring excess deaths in 24 European countries.

New deaths since May have predominantly been in the Americas. "Obviously, the US was very hard hit and Latin America has been very hard hit regionally," says Ritchie. More people have been killed in New York than in any other US state. More than half of the global deaths so far have been in the Americas.

In recent weeks, another shift, as India has become the country with the second highest number of cases after the US. This has been accompanied by a rising death toll, which is now at more than 80,000. "India has had a fairly consistent upward trajectory for some months and isn't showing indications of slowing. But in terms of total population size, it's still a very small fraction," says Oliver Watson at Imperial College London.

In the early days of the pandemic, limited testing for covid-19 hampered the ability of governments and researchers to see how many people the illness was really killing. "At that point, we were slightly confused by the geographical distribution," says Ritchie. "We didn't really know the story elsewhere in the world, particularly in lower-income countries."

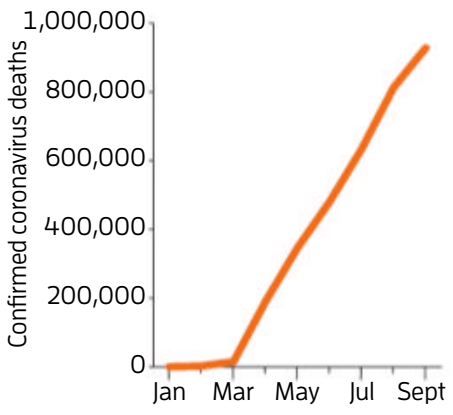
As that picture begins to crystallise, some questions remain. "I think the surprise has been in lower-income countries, specifically in Africa," says Dowd. "If we believe the mortality statistics, it hasn't been as bad there [as expected]." Official counts in African countries have been low. South Africa is the exception, with 15,000 deaths.

Researchers are still working out why case numbers are low in many lower-income countries. Possible reasons include a lack of data, having a younger population or simply that many imposed lockdowns quickly. Another explanation is that they haven't been as heavily seeded by infections from air travel.

This seeding could also explain why, over time, there has largely been a shift from deaths in high-income countries to lower-income ones. As of 8 September, Watson has found that 45 per cent of deaths have been in high-income countries, 40.5 per cent in upper-middle-income, 13 per cent in lower-middle-income and just 0.6 per cent in low-income nations.

As for personal risk, when the first deaths struck each country, media reports often focused on whether those who had died had underlying health conditions, ›

Global deaths from the coronavirus have been rising rapidly since March



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Can we trust the numbers?

Counting covid-19 deaths, and comparing them between countries, is surprisingly hard. While researchers want consistent ways of counting, the reality is anything but. Some countries only count a covid-19 death if the person had tested positive using a polymerase chain reaction (PCR) test. A lack of these tests in some places can be a hindrance to counting deaths accurately.

Some countries also include probable deaths, where symptoms and clinical patterns imply covid-19 was the cause but no test was administered. In some European countries, for example, if there is one confirmed covid-19 death in a care home and others died around the same time, they are also recorded as covid-19 deaths. That is likely to lead to overestimates, says Oliver Watson at Imperial College London.

Accounting methods change over time, too, and not all settings for death are counted by all countries. Counting hospital deaths is a given, but care home deaths were only added to official tallies several months into the epidemic in some countries. In April, the death toll for Wuhan in China jumped by 50 per cent after officials added deaths outside hospitals.

Tallies have also sometimes been revised down. The UK removed more than 5000 deaths from its official count in August after researchers pointed out that covid-19 was attributed as the cause of death to anyone who tested positive and died later, no matter how much later. Now only deaths within 28 days of a positive test are included.

For these reasons, using excess deaths is considered the gold standard. This usually involves comparing weekly data for all deaths in a country against a five-year average for that week. But the baseline is often lacking in low-income countries, meaning other methods are needed to fill the gap. One way will be for researchers to do household surveys on deaths in local communities, and extrapolate the results to national levels.

such as high blood pressure. "The initial question was how lethal is this virus, is this just picking off the sickest and most frail," says Dowd. Many comparisons were made with flu, which kills between 290,000 and 650,000 people a year globally.

What has become clear is that covid-19 isn't just killing those likely to die soon. "On average, these people had a lot of life expectancy left," says Dowd. "Some estimates are for the average person dying of covid, they had 11 years left."

Excess deaths

Excess death statistics also imply that most of those who have died from covid-19 weren't about to die imminently. The US has already had more than 200,000 excess deaths this year, and the UK more than 60,000. If covid-19 was pulling forward deaths by a few months, those countries would have seen far fewer deaths than the long-term average after their covid-19 peaks. That hasn't appeared and looks unlikely to do so, says Dowd.

Nonetheless, there are chronic health conditions that do increase the risk of death from covid-19, with diabetes and severe asthma among them. In the US, 94 per cent of people who died from covid-19 had underlying health conditions, known as comorbidities, with an average of 2.6 conditions per person.

Those figures were spun last month into a false narrative, repeated by US President Donald Trump, that only 6 per cent had really died of covid-19. In reality, many of the comorbidities were things brought on by covid-19, such as pneumonia.

Being a man, poorer, older and of black or South Asian rather than white ethnicity have also been associated with increased risk of dying from the illness in some countries. In England, for instance, death rates were higher for black and Asian ethnic groups than white ethnic groups, which was linked to working in occupations more likely to be exposed to the virus, among other things.

"On average, people dying from covid-19 had a lot of life expectancy left. Some estimates are 11 years"

"The very obvious risk factor is age," says Ritchie. "From 60 onwards, there's just this very strong gradient. When it's 80-plus, the case fatality is much higher." Even so, the disease is unpredictable, and young, healthy people have also died. "It is by far elderly, but middle-aged and younger groups are not spared," says Vestergaard. Figures collected by EuroMOMO show that 90 per cent of deaths were in those aged 65 and up, 8 per cent in those aged 45-64 and 1 per cent for ages 5-44.

While immediate deaths are the focus today, experts say the pandemic's effect on mortality will be long lasting. "The health impacts will carry on much longer, possibly years down the line," says Ritchie. "It's not just about who's dying right now. The health impacts accumulate over time."

It might take a year or two to see the effects of later diagnosis of cancers due to stressed healthcare systems, for example, or missed vaccinations for diseases like TB.

Similarly, Dowd says we are only just beginning to understand the chronic impacts of covid-19, or "long covid". "That's sobering," she says. "Even if we lower mortality now, what other types of scars on health and trends might we see from covid?"

In the meantime, hotspots of covid-19 deaths are still burning brightly. Large numbers of people are dying each day in South America, in particular Brazil, Peru and Argentina, as well as Mexico. India is driving Asia's toll. And while the US has a better grip on its epidemic, covid-19 is still killing thousands there each week.

There is some good news. Due to the way the world has adapted to the pandemic, from face coverings and social distancing to earlier detection and better treatments, a repeat of the steep jump in deaths experienced earlier this year is seen as unlikely. "I really don't see the deaths spiking as much as they did in the beginning, because we've learned a lot," says Dowd.

CJ GUNTHER/EPA-EFE/SHUTTERSTOCK

The Grant African Methodist Episcopal Church in Boston hangs ribbons for those who died from covid-19

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

Genetics

Family tree of a deadly virus

Genetic sequencing shows the virus behind covid-19 has barely evolved, which is good news for vaccine developers, finds **Graham Lawton**

LIKE any other biological entity, the virus behind covid-19 has a family tree. It isn't a very old one – SARS-CoV-2 has only been recognised since December – but it has tales to tell.

Most of what we know about this virus comes from genetic analysis. The first complete SARS-CoV-2 genome sequence was read from someone who worked at a seafood market in the Chinese city of Wuhan, who had been admitted to hospital on 26 December 2019 with symptoms of what turned out to be a new disease. Known as Wuhan-Hu-1, the sequence is a bit like the type specimen of a species – the reference against which all others are compared.

The sequence showed that the new disease was caused by a novel coronavirus closely related to a group found in bats. That was good news and bad news. Coronaviruses are RNA viruses, which generally have the highest mutation rates of any known biological entity. RNA viruses are slippery customers, mutating often and hence evading drugs and immune defences.

But most coronaviruses are an exception because their RNA-copying enzyme has a proofreading function. The assumption was that the new coronavirus would follow that rule and rarely mutate.

Tens of thousands of genomes from all over the world have since been sequenced. These are constantly slotted into an ever-growing family tree by the pathogen-tracking project Nextstrain at Fred Hutchinson Cancer Research Center in Seattle.

At first all was quiet. Sequences seen in China in December and early January were identical to the reference. So were the first from outside China – three in Thailand and one in Nepal – that were analysed in January.

Then mutants started to appear. The first was collected in the Chinese province of Yunnan on 17 January. An identical one popped up in the US two days later. These were only two mutations away from the reference case, but in virology they are a new lineage.

30,000

The number of letters in the SARS-Cov-2 genome

Lineages aren't necessarily biologically different, and that proved to be the case with this new lineage. It had no reported differences in its ability to cause an infection or its virulence.

The new lineage began circulating in Asia and was soon common enough to be classed as a "clade", which is a lineage that accounts for at least 20 per cent of cases within its branch of the family tree. As more samples were sequenced, it became clear that this new clade had actually appeared in late 2019. It was given the name 19B, to distinguish it from the original 19A clade.

For the first few weeks of 2020, these two clades – 19A and 19B – stood alone. They circulated in Asia and cropped up in North America, Europe and Australia.

In late January, a new lineage appeared in Australia and Europe. It was four mutations away from the reference genome, though again it didn't appear to be biologically different. This lineage soon attained clade status, 20A, and dominated the European outbreaks of early 2020. It has since diverged into two other clades: 20B, which appeared in Europe, and 20C, a predominantly North American clade.

That, for now, is where we stand. All five clades constantly spawn new lineages, but none is yet common enough to become a clade. All are found worldwide, though 19A remains largely confined to Asia.

This is a lower rate of divergence than might have been expected. According to an analysis by a team at the Walter Reed Army Institute of Research in Silver Spring, Maryland, the virus has evolved to a minimal degree since December.

"The coronavirus genome is exceptionally stable," says Samuel Díaz-Muñoz, an evolutionary virologist at the University of California, Davis. "Since the beginning of the pandemic, we've seen like six mutations in a 30,000-base genome. It's one strain with minor variations."

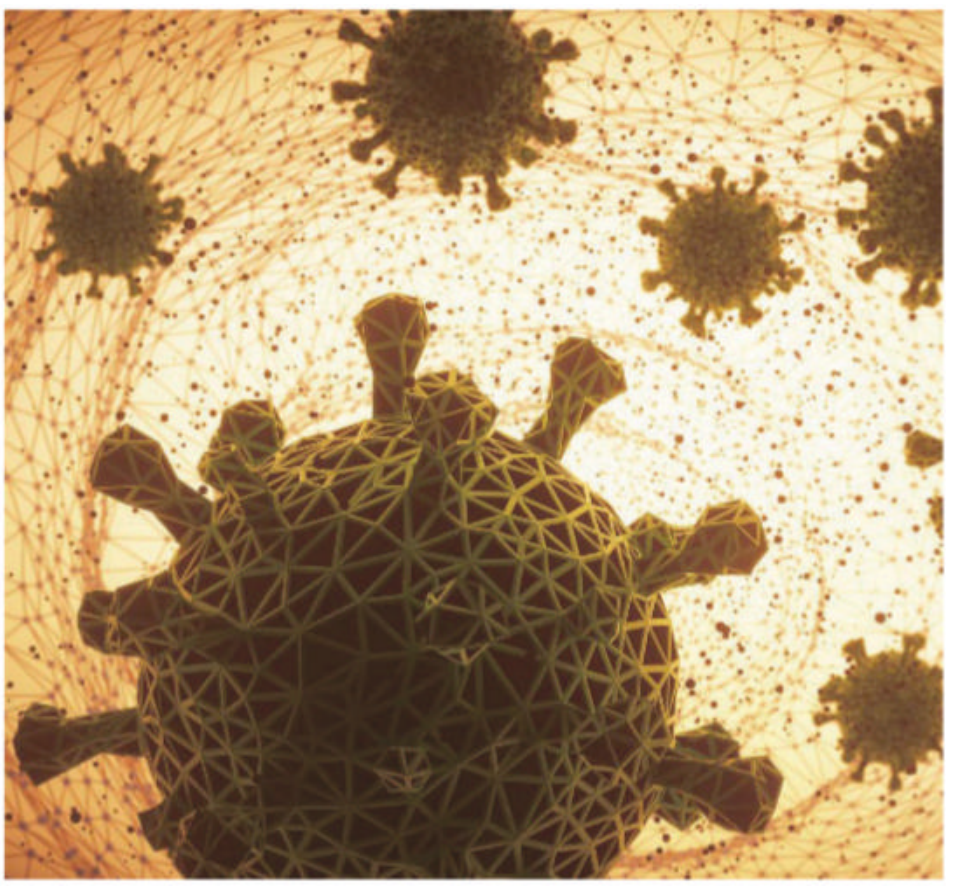
This is probably down to two key factors: a relatively slow mutation rate and the fact that most mutations are a hindrance to the virus and so are weeded out.

As yet there is no conclusive evidence that any of the clades has progressed to become what virologists call a "strain" – that is, a biologically different entity, perhaps a more virulent one.

One mutation, D614G, attracted attention in May after an international team warned that it appeared to be spreading rapidly, perhaps because it was more transmissible though possibly less deadly. However, that remains an unproven claim. According to the Walter Reed team, all the currently circulating viruses are sufficiently similar that a successful vaccine will immunise against them all.

But as the virus spreads, there are signs of different strains emerging. Three recently reported cases of reinfection in Hong Kong, Nevada and Belgium were caused by mutants that are all sufficiently different to evade the patients' immune memory (see page 14). Time will tell if these constitute new strains of SARS-CoV-2.

KIYOSHI TAKAHASE SEGUNDO/ALAMY



The SARS-CoV-2 virus has evolved minimally since December

Reinfection

How worried should we be about reports of reinfection?

Jessica Hamzelou

IN RECENT weeks, the first confirmed reports of people who have been reinfected with the coronavirus have begun to trickle in. Such cases suggest that, in some people at least, the immune system doesn't develop lasting protection against the virus.

Immunologists weren't surprised that there were cases of reinfection, as we see this all the time with many viruses, such as seasonal strains of the flu. This may be because the defences raised by our immune systems for one form of a virus don't work as well for another.

Long-lasting immunity is thought to be generated by memory immune cells. Some produce antibodies – molecules that can either prevent a future infection from occurring or stop a second infection from causing disease. Memory T-cells, on the other hand, guide the immune response and kill infected cells.

So far, research in humans and monkeys suggests that many people who have been infected will have antibodies against the coronavirus for months. So why do some people appear to have caught it twice? Immunity might not last for everyone, while in other cases, it is possible that the initial immune response wasn't strong enough.

Some immunologists predict that the current coronavirus is likely to trigger immunity in a similar way to the virus behind the SARS outbreak in 2003, as they are genetically similar. One recent study found that people who had recovered from SARS still appear to have T-cells for the virus that causes it 17 years later.

Yet John Brooks at the US Centers for Disease Control and Prevention cautions against assuming that the viruses act in the same way. "The diseases they produce and the way they are being transmitted are remarkably different," he says.

The first confirmed case of reinfection by the coronavirus is thought to be that of a 33-year-old man in Hong Kong, who had mild symptoms when he first tested positive. Four-and-a half-months later, he tested positive again, despite having no symptoms. Genetic analyses of the two virus samples suggest they were caused by different forms of the virus, indicating they were indeed two separate infections.

17

years on, people who had SARS seem to have T-cells for the virus that causes it

This case was somewhat reassuring to Petter Brodin at the Karolinska Institute in Stockholm, Sweden, because it indicates that the man's immune system had developed a lasting response that protected against future disease, if not reinfection. "This is a textbook example of how the immune system should respond," he says.

Another reported case of reinfection in a 25-year-old man in Nevada is more worrying. The man first fell ill with covid-19 in April. He recovered and tested negative for the virus twice, but 48 days after initially testing positive, he tested positive again. The virus appeared genetically different to the one from his first infection, but his symptoms were

Epidemiology

What we can expect for the future of the pandemic

In an ever-changing situation, it is hard to predict where we are in the course of the covid-19 crisis. **Clare Wilson** asks five experts about what may lie ahead and whether we have reason to believe the worst is behind us

David Hunter
Professor of epidemiology and medicine, University of Oxford, UK

There is a lot of discussion about a second wave, and when is a wave a wave, or will it be a ripple. Or some people suggest that a better analogy is tides. I sincerely hope there won't be another pandemic like in March-April, that it would be much more attenuated. I suspect it will be, because we've got a lot of things in place: a better-educated population, social distancing, handwashing and mask-wearing.

That should mean that the epidemic curve is attenuated. If we can, as the virus persists, do a better job of protecting the very old, there should be many fewer deaths, even if there are a lot of infections. So we're in a much better place than we were six months ago, and even if there is a second wave or the tide comes in again, hopefully there'll be a lower fatality rate.

Devi Sridhar
Professor of global public health, University of Edinburgh, UK

If you have mass-testing capabilities, you could clear the virus. And then you add into the mix a vaccine, perhaps by early 2021.

If we move towards the saliva-based tests that are rapid and cheap, that'll make testing easier. There are ways to get around testing everybody on a weekly basis if you use your testing in a strategic way, targeting where your highest risk is. But at the start, we can't get around that we're going to need millions of tests, and the logistics are complicated.

Another scenario is that we may see a certain strain of this virus that is more infectious but less severe start to become the predominant strain, but I think that is years away. The third bet is T-cell immunity. We have antibody tests, but some immunologists think that antibodies underestimate the number of people who have protection. Could we already have more people exposed to this than we think?

Zoë Hyde
Epidemiologist, University of Western Australia

I am hopeful that high-income countries such as Australia will be able to start a vaccination

ANTHONY KWAN/POOL VIA REUTERS

Medical professionals collecting samples for covid-19 testing in Hong Kong on 1 September

worse in the second instance.

This could be "really bad news", says Brodin, because it suggests that the immune system's first response could make the disease worse the second time around through a mechanism known as antibody-mediated enhancement of disease. In this process, the virus can essentially hijack antibodies that have been trained to recognise it, then use them to enter more cells in the body.

It is also possible that the Nevada man's second positive result was due to his continued shedding of non-infectious viral RNA from his initial infection, says Brooks. A person can become infected with two forms of the coronavirus at the same time, but the man's symptoms could have been caused by another virus, he says.

A report by the Korea Disease Control and Prevention Agency supports this idea. Researchers found that none of the 285 people they studied who appeared to have been reinfected with the virus passed it on to any of their contacts. Those behind the report say that, rather than referring to "reinfection", they will now refer to people being "re-positive", clarifying that such individuals merely test positive a second time.

It isn't yet clear how many of the millions of people who have caught the virus might have done so twice. "We have no evidence to suggest [reinfections] are anything but very rare," says Angela Rasmussen at Columbia University. ▮

programme early next year, assuming phase III trials are successful. A vaccine won't immediately make things return to normal. The first vaccines might not be sterilising – however, I think they will be sufficient to get our economies functioning again. We can then explore options such as boosting with a different type of vaccine.

The picture won't be so rosy in many low-income countries, as they will struggle with the logistics of vaccinating their populations.

I am concerned about India, which is on track to become the epicentre of the pandemic. In addition to the human cost, I expect there to be global implications because of its key role in the manufacture of pharmaceuticals. The knock-on effects would be felt most strongly in the developing world, where interruption to the supply of medicines could lead to many indirect deaths.

Benjamin Cowling
Professor of epidemiology and biostatistics, University of Hong Kong, China

We are hoping to get a vaccine probably next April to June. We'll vaccinate the most vulnerable people first. So what we may see is that we still have some social distancing, but maybe not as strict as right now – just trying to slow down the spread so that we can vaccinate everybody. And then things can go relatively more back to normal.

But even after a whole population has been vaccinated, if the effectiveness isn't as good as we hoped for, or if a strain of the virus emerges that can escape the vaccine protection, then we're going to see winter epidemics of covid-19, like we do for flu. Even in a vaccinated population with partial protection, a winter outbreak of covid-19 could still cause more impact than a winter epidemic of flu because, on an individual basis, [covid-19] is 10 to 20 times more serious.

Raina MacIntyre
Head of biosecurity research, Kirby Institute, University of New South Wales, Australia

In the absence of an effective vaccine, we're going to have waxing and waning periods of the epidemic, and these will vary by country. There will be more disease around and health systems will be stressed, and then interventions will be brought [back] in. It will cycle.

It may not be that far away before we have vaccines, sometime next year hopefully. But you're not going to be able to make 7 billion doses overnight. Rich and powerful countries will probably buy up a lot of the supply and other countries will have to stand in line.

If you can't achieve mass vaccination in those countries, you could just chase the outbreaks and do ring vaccination. That's what happened with smallpox, and with Ebola as well. That's when, if you have an outbreak, you vaccinate all close contacts.

But we're going to have hotspots of covid-19 in the world for a long time. Smallpox took more than 20 years to eradicate – that's the time frame we're talking about living with covid-19. ▮

Biodiversity

Wildlife populations around the world see 'catastrophic' falls

Donna Lu

GLOBAL wildlife populations are plummeting, according to the 2020 *Living Planet Report* by conservation group WWF. It reveals that populations of mammals, birds, amphibians, reptiles and fish have fallen an average of 68 per cent globally since 1970. This is even worse than ecologists feared.

"Let's be clear: this is catastrophic," says Mark Wright at WWF in the UK. "Despite ongoing verbal and written commitments by governments around the world and by businesses around the world to seriously address the climate crisis... we are clearly failing."

The report draws on data from the Living Planet Index, produced by the Zoological Society of London. The index tracked global biodiversity between 1970 and 2016, based on monitoring 20,811 populations of 4392 vertebrate species. The largest drops identified by the index are in South America, Central America and the Caribbean, where the average size of monitored wildlife populations fell by 94 per cent.

Nearly one in three freshwater species around the world are now threatened with extinction, and the 3741 freshwater populations monitored showed an average decline of 84 per cent since 1970.

Some animal populations have increased due to conservation efforts: from 2008 to 2014, the tiger population of Nepal rose by 64 per cent, while loggerhead turtles increased by 154 per cent in a protected area off the coast of South Africa from 1973 to 2009.

"Things are not written in stone and we can turn them around if we choose to," says Wright. But some efforts still aren't moving the needle enough, says David Symons at consulting firm WSP, including a UK plan to protect biodiversity enacted in 2018. "Less than half of the [UK] 25 Year Environment Plan indicators are showing improvement, so there is a huge job of work to be done [there] to reverse biodiversity loss," says Symons.

"These declines are not written in stone. We can turn them around if we choose to"

MICHEL GUNTHER/WWF

Some populations of the loggerhead turtle, shown here in Greece, are rising

Improving biodiversity will require minimising habitat loss as a result of food production, including restoring degraded land and a greater shift to plant-based diets, says Wright.

In upcoming UK environment, agriculture and trade bills, the WWF is advocating for a legal obligation to track environmental impact and for companies to prove that their supply chains caused no deforestation. "We do not want the UK to be party to any activities, or import any products, that result in any environmental destruction," says Wright.

Symons says the government's Environmental Land Management scheme is a step in the right direction. "[It] will provide us with an opportunity to use public money for public good: rewarding farmers for tree and hedge planting, rewarding farmers for better river management," he says.

Autism

Autistic children may prefer cats as they don't hold your gaze

THE fleeting way cats make eye contact may be why some autistic children have stronger relationships with pet cats than pet dogs.

"Cats don't hold a stare but tend to look away after short bouts of eye contact, and it's possible that this feels more comfortable for people with autism," says Marine Grandgeorge at the University of Rennes in France. Previous research based on questionnaires with parents has shown that autistic children develop relationships with pets and often have "privileged" relationships with cats, she says.

She and her colleagues visited 42 homes in western France and observed 23 autistic boys and 19 neurotypical boys and girls, all aged 6 to 12, who had either a pet cat or dog. By analysing the videos made during these visits, the team found that neurotypical children tended to gaze longer at their pets than children with autism did.

They noted that dogs – as well as children who aren't autistic – tended to gaze for at least a second at a time during eye contact, she says. Cats – and autistic children – tended to give far shorter glances (*Frontiers in Psychology*, doi.org/d8qg).

"There's this belief that autistic children don't want social contact with humans, but maybe they just don't want humans to insist on creating a connection through long gazes, because that feels too intrusive," says Martine Hausberger at the French National Centre for Scientific Research, who worked on the study.

The findings are somewhat surprising for James Cusack, CEO of the UK autism research charity Autistica. "Many of the autistic adults in our organisation actually prefer dogs!" says Cusack, who is autistic himself. "But autistic people are enormously diverse, so it's normal to have both 'dog people' and 'cat people' in the autism population."

Even so, the gregarious nature of dogs might seem "intimidating" to some autistic children, who "might find them unpredictable", he says.

"The important thing here is that having a pet in the house can be very positive for autistic children's well-being," says Cusack.

Christa Lesté-Lasserre

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Space

Out-of-this-world advertising

NASA is trying to turn the ageing International Space Station into a hub for commerce. Are cosmetics commercials the best use of an orbiting outpost, asks **Mark Harris**

SHUTTERSTOCK/NASA

LAST year, NASA declared the International Space Station open for business. Although firms could already do research on the ISS under contract with NASA, the agency hoped to stimulate pure commerce, including the manufacture of biotech and the development of on-orbit industries that could support NASA's deep space exploration goals – not to mention bringing in some cash.

Instead, it got beauty product marketing with Estée Lauder, sports shoe design with Adidas and the transport of space tourism trinkets.

Space Act Agreements between the agency and various companies show that some of the first purely commercial activities that NASA astronauts will participate in have little to do with advancing science or enabling future space missions. They are also effectively being heavily subsidised by the agency, which is charging below-cost cargo fees to the firms involved.

Space souvenirs

In November, a SpaceX resupply mission to the ISS is scheduled to carry essential supplies, a new airlock and a bag of commemorative items supplied by French company Toucan Space. Consumers can already pre-order a "Flown to the ISS" sticker for €199, a bookmark for €299 or a postcard featuring a classic NASA photo for €499.

The enterprise has been organised through a US start-up called Techshot. "Demonstrating the business viability of selling space-flown items will support development of a sustainable LEO [low Earth orbit] economy," reads NASA's agreement with the firm. "Techshot's proposal to fly these items will provide a pilot demonstration to markets to stimulate further business interest... and eventually achieve reinvestment of profits into further commercial LEO ventures and infrastructure."

Meanwhile, Alpha Space, a Texas-based firm with a testing facility permanently installed to the outside of the ISS, has signed an agreement with NASA to repurpose some of its scientific cargo capacity for "luxury goods and memorabilia" flown to space.

Techshot and Alpha Space will each pay NASA $10,116 for every kilogram of items carried to and from the space station. This represents a significant discount on the agency's actual costs. According to a 2018 analysis of transport costs to the ISS, NASA is paying more than $70,000 to ship each kilogram of supplies to the station. Neither agreement requires the companies to reinvest profits in future space activities or with NASA itself.

NASA's funding for the International Space Station is due to end in 2024

$10k

Cost per kilogram NASA is charging for sending commercial cargo to the ISS

A NASA spokesperson told *New Scientist* it developed its pricing policy to stimulate demand and that the price covers only some of its costs. "[The agency] will periodically reassess the pricing policy with the goal to eventually move to full cost," they said.

"We need to kick-start this new way of working with NASA," says Rich Boling at Techshot. "If there is a terrific demand, perhaps the number should be increased to fully recoup costs."

Toucan Space's and Alpha Space's objects are likely to remain in cargo bags within the SpaceX spacecraft until they return to Earth, but that isn't the case for NASA's first purely commercial project, which is due to go up on a Northrop Grumman resupply mission at the end of this month.

Boston-based company Space Commerce Matters (SCM) has signed an agreement with NASA to send up to 10 bottles of a "newly formulated" Estée Lauder product to the ISS as part of a maximum 5-kilogram payload. Under the deal, NASA astronauts will spend over 4 hours producing video and other imagery of the bottles. In all, SCM will pay NASA $128,000, which includes astronaut time at around $17,500 per hour.

Neither SCM nor Estée Lauder replied to requests for comment. However, in an online panel discussion in August, Stéphane

"If the circus is necessary to maintain the International Space Station, it's probably a good trade-off"

de La Faverie, group president of Estée Lauder, revealed that the bottles were a new formulation of its Advanced Night Repair skin serum. "We're constantly pushing the boundaries of how to showcase our products," he said.

The right sniff

ISS residents might appreciate the arrival of fragrant products. In an interview with *Wired* in 2017, astronaut Scott Kelly likened the space station's aroma to that of a jail, a "combination of antiseptic, garbage, and body odor".

However, former astronaut Tim Kopra, who flew on two ISS missions, says most perfumes and lotions are forbidden on board. "We have very select personal hygiene products that have been tested and approved to ensure they don't mess up our hardware," he says. For example, anything containing alcohol is banned as it can foul up the air filtration equipment. NASA confirmed that the Estée Lauder product won't be used on the ISS.

Adidas is also exploring the possibility of getting its products into orbit, having signed an agreement with NASA to collaborate on technologies to help astronauts train for space and on developing more sustainable footwear. Part of that effort could include testing materials, clothing and shoes on the ISS, the deal says.

NASA has long had strict rules about not endorsing specific products or services, and recently added new guidelines for the ISS. Commercials made there cannot depict NASA astronauts or mention that they or the agency helped with filming.

But any time that NASA crew spend on commercial activities could detract from their other duties. "We have a prescribed number of hours that we work on science every day," says Kopra, who now works for Canadian company MDA, which made robotic arms for the space shuttle and the ISS. Astronauts also maintain the space station and exercise every day to preserve bone density and muscle mass, he says. "It's a pretty jam-packed time frame."

TOUCAN SPACE

A sticker that has travelled to space will be sold for €199

In addition, every cargo bag of mementos or beauty products that makes it to orbit means one fewer bag of scientific experiments. In the August panel discussion, Christine Kretz at the ISS National Laboratory, which organises research on the space station, noted that NASA was now allocating 5 per cent of its annual payload to commercial "non-research, non-sciencey" activities like the Estée Lauder promo. That corresponds to as much as 175 kilograms of non-essential products, alongside 90 hours of crew time, each year.

"Undoubtedly, [a beauty product video] gets in the way of real science," says Todd Humphreys at the University of Texas at Austin, who had an experiment installed on the ISS in 2017. "But if the circus is necessary to maintain the station, and serious lab work can still be done when the cameras aren't rolling, it's probably a good trade-off."

Time for science is likely to become even more limited once private individuals begin flying to the ISS, replacing NASA astronauts on crewed flights. NASA is already working on a feasibility assessment for private missions with Virgin Galactic astronauts. Actor Tom Cruise is even due to film scenes for a movie there.

The clock is also ticking on the space station itself, which is due to lose official NASA support in 2024. "The ISS could be a stepping stone to what may be possible on the moon," says Saadia Pekkanen at the Space Policy and Research Center at the University of Washington, Seattle. "We have to start changing our ideas and build some sort of a commercial platform."

For its part, Estée Lauder has indicated it is interested in more than just an orbital photo shoot. The company has committed to sponsoring research into producing sustainable alternatives to plastic in microgravity. "Our mission is to make every woman beautiful, but if we can also make the world a better place [that would be] critical," said de La Faverie during the online panel.

"The ISS has been a huge boon to science over its lifetime," says Humphreys. "I much prefer the prospect of a commercial ISS than no ISS at all after 2024, or one controlled only by international partners." ▮

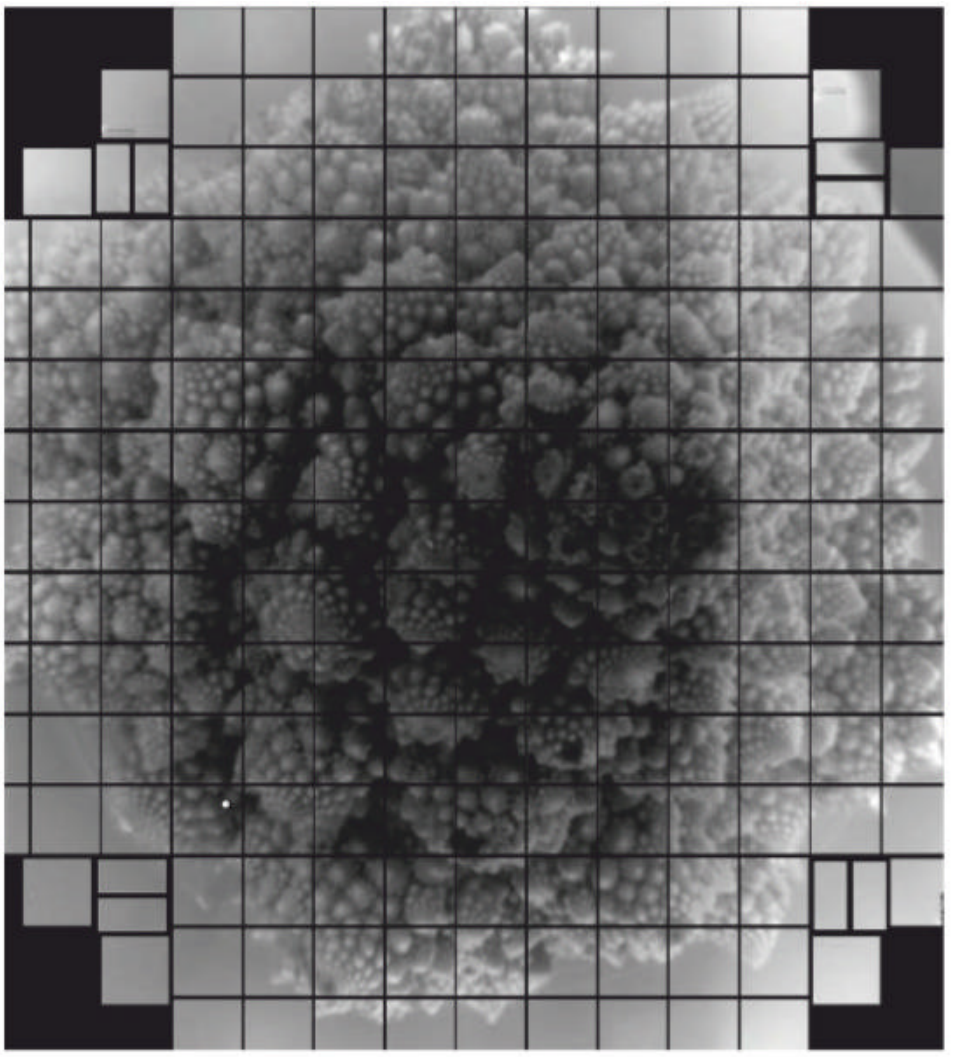
Selling in orbit

While an Estée Lauder video will be the first advert US astronauts have shot in space, NASA has dallied with product promotion in the past. In 1985, both Coca-Cola and Pepsi shipped modified drink cans on the same space shuttle flight to see if their fizzy drinks could be dispensed in microgravity without causing a mess. Neither product made it into NASA's regular food pantry.

Other countries have looser rules around commercial activity in space. Canadian astronaut Chris Hadfield recorded a cover version of David Bowie's *Space Oddity* while on the International Space Station in 2013 that later ended up on an album on Earth.

Russian cosmonauts have also embraced extraterrestrial advertising. They first filmed an advert for milk on board the Mir space station in 1997, and have since marketed cup noodles, golf clubs, Radio Shack and Pizza Hut from the ISS.

Digital photography



SLAC NATIONAL ACCELERATOR LABORATORY

Largest single photo ever taken is of... a cauliflower

THIS unassuming image of a Romanesco cauliflower is one of the largest digital photographs ever snapped, at 3.2 gigapixels. Larger composite images have been produced, but this is the biggest single photo ever made.

The image was taken with the sensor array that will eventually be part of the world's largest digital camera. When attached to a telescope at the Vera C. Rubin Observatory in Chile, the camera will take enormous images of the southern sky for the Legacy Survey of Space and Time (LSST).

The first test images with the array are of objects chosen for their detail, including this cauliflower. The images were projected onto the surface of the detectors using a pinhole camera. "I wanted something that had an interesting structure and would just look cool," says Aaron Roodman at SLAC National Accelerator Laboratory in California, who is in charge of the camera's assembly and testing.

More importantly, these photos show the detectors are working. The 189 sensors used to take this image have such high resolution that they could show you a golf ball about 24 kilometres away.

The LSST observations are due to begin in 2021. It is expected to take more than 200,000 pictures every year for 10 years.

"We'll be able to see asteroids, look for planets in the solar system and look into the deep universe," says Roodman. "We'll be able to study the expansion of the universe, the nature of dark energy, and dark matter both in our solar system and the universe at large." **Leah Crane**

Video editing

AI edits unwanted objects out of video

OBJECTS can be removed from videos, and the field of vision of the camera can be expanded thanks to a new technique powered by artificial intelligence.

Film studios invest a lot of time and money in editing unwanted objects out of video footage. Machine learning could potentially do the job at a fraction of the cost, but it has rarely been used to visualise what lies behind objects or outside a frame.

Jia-Bin Huang at Virginia Tech University and his colleagues at Facebook have used deep-learning software known as a convolutional neural network to manipulate video footage by analysing two frames from different time points in a video feed. Then by singling out the pixels belonging to a particular moving object that appears in both frames, the neural network can calculate the relative motion of the object through the video.

The convolutional neural network uses that motion to calculate where the object lies in frames when it is obstructed from view (arxiv.org/abs/2009.01835).

"Our flow algorithm tells you where a pixel in frame one will go in frame two," says Huang. The AI is able to remove objects and uncover the background. It can also expand shots, calculating where objects lie even if they are outside the film frame.

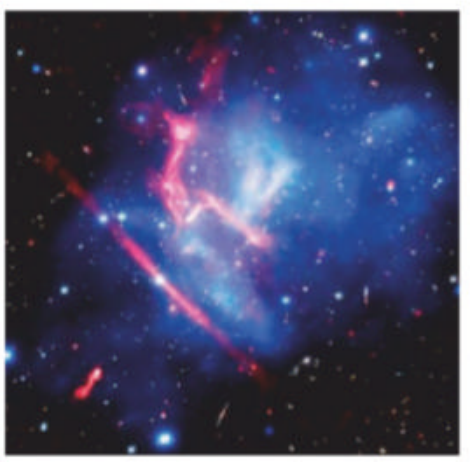
There are some limitations in the system, though, says Huang. The algorithm stumbles when confronted by organic bodies or objects, like fire or water. Faces would also prove problematic, because the system doesn't have a semantic understanding of what it is amending. "You'd have to have some understanding that human faces have two eyes and are symmetrical, roughly," he says. "Right now, our algorithm doesn't have that." **Chris Stokel-Walker**

Cosmology

Dark matter in galaxy clusters is being odd

SOMETHING doesn't look right in clusters of galaxies. The structure of the dark matter that suffuses them is different to what we would expect, and we don't know why.

One way to measure dark matter in distant galaxies is by analysing how they affect the light coming from objects behind them. When light passes, the gravity of a galaxy can bend it in what is known as gravitational lensing.



UPI/ALAMY

Priyamvada Natarajan at Yale University and her colleagues examined the lensing data from 11 galaxy clusters to determine the structure of the dark matter in them. They then compared that data with 25 simulated clusters.

"You can think of a cluster as a big mountain range with a lot of little peaks that are associated with the cluster's galaxies," says Natarajan. "Around these little peaks of dark matter around the galaxies, you could see little events of extra lensing," she says.

Those relatively small lensing effects were 10 times stronger than simulations predicted, and it wasn't clear where the discrepancy came from (*Science*, doi.org/d8rd).

Either there is some error in the simulations, which are consistent with other observations, or dark matter behaves differently from how physicists thought it did. Either way, the discrepancies in these lensing events hint that we are missing something big about our universe. **LC**

Really brief

ALAIN HERZOG/EPFL

Self-cooling microchips

Microchips with an inbuilt system of tiny water-filled pipes can stay cool without the need for bulky heat sinks. The microchips have a cooling power 50 times greater than that achieved with conventional cooling methods, and could lead to a new generation of more efficient electronics devices (*Nature*, doi.org/d8pn).

Plenty of poodle in the labradoodle

The Australian labradoodle, a cross between a Labrador and a poodle, has DNA drawn mostly from the poodle. The dog has been bred for 30 years, and genes for a poodle's coat have dragged large portions of the rest of the poodle's chromosomes into the labradoodle (*PLoS Genetics*, doi.org/d8p9).

Citizens' assembly backs flight taxes

The UK's first citizens' assembly on climate change has recommended taxes on flights that increase the further or more frequently someone flies, to help cut carbon emissions. The group of more than 100 people from across the UK also supports a ban on sales of new gas boilers.

Human brain

Our brain changes how fast time passes

TIME may sometimes seem slower than it is because part of our brain becomes fatigued.

"One might have experienced this manipulation after hearing music with fast tempo," says Masamichi Hayashi at Osaka University in Japan. "The next song with a slightly slower tempo will feel even slower."

Hayashi and his colleagues have scanned the brains of 20 people, with an average age of 21, as they were shown a quick succession of grey circles on a screen. The circles were used to manipulate the participants' sense of time. Some participants only saw each circle for 250 milliseconds, whereas others saw them for 750 ms.

After this, each person was shown another grey circle for a different amount of time, followed by a loud beep for 500 ms. The participants were asked to judge whether the amount of time they saw the second circle for was shorter or longer than the beep.

Participants who initially saw the grey circles for 250 ms overestimated how long the new circle was on screen, while the other group underestimated.

Brain scans showed that the participants who reported bigger time distortions had a greater reduction in the activity of the supramarginal gyrus (SMG) (*Journal of Neuroscience*, DOI: 10.1523/JNEUROSCI.0078-20.2020).

Hayashi speculates that this is because the first phase of the experiment fatigued the time-sensitive neurons in the SMG, making them less likely to fire as they became tuned to repeated stimuli. **Jason Arunn Murugesu**

Animals

THOMAS MARENT/MINDEN/NATUREPL.COM

Hummingbirds drop their temperature to save energy

AT NIGHT, hummingbirds can enter a hibernation-like state, lowering their body temperature to under 4°C to preserve energy for the day.

Previous studies have found that hummingbirds can drop their body temperature from 40°C to about 17°C at night, but now Blair Wolf at the University of New Mexico and his colleagues have found that some species can reach 3.26°C. "You'd think they're frozen," he says. "They feel like a cold rock."

His team studied six types of hummingbird at up to 4000 metres above sea level in the Peruvian Andes where temperatures can drop to between 2°C and 6°C at night. By day, the birds expend massive amounts of energy, hovering to consume nectar from flowers. At night, they can reduce energy expenditure by more than 95 per cent. Even their heart rate drops from 1000 beats per minute to around 50, says Wolf (*Biology Letters*, doi.org/d8rc).

At around sunrise, the birds started quivering, increasing body temperature by more than 1°C per minute. The behaviour has a price, says Wolf, because the inert state makes the birds easy prey. The tropical Andes, however, is a pretty predator-free environment, he says. Christa Lesté-Lasserre

Artificial intelligence

Speedy AI makes people lip sync

ARTIFICIAL intelligence can adjust video footage in real time to make people lip sync to any talking or singing.

Prajwal Renukanand at the International Institute of Information Technology in India and his colleagues trained a lip-syncing algorithm on short video clips, tasking it with marking out the lip shapes of people talking.

The algorithm is a generative adversarial network made of competing AIs. One AI – the generator – adjusted the imagery of the person's lips to match the words being spoken. Two other AIs, the discriminators, had to distinguish whether the footage was real or fake. After several rounds, the discriminators could no longer tell the difference (arxiv.org/abs/2008.10010).

"To lip sync a 1-minute video, it would take around 2 minutes," says Renukanand. Most of the time required is for the algorithm to detect a person's face in the video, while the lip-syncing component occurs in real time.

The researchers hope to use the algorithm to dub video content in different languages, and increase the ease of syncing CGI characters with the sound of voice actors. **Donna Lu**

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**

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Serving Mankind

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.

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Views

Comment

Vaccine hope is still alive

The halt to the Oxford vaccine trial wasn't cause for worry – it was a sign of the research process working as it should, says **Clare Wilson**

Clare Wilson is a medical reporter at *New Scientist*
@ClareWilsonMed

THERE was great alarm last week when a trial of a vaccine candidate for the coronavirus, from the University of Oxford and drug firm AstraZeneca, had to be put on hold after a participant developed strange neurological symptoms.

It might seem a cause for concern, but, in fact, it shows that research and development for this vaccine is proceeding exactly as it should. It also highlights the danger of bypassing the normal stage of large safety trials, as Russia and China seem to be doing with their vaccines.

We don't yet know the full details, but AstraZeneca has said vaccination was paused due to a single "unexplained illness" in a UK participant. According to an anonymous source quoted in *The New York Times*, this illness is a condition called transverse myelitis. Rather than a precise diagnosis, transverse myelitis is more of a descriptive term for inflammation of the spinal cord. It can have many causes, but is sometimes triggered by a viral infection, which means it could be linked to the vaccine.

On the other hand, it is also plausible that it isn't. Many thousands of people have received this vaccine candidate so far, in the UK, US, Brazil and South Africa. Statistically, some of them are bound to develop new illnesses during the trial that are nothing to do with it. Investigation is vital.

The alarm is perhaps inevitable given the stakes involved in coronavirus vaccine research. In the UK, the great attention paid to the Oxford vaccine trial – which is thankfully now to resume – seems to partly stem from national pride. But there are nine vaccine candidates around the world that have reached phase III trials, the large, final stage of testing that usually comes before regulatory approval. It is likely that not all of them will reach the clinic.

MICHELLE D'URBANO

The standard development process for vaccines and medicines involves testing them in ever-larger trials. Earlier this year, for instance, the AstraZeneca vaccine was successfully tested in a phase II trial involving about 1000 people, half of whom got the vaccine, with no reported side effects. If it had the capacity to cause a serious side effect in one in 1000 people, or 2000 people, that might not have shown up in a trial that size. That is why it is so important that phase III trials involving thousands of people are done before any vaccine is approved. Even these cannot rule out the risk of very rare side effects emerging later on.

What is more worrying is that some countries seem to be rushing through the development of their vaccines before these necessary final-stage trials have been done. Last month, Russia's president, Vladimir Putin, said his country had approved a vaccine against the coronavirus. The apparent plan is to start mass immunisation next month. China National Biotec Group, a state-owned drug firm, has reportedly given one of the two vaccines it has developed to hundreds of thousands of its citizens.

Unfortunately, long before the covid-19 pandemic, anti-vaccine sentiment had been growing in some countries. In the UK, it was largely triggered by unfounded claims that the measles, mumps and rubella vaccine caused autism. In the US, it initially stemmed from concerns over some of the additives in vaccines.

Now anti-vaccine groups swap all kinds of outlandish conspiracy theories online (see page 24). Even when we do finally get a safe and effective coronavirus vaccine, some nations will have a battle on their hands if they hope to achieve herd immunity by vaccinating enough of their population.

So the prompt action taken by the Oxford vaccine researchers at the first sign of a possible side effect was absolutely necessary. Contrary to what many anti-vax groups say, it shows the immense effort that goes into making sure vaccines are safe. ▮

No planet B

The war against reality

An absurd political conspiracy theory is branching out into science denial. Combating it is important, but it won't be easy, writes **Graham Lawton**

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

Graham's week

What I'm reading
I'm writing a book in my spare time, so can just about manage to keep an eye on Twitter.

What I'm watching
Mortimer & Whitehouse: Gone Fishing. *Banter and poignancy in idyllic settings.*

What I'm working on
Did I mention I am writing a book?

This column appears monthly. Up next week: Annalee Newitz

AS THE weeks and months of covid-19 drag on, I have found myself dragged into an increasingly bewildering and frightening conspiracy theory. I am no conspiracy theorist myself, unless you count the belief that much of the world is currently run by buffoons. When I first heard of QAnon, I filed it alongside "flat Earth" as an infuriating but essentially harmless fringe belief. But the more I learn about it, the more worried I become that it could kill off any chance we have of emerging from the pandemic into a greener, more enlightened world.

You may think, like I did at first, that QAnon isn't worth spilling ink over. You may also think that an article about it has no place in a popular science magazine. But bear with me.

To cut a long story short, QAnon is a far-right conspiracy theory that contends the world is run by satan-worshipping paedophiles who traffic children for sex and for a life-extending compound that are extracted from their adrenal glands. It is named after a shady character called Q, who posts "inside information" on internet message boards. While it is all total and utter nonsense, two US presidents loom large in the QAnon narrative: Obama as one of the controlling elites and Trump as Q himself or the leader of the fight against the elites and the "deep state", a shadowy organisation that really runs the US.

None of it has any basis in fact and preposterous, fetid conspiracy theories are nothing new. But QAnon has taken them to a new level. It has evolved into an umbrella conspiracy theory that can accommodate all deranged beliefs and unite previously antagonistic conspiracies under the same banner. Its beliefs are seeping into everyday discourse, including mainstream media. Several Republicans standing for office are open QAnon supporters and its followers are an increasingly visible and vocal presence at Trump rallies. If Trump defies the polls and retains the presidency, QAnon votes will have helped put him back into the White House. And if he loses but cries foul, QAnon followers will be among those trying to restore him to power despite the result.

Don't get me wrong, US voters are entitled to vote for whoever they think will make the best president, and the result must be legitimate. But another four years of Trump would be disastrous for our existential battles against climate change, biodiversity loss, environmental degradation and more pandemics. Only science-based policies can dig us out of those holes.

"It seems that when you have unshackled yourself from one bit of reality, letting go of the rest comes easily"

Unsurprisingly, QAnon doesn't have much time for science or science-based policies. In its world view, they are just another tool of the elite to distract from what is really going on and an excuse to implement policies to cement their status. During the pandemic, QAnon has evolved to be explicitly anti-science. Recently, Q has declared that covid-19 is either a hoax or a bioweapon and that climate change is a con.

That was evidently a smart move on Q's behalf. According to research carried out by a coalition of environmental groups, Q has tempted some prominent climate-change deniers – who were already expanding into the covid-19 denial business – to start spreading QAnon poison. I fully expect anti-vaccine activists to be next to join the bandwagon. It seems that when you have unshackled yourself from one bit of reality, letting go of the rest comes easily.

QAnon hasn't just cornered the market in conspiracy theories, but is morphing into a conspiracy-industrial complex of reality denial that threatens to sway the most important US general election since the last one.

Combating it will be difficult, if not impossible. Many articles of QAnon faith have been proven spectacularly and blatantly wrong, such as the allegation that a basement of a famous pizza restaurant in Washington DC was the centre of the paedophile ring (it wasn't and it has no basement). But these setbacks only serve to strengthen true believers' faith.

On a good day, I think of QAnon as a fascinating case study of human psychology and behaviour, laying bare how far from reality our minds can stray, how social forces can drag people into parallel universes and how we can sustain beliefs in the face of what is irrefutable evidence to the contrary. But then I wake up.

Believe me, I don't want to give these people the oxygen of publicity or stoke a counter-conspiracy theory that fervidly imagines QAnon wields greater power than it actually does. But I think it is time that a wider audience was made aware of just how dangerously influential this is becoming. QAnon believers aren't mildly eccentric flat-Earthers or shills for the fossil fuel industry. They are fighting a war against reality. That is one existential battle you really don't want to lose. ▮

New Scientist events

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In this talk, Ilyas Khan, CEO and founder of Cambridge Quantum Computing reveals how quantum computing is emerging as a reality with investors and large corporations entering the ring. He'll review the rapid progress being made by a range of companies including Google, IBM and Microsoft and ask whether it's time to believe the hype.

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Shiniest spiral

Insight Investment Astronomy Photographer of the Year Awards 2020
rmg.co.uk/astrophoto
Photographer Nicolas Lefadeux

RARELY has the universe looked so tantalisingly within reach as in this enchanting photo of the Andromeda galaxy, taken by French photographer and optical engineer Nicolas Lefadeux.

To get the shot, he positioned his camera at an angle to the telescope's focus, which softens the edges of the image so that the galaxy appears to be close. It won him the top prize at the Insight Investment Astronomy Photographer of the Year Awards, a competition organised by the Royal Observatory Greenwich, UK. The winners of each category were announced in an online ceremony on 10 September.

Just 2.5 million light years away from Earth, the spiral Andromeda galaxy is the nearest major neighbour of the Milky Way and is bright enough to be spotted with the naked eye as a pale blur in the night sky. The sparkle and glitter of the photo is down to the trillion or so stars that make up Andromeda. For comparison, the Milky Way contains between 100 billion and 400 billion stars.

At Andromeda's centre is a supermassive black hole surrounded by a disc of stars, dust and gas, as well as an outer gas "halo". Researchers estimate that Andromeda will collide with the Milky Way in 4.5 billion years, at which point they will merge into a single, giant galaxy that has been nicknamed "Milkomeda".

An exhibition of the competition's winning images will open at the National Maritime Museum in Greenwich on 23 October. Tickets are on sale now.

Gege Li

Editor's pick

Long live the virtual ecological conference

22 August, p 24

From John Gee, Capel Dewi, Carmarthenshire, UK

I was surprised to find Graham Lawton relishing the thought of a trip to an Ecological Society of America conference in California. If ecological groups, of all organisations, can't abandon their fixation with physical international conferences, then we really are in a pickle.

Does the chance to exchange ideas over a couple of drinks really justify flying thousands of miles when, by Lawton's own admission, video conferencing ticks almost all the boxes? Virtual events are also fairer for scientists from low-income nations who may lack the funds to attend in person. So what if "aviation is only 7 per cent of global oil consumption"? When emissions come from such a wide range of sources, we can all play the game of claiming our favoured activity is responsible for only a small amount.

Why working from home failed to launch earlier

15 August, p 32

From Robert Willis, Nanaimo, British Columbia, Canada

Amid the pandemic, you posit reasons why remote working didn't take off sooner, despite the urgings of experts like Peter Drucker. In all the discussions, you missed the most obvious and – based on my studies – probably the most influential reason: loss of power by supervising management.

There is a fairly large body of research showing that the major cause of resistance to remote work – called "telework" in the early days described by Drucker – was the management attitude of "how will I know they are working if I can't see them?". Even under current conditions, there remains an ingrained school of thought among management that resists anything minimising direct, personal control.

We like to think that this command-and-control model is outdated and long-since discarded, but if you walk into just about any organisation (profit, non-profit, charity, NGO etc.) you will find that reports of its demise have been greatly exaggerated.

Other reasons we may react badly to out-groups

29 August, p 38

From Emma Lamerton, St Austell, Cornwall, UK

Your feature on unconscious bias mentions MRI experiments in which participants shown a face they saw as part of an out-group displayed increased activity in the amygdala, "the part of the brain that governs our threat response".

Are we sure this always means they are seeing that person as a threat? Could it be a fear of communication issues instead? Accents and cultural customs with which we are unfamiliar may cause such a response – we are afraid we may mishear, misunderstand or, worse, inadvertently offend.

The article suggests that having "a diverse set of peers" may decrease bias, and likewise being exposed to and becoming familiar with a range of accents and cultures would lessen the fear of miscommunication.

From Keith Macpherson, Clevedon, Somerset, UK

You say that "using blind or anonymised hiring practices" may weaken unconscious bias. This reminds me of a tale, probably apocryphal, of the hiring methods of the chief pilot of an airline. The story goes that he would take the pile of application forms and throw them down the stairs. The applicant whose form went the furthest got the job. When asked why he did things this way, he replied: "I don't want any unlucky pilots working for me."

Russia needs to test its coronavirus vaccine fully

22 August, p 11

From Simon Goodman, Griesheim, Germany

Michael Marshall notes that Russia's "Sputnik V" coronavirus vaccine hasn't started phase III clinical trials, but has already been approved there. Phase III assesses the efficacy of a medical treatment, and some 50 per cent of all medicines tested initially fail at this stage, so it is no small issue.

Phase II trials are often designed to indicate a potentially useful safe dosage. They can only detect if a drug has any statistically relevant effects if the trials are large – including hundreds of patients. The Sputnik V "trials" reportedly involved a total of just 76 patients. The problem with this is that therapeutically effective drugs that have severe adverse effects in less than one in 1000 people are routinely withdrawn from sale.

On the fall in death rate for those who catch the virus

29 August, p 7

From Bryn Glover, Kirkby Malzeard, North Yorkshire, UK

You say that the lower age of those getting infected with covid-19 doesn't, on its own, explain the apparent decline in its deadliness. This is amid speculation of the rise of a less lethal strain. I favour a broader explanation for what we observe: we have effectively self-selected into two cohorts, those who fear the outcome of infection and those who don't.

There are many predisposing factors for severity of the illness, of which age is but one. As a result, we have split into two halves: those continuing to practise strict isolation out of fear and so are avoiding infection, and those who are indifferent about catching the virus and so are probably doing just that. It is most likely that the second group will experience lesser illnesses overall, and so there will be proportionately far fewer cases needing a hospital bed.

Oil billionaires never asked permission

5 September, p 18

From Richard Jefferys, Berkhamsted, Hertfordshire, UK

Mark Harris asks: "Should billionaires be able to start tinkering with the climate without asking the rest of us?" Surely removing carbon dioxide from the atmosphere is pretty benign. Shouldn't we worry a whole lot more about the billionaires (and the rest of us) who are geoengineering the climate by adding CO_2 without asking?

To find ET, we must learn to think like ET

Letters, 15 August

From David Edwards Hulme, Stockport, Greater Manchester, UK

The "Star Tugs" envisioned by Yale University's Alexander Svoronos as a form of engineering by aliens have generated quite the reaction among readers such as Chris Eve. Yet imagining that an advanced civilisation would devise a means of moving a star system out of the way of trouble falls into the trap of applying human ingenuity to a problem. Any civilisation that is advanced enough to move a star would have their own ways of avoiding disaster that our human minds can't begin to envisage. ▮

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

For the record

▮ **The Vulcan character pictured in our look at the *Star Trek* franchise was Sarek, played by James Frain (5 September, p 34).**

The Industrial Revolution

In the September issue of AQUILA, children can explore an era that changed the world. They can read about Mudlarking and the whacky inventions of the bi-cycled revolution; meet 'the other Brunel' and history's biggest fraudster, Gregor McGregor. PLUS: moth mutation in sooty British cities; the story of cotton and have fun with an Arts & Crafts printing project.

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The making of Nurse Ratched

Netflix's stylish new thriller *Ratched* explores one of fiction's great villains, but peddles harmful stereotypes about mental health, finds **Bethan Ackerley**

TV

Ratched
Evan Romansky
Netflix

COURTESY OF NETFLIX

Nurse Ratched (Sarah Paulson) setting out on a path to villainy

"SHE likes a rigged game," says Randle McMurphy, the belligerent anti-hero of the film *One Flew Over the Cuckoo's Nest*. McMurphy is talking about his nemesis, Nurse Ratched, the sadistic overseer of a psychiatric hospital ward – and one of fiction's most terrifying villains.

Netflix's new TV series *Ratched* is a prequel to that iconic 1975 film, which was based on a 1960s novel by Ken Kesey. It promises to delve into the eponymous nurse's psyche to explore the origins of her behaviour. It kicks off in 1947, when Mildred Ratched (played by Sarah Paulson) seeks work at Lucia State Hospital, a psychiatric facility in California, where unsettling research is taking place.

After fooling hospital director Richard Hanover (Jon Jon Briones) into believing she is the perfect nurse, Ratched carries out a secret plan to help a patient escape that unleashes her darkest tendencies and wreaks havoc at the facility.

Lucia's spa-like opulence and the stylish feel of the series seem a world away from the austerity of the ward in *Cuckoo's Nest*. Yet the seeds of that facility and Ratched's authoritarian inclinations are already on chilling display. Just as she shames her charges into submission in the film, Paulson's Ratched quickly identifies and exploits the weaknesses of those in her way.

Ratched is at its most enjoyable when it replicates the chase scenes and tense confrontations of old-school thrillers. It is also riveting as it confronts 1960s anxieties about women being as cruel and violent as men.

There are other women who are violent, but here Ratched gets her hands dirty in a way you don't see in the film. By the end of the second episode, for example, she has lobotomised someone.

Stripped of the misogyny now clear in the book and film, the TV series provides an unlikely setting in which to explore relationships between women, from rivalries to romances, but it works well.

> **"The show is riveting as it confronts 1960s anxieties about women being as cruel and violent as men"**

The primary relationship is a romantic one between Ratched and Gwendolyn Briggs (Cynthia Nixon), an adviser to the governor. And there is the rivalry-friendship between Ratched and Nurse Bucket (Judy Davis), who Ratched initially tries to usurp.

But it is a shame that a show serving one marginalised group well doesn't do the same for another. The people under Ratched's care end up feeling like stereotypes because the show doesn't spend enough time developing them as rounded characters – or it uses them as pawns in the machinations of the hospital staff.

Meanwhile, hospital director Hanover lobotomises patients with abandon as he stumbles towards psychiatric "progress" and a nurse locks women in baths at extreme temperatures to "cure" them of lesbianism. These "treatments" were of their time, and the series rightly recognises them as monstrous, but the dehumanising handling of those subjected to them leaves that interest looking voyeuristic and providing cheap shock value.

So, too, does its portrayal of patient Charlotte Wells (Sophie Okonedo), where the show peddles stereotypes about people with certain mental health conditions being violent. As such, we have to ask who is served by a chic show seeking to humanise an abusive nurse in a world where the mistreatment of those who use mental health services is still rampant.

A 2019 review of research in *Frontiers of Psychiatry* found that while coercive measures used in psychiatric settings can cause harm and even death, their incidence is under-researched. And between 2012 and 2017, at least 271 people using NHS mental health services in England died as a result of failings in their care.

In such a climate, when a show perpetuates obvious and harmful stereotypes about mental health, it is hard to applaud its vision, no matter how stylish and compelling a thriller it is. ▮

Fighting for a better future

David Attenborough's new documentary is a bleak look at our eradication of the natural world, says **Adam Vaughan**

TV

Extinction: The Facts

BBC One and BBC iPlayer

IN THE BBC's new documentary on global biodiversity loss, we see a ridiculously young-looking David Attenborough laugh and play with an infant gorilla called Poppy. It is a welcome moment of light relief.

The scene comes at the end of a difficult hour-long examination of the ways in which humanity may be driving a sixth mass extinction and how this loss is affecting us in turn, including links to the covid-19 pandemic. Given that the facts are so dire, the show is often unbearably and unremittingly bleak too.

Loosely hooked to a major UN biodiversity report published last year, which found that the survival of 1 million species was at risk, *Extinction: The Facts* is a whistle-stop tour of our destruction of nature. A stellar cast of academics and experts from NGOs tell the story of a decline in mammals, plants and fish that Attenborough says "isn't just disturbing, it's deeply tragic".

The big drivers of this devastation are ticked off: habitat loss, climate change and the "escalator to extinction" as species try to adapt to higher and cooler homes. The illegal wildlife trade is also covered, with harrowing footage of ivory, endangered species and more. Even less photogenic subjects, such as the organisms we are losing from our soils, get a look in.

At times, too much has been crammed into an hour – some sections are an unsatisfying mix of shallow sound bites and generic-looking footage of overfishing and power plants, for instance. It would have been better to cut some parts to allow others to breathe.

Still, the film-makers made some smart decisions on what to include. Viewers expecting a simple nature documentary will be confronted with facts about the pressures from a global population heading to 9 billion and overconsumption by high-income countries, plus the links between animal feed for chickens in China and deforestation across South America.

The show is made more relevant by delving into the links between our destruction of nature and the emergence of spillover diseases such as SARS, swine flu and, of course, covid-19. Peter Daszak, a zoonotic disease expert and the president of research group EcoHealth Alliance, eloquently lays the blame on humans encroaching on wild animals' habitats. Felicia Keesing at Bard College in New York points out that our disruption of ecosystems favours the small-bodied species, such as bats, that can transmit diseases to us.

The diversity of the talking heads is another highlight. While there is a star turn from the charismatic Bob Watson, chair of the body behind last year's biodiversity report at the time it was published, there are also welcome contributions from people in regions of Africa and South America where nature is being especially plundered.

The documentary is at its strongest when it zooms in and slows down. It delves into the exploitation of pangolins across Asia and the baby-carrying giant anteaters that are dying at roadsides in Brazil's Cerrado region, before focusing on a ranger who is looking after the last two northern white rhinos in the world and then switching to Attenborough on the recovery of mountain gorillas.

These closing minutes on mountain gorillas, numbers of which rose from around 250 in the 1970s to more than 1000 now, feel a little glib as an example of how to stem biodiversity loss, given the scale of the problem laid out earlier. Yet despite its minor flaws, *Extinction: The Facts* is a success, right down to Attenborough's final rousing call for us all to fight for a "better future".

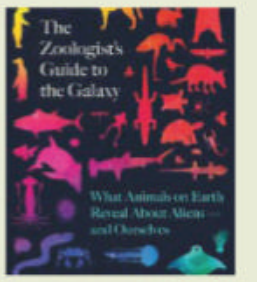
There are only two northern white rhinos left in the word

BBC/CHARLOTTE LATHANE

Don't miss

Watch

How to Make the World Add Up has economist and broadcaster Tim Harford delve into the misuse of numbers in politics, journalism and PR in a live-streamed talk from the Royal Institution. Tune in at 7pm BST on 22 September.



Read

The Zoologist's Guide to the Galaxy sees University of Cambridge scientist Arik Kershenbaum explore how we can learn more about the possibilities for life and culture in unexpected corners of the universe by observing animals closer to home.

Learn

Sustainable Fashion is one of a series of webinars organised by consulting firm McKinsey for Climate Week NYC. Anna Granskog (above) asks how to green the polluting fashion industry. Join in at 3pm BST on 23 September.

TOP: MICK SINCLAIR/ALAMY

The sci-fi column

Riders on the storm The author of *The Inheritance Cycle*, a wildly popular young adult series, is back with his first adult sci-fi. This hallucinatory space opera is a perfect reminder that we need to look beyond our current troubles , says **Sally Adee**

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

MATJAZ SLANIC/GETTY IMAGES

Could we really be the mind of the universe – watching and learning?

THE first 50 pages of Christopher Paolini's new blockbuster, *To Sleep in a Sea of Stars*, are standard-issue space opera. Kira Navarez is a xenobiologist in a skeleton crew surveying a barren planet for colonisation. On the last day of the mission, she investigates an unexpected sign of life and does her job a bit too well. Soon enough, a xenomorph is clawing its way out of her innards.

Yet the moment you think, "wait a second, isn't this kind of familiar?", Paolini is right there ahead of you with a spaceship AI winkingly named Bishop and a planet called Weyland. Just as you recognise the homages to the *Alien* franchise, Paolini seamlessly slides into the next theme – a symbiote straight out of *Venom* – before morphing into *Starship Troopers*. Suddenly, the captain of a janky starship appears, with a wicked smile and a blaster strapped to his thigh. Next up: Lovecraftian extra-dimensional horrors with many tentacles.

Paolini's previous effort, *The Inheritance Cycle*, is an incredibly readable young adult fantasy series that came under fire for borrowing a bit too liberally from source material like *The Lord of the Rings* and *Star Wars*.

Even so, the books soared to the top of all kinds of lists. You could forgive Paolini given he started writing the first instalment, *Eragon*, when he was 15 – he was even awarded a world record as the youngest author of a bestselling book series. At 36, his first adult sci-fi novel doesn't have the excuse of youth or a young audience unexposed to his sources of inspiration. So is it derivative? Yes – and it is brilliant.

"Suddenly, the captain of a janky starship appears, with a wicked smile and a blaster strapped to his thigh"

Detailing each borrowed part at length would be as irrelevant as pointing out, for example, that few of today's songs succeed without the scaffolding of much older funk, soul, house and rock samples. The pearl-clutcher song du jour, *WAP* by Cardi B and Megan Thee Stallion, is built on a 1992 club track by Frank Ski. Sampling has been going on since the 1940s, so questions about the line between inspiration and derivativeness are hardly new.

In *To Sleep in a Sea of Stars*, Paolini's "samples" are less like those in *WAP* and more like the ones used by Gregg Gillis, the late-2000s mash-up artist better known as Girl Talk. Gillis gleefully skirted copyright laws by sampling just enough of a song to be recognisable before layering it into the next short sample. Each of the resulting songs was a beautiful mosaic of dozens of tracks fractionated and overlaid to create a new resonance and meaning.

Like a Girl Talk album, the point is the larger quilt that Paolini stitches out of all these samples. It is a beautiful reminder – straight out of the hallucinatory writing of Italo Calvino – that even as we slog through this uniquely rancorous era, in which everyone is fighting everyone over disease, populism, climate change and inequality, we still have a much bigger calling to attend to.

"We are the mind of the universe itself," Navarez learns. "We are the universe watching itself and learning." Learning, perhaps, how to escape the inevitability of extinction.

My advice? Ride out the ongoing threat of covid-19 and the end of democracy with this doorstopper. There is nothing quite like a 1000-page tome with undersized font, oversized pages and immense themes to remind us that this, too, shall pass, and that our purpose is bigger than the strife in which we are now mired. ▮

Book

To Sleep in a Sea of Stars
Christopher Paolini
Tor

Sally also recommends...

Book

The Stars Are Legion
Kameron Hurley
If you like badass women fighting tentacle horrors in space, do try Kameron Hurley's smaller epic – it is a comparatively light 400 pages.

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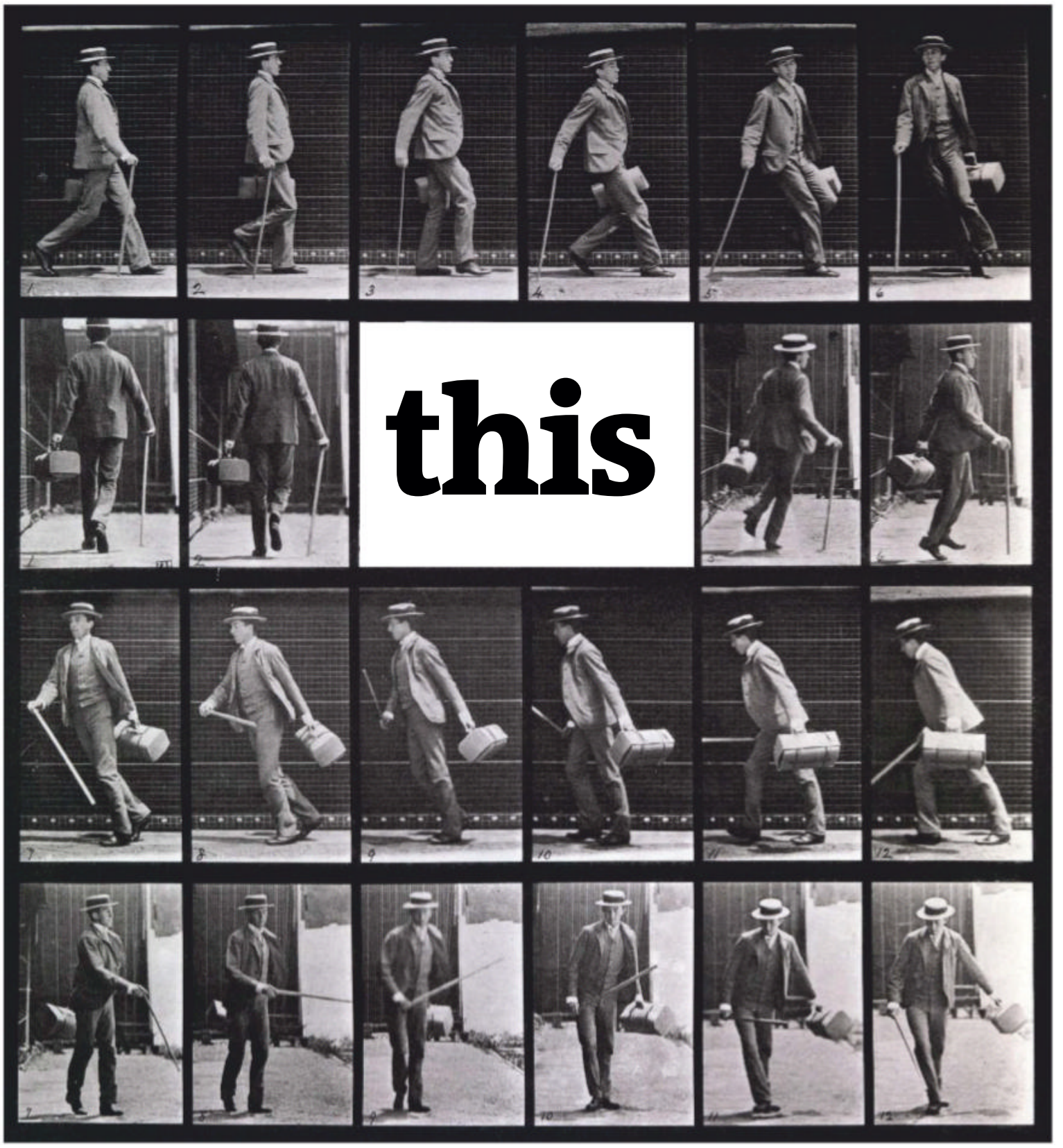


SCIENCE HISTORY IMAGES/ALAMY

Your gait is as unique as your fingerprint and could soon be used just as widely. Should we be worried? **David Adam** investigates

LIAM GALLAGHER, formerly of the band Oasis, tends to stroll with a roll to his shoulders. John Wayne's slow swagger has been linked to everything from a misaligned leg to small feet. Some say Vladimir Putin's distinctive shuffle is thanks to KGB weapons training that encouraged operatives to dampen the swing of one arm to keep it closer to their gun.

Considering that walking is such an everyday function of a bipedal species, it is incredible that we find so many different ways to do it. Perhaps that's why our gaits – and what they say about us – are so fascinating. It takes dozens of muscles working together throughout the body to put one foot in front of the other. These subtle patterns of muscular flexes and strains are highly distinctive, so much so that scientists who study gait increasingly believe they are as unique to you as your fingerprint.

Gait analysis has been around for years, but now it is going mainstream. China is using it to track its citizens. Transport companies want to use it to identify ticket holders. Doctors say an analysis of your strides might provide an early hint of health problems. But is this technology on a solid footing? And is it offering a step in the right direction or is it merely another worrisome invasion of our biometric privacy?

We have watched other people walk for centuries. The ancient Greek philosopher Aristotle was one of the first to pay attention, but no one was more obsessed with the subject than the 19th-century French novelist Honoré de Balzac. He peppered his books with extravagant descriptions of how his characters got from A to B, often linking their walking style to their personalities, social status and occupation. Describing an elderly woman in his 1832 book *The Vicar of Tours*, he wrote that "her movements were not equally distributed over her whole person, as they are in other women… She moved, so to speak, in a single block."

The Paris strut

Balzac also produced one of the first serious examinations of gait. "It seems, the science is mine," he wrote on realising the topic had been largely ignored. His *Theory of Walking*, published almost 200 years ago, was based on watching people as they strutted the streets of Paris. He made some pertinent observations: sailors, who were used to counteracting the rocking motion of the sea, would move with their legs wider apart. It wasn't science as we know it, but it showed beyond doubt that walks vary a great deal.

Balzac doesn't have the field to himself any longer. Gait analysis has grown as an academic pursuit and is producing practical applications. Among the first to spot the potential were criminal investigators, who have used forensic gait experts to identify a suspect from the way they walk in CCTV footage.

More recently, advances in computer vision have allowed gait analysis to make big strides, using precision imaging to measure details the eye can't perceive. Some gait scientists record and compare specific biomechanical measurements, such as how far an ankle rotates, or how large the angle between the upper and lower leg gets as the knee flexes. Computerised gait analysis looks at the total set of such differences. "Everyone has a unique gait pattern. And that, of course, means they could be identified," says Sebastian Heinzel, who studies gait at Kiel University in Germany.

"One of the biggest breakthroughs in the early days of gait recognition was realising that you can recognise someone by their silhouette," says Patrick Connor, a gait-recognition researcher with the company Stepscan Technologies in Canada. He is talking about what is known as gait energy imaging. This involves taking a series of snapshots of a person's profile as they walk, usually from the side, and merging them into a single image, each unique to their owner. "The head's in the same place and the torso's in the same place and you get this kind of blurry arms and legs movement," says Connor.

How reliable is it? Gait researchers say a ›

What your walk says about you

It is a common belief that the way someone walks offers clues to their personality. A long, quick stride is often believed to betray confidence or arrogance, while a shuffle is a sign of an introvert. But are gait and personality really linked?

In 2012, researchers at Durham University in the UK asked volunteers to judge the personality of 26 people as they walked. Although the volunteers agreed with each other – that someone who walked with a loose, expansive style was an adventurous, trustworthy, warm extrovert, for example – they didn't generally agree with how the walkers rated their own personalities.

Still, some studies do find a link. In 2017, psychologists at the University of Portsmouth, UK, looked for correlations between someone's personality and biomechanical analysis of their gait, such as how much they swayed. They found some: self-reported aggressiveness correlated with larger relative movement between the upper and lower body. As their left foot went forward so did the right shoulder, in what has been called a "pimp roll" or the "gangster glide".

Ask the inmates

In a separate study, Canadian psychologists took videos of a dozen undergraduate students walking and showed them to 47 inmates who had been imprisoned for violent crimes. Each student had been asked by the researchers to say how often they had felt "victimised", with the definition left intentionally broad.

The prisoners who scored highest on a test of psychopathic traits were better at telling from the students' walks which had said they had been victimised most often.

That leaves us rather uncertain as to what your walk really says about you. Most psychologists reckon there is no link between personality and walking style. But studies on this topic are so small and varied in their design that it is tough to confidently draw any conclusion.

system "works" if it can correctly identify 90 per cent of volunteers from their walks. As the technology improves, they test it against bigger and bigger groups. "When I started, we could just about identify 10 people," says Mark Nixon at the University of Southampton, UK. "These days, people are getting 90 per cent on enormous databases of tens of thousands of people."

It is also beginning to work with less than ideal imagery. In 2017, computer scientists in Portugal showed that they could reliably recognise people walking under a downward-pointing camera solely from their shadows. This may mean drones can carry out covert gait analysis – on sunny days, at least.

Secret stalking

All this might prompt thoughts of face-recognition technology, which is becoming widely used to identify people without their knowledge in many countries. In the UK, police use of this technology has been subject to a court case in which a man claimed that his human rights had been breached. Gait analysis could be an even more powerful tool because it can work with lower resolution pictures and is much harder to avoid than face recognition systems. You can generally fox these by wearing a mask – which wouldn't exactly look suspicious these days.

Paul Wiles, the UK's biometrics commissioner, points out that people upload lots of video clips to social media where faces aren't easily made out, but gaits are. He says police in the UK are interested in pairing gait analysis with face recognition to make better use of this kind of footage, though this is on the back burner at the moment due to the coronavirus pandemic.

Gait analysis is nowhere near as widely used as face recognition yet. This is mainly because it requires a series of sequential pictures that cover the seven stages of walking, as each leg moves and lifts. Processing these images requires serious computing heft and most gait analysis systems don't have enough of this to work in real time. This is why these systems are

UNIVERSAL IMAGES GROUP VIA GETTY IMAGES

Studying the way people move after a stroke can guide their rehabilitation

“Gait analysis could be an even more powerful tool than face recognition”

of limited use to police; a crucial requirement for use in law enforcement is that the systems can recognise those they want to apprehend quickly enough to give authorities a shot at detaining them.

The one place where gait analysis is being used a lot is China. In late 2018, reports emerged that state authorities had extended the biometric surveillance of its population to include this type of analysis. Huang Yongzhen, the CEO of Watrix, the tech firm that developed the Chinese system, said at the time that it can identify people up to 50 metres away with 94 per cent accuracy. Wanted criminals should watch out, Yongzhen warned: the company’s database includes many of their distinctive walks.

Other experts in the field are sceptical that Watrix’s technology is as powerful as it claims. (The company didn’t respond to questions from *New Scientist*.) But most agree it is only a matter of time before such real-world identification is possible.

For Wiles, that is worrying. He has said that the use of gait analysis by police and others might need to be controlled or limited by new legislation. Such biometric analysis is ethically problematic because it can be done without an individual’s knowledge or consent, he said, and because “some uses of new technology may... not be in the public interest nor justified by the benefits”.

Wiles says his preferred way forward would be for governments to draw up frameworks that set out the broad principles for using gait and other biometric identifiers. The Scottish government has already started down this road by introducing a bill that would pave the way for codes of practice for biometric identification technology.

All this applies to situations in which people don’t necessarily want to be identified. But there are upsides. For those looking to be recognised, gait analysis offers advantages. Take airport security, where rapid, accurate identification is a must. Gait recognition could simplify the whole process.

If people want to be identified, there is no need to go to the trouble of measuring silhouettes, as in gait energy imaging. Instead someone might be asked to wear sensors that would feed back precise information about their movements. These needn’t be anything too sophisticated. Computer scientist Maria De Marsico at the Sapienza University of Rome uses this method to recognise people from the information sent from the accelerometer inside a standard smartphone as it jerks around in their hand or pocket as they walk. Her team has built a prototype smart door that opens when it recognises an approaching person in this way.

In principle, this is much more convenient than, say, pausing to scan an iris or fingerprint at a checkpoint. “Naturally, that’s going to slow down the amount of traffic that can flow through any particular entry point,” says Connor. “But if you have to walk up anyway to the access point, you’ve already presented your gait. There’s nothing more to do.” ›

DAVID MADISON/GETTY IMAGES

Monitoring our motion could give an early warning of disease

“Could someone impersonate your walk to get inside a secure location?”

Several firms appear to agree. Mastercard says it is working with transport companies on how gait analysis could be used to authenticate passengers as they approach a ticket barrier. Nuclear energy officials in Indonesia want to beef up security by adding video checks on how people walk.

Others are taking an even simpler approach by comparing not patterns of muscle movement, but footsteps. “When we see a footprint in the sand, we see an image. But there’s actually a sequence of events that occurs during the footstep and a certain amount of pressure that’s applied in certain locations,” says Connor. The way these patterns change from person to person is already used to help design and fit sports shoes. By fitting pressure sensors inside floor tiles, scientists can read and compare these signatures, so our footsteps can open doors.

One concern here is “spoofing”, where someone analyses and impersonates a walk in order to, say, get inside a secure location. “I think that probably the biggest concern is whether someone can steal your identity and use it for their own purposes,” says Connor. It remains to be seen how vulnerable gait-recognition systems are to this sort of attack.

Rate my gait

Once scientists, companies and the police have your gait information, what could they tell about you, beyond your identity? Just as Balzac linked walking styles with temperament two centuries ago, people often claim to be able to judge a person by their gait. Whether this can be done is controversial, however (see “What your walk says about you”, page 38).

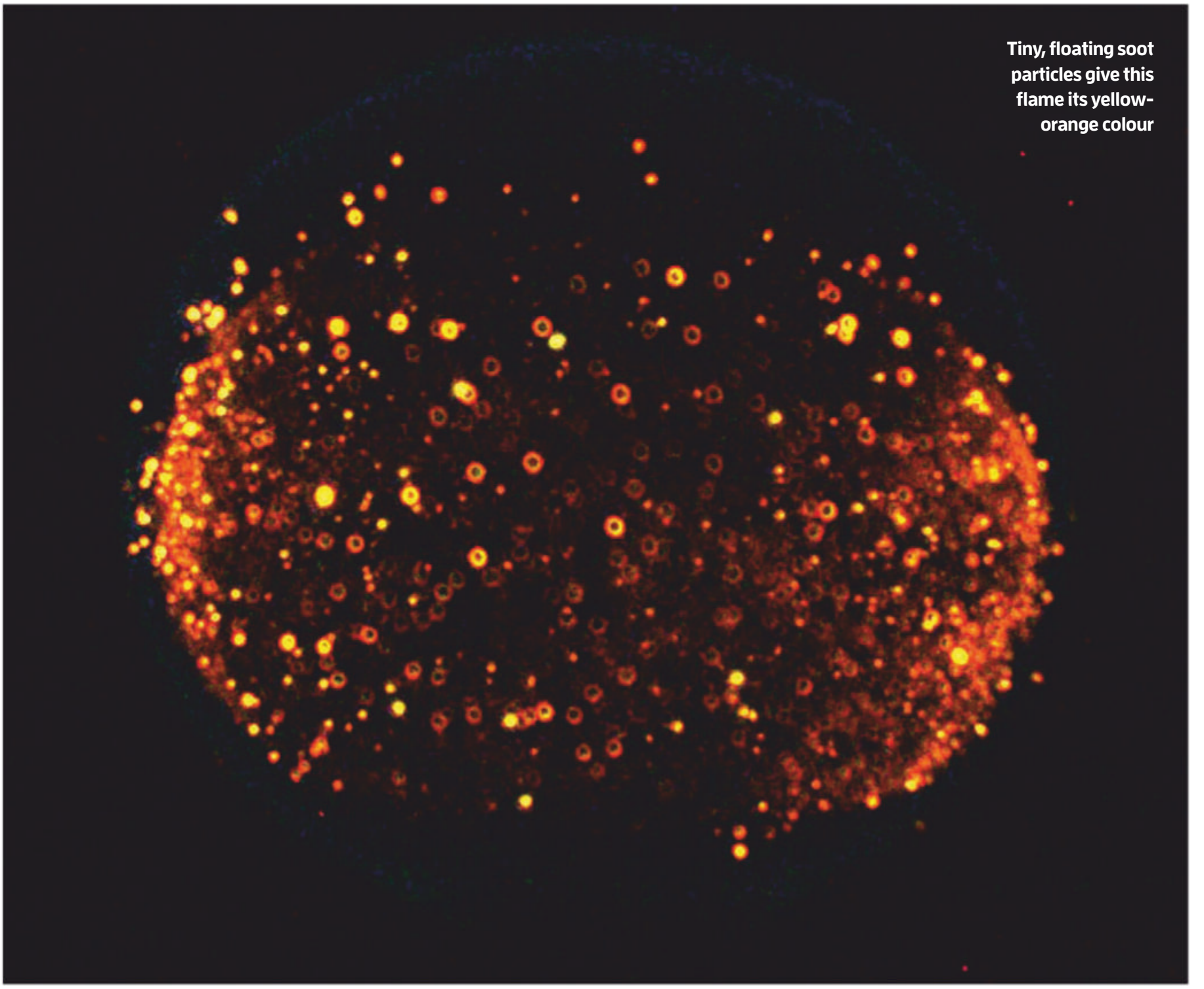
More usefully, there is growing interest in using gait analysis to track people’s health. Heinzel uses sensors fitted to the lower backs of people with Parkinson’s disease to analyse their walking movements. Videos of people walking are already routinely used to spot muscular problems, but Heinzel hopes to use this technique to diagnose the disease, track physical deterioration and assess how much drugs are helping.

It is early days, but he says the approach could be used to signal the onset of other conditions too. “How you move in a supermarket may change when you develop mild cognitive impairment or when you have diseases like multiple sclerosis,” he says. Catching such conditions early would allow better treatment and could mean a better prognosis.

Knowing precisely how you walk can also help you do it better. Kyle Reed, a biomechanics researcher at the University of South Florida, uses the same body-sensing technology and cameras used to make the film *Avatar* to examine the impaired gait of people who have had a stroke. This can improve rehabilitation programmes, he says, because the technology adds information that a physiotherapist can’t see. “There’s a gap right now between what therapists do sort of intuitively and what the computer models are saying,” he says. “One of the things I’m trying to do is bridge that gap.”

His research has confirmed what Balzac knew all those years ago: there is more than one way to walk. The writer couldn’t have foreseen that what he observed from the Paris pavements might one day provide a means of identifying every individual on a planet of nearly 8 billion people. Had he lived to hear of it, perhaps he might have walked with a little more swagger. ▮

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



Tiny, floating soot particles give this flame its yellow-orange colour

NASA

The magic of fire in space

Flames unfettered by gravity are more than just beautiful. Studying them is a powerful way to help us control combustion on solid ground, reports **Philip Ball**

IF YOU are floating in Earth orbit in the life-sustaining bubble of air that is the International Space Station (ISS), surrounded by nothing but a frigid vacuum, the last thing you want is a fire on board. So it may sound worrying that, for the past decade or so, NASA has been lighting fires up there on purpose.

"Any time you mention starting a fire on the ISS, you're going to raise a lot of eyebrows," says Daniel Dietrich at NASA's Glenn Research Center in Cleveland, Ohio. However, these particular incendiary escapades are perfectly safe.

Fires can't start in space itself because there is no oxygen – or indeed anything else – in a vacuum. Yet inside the confines of spacecraft, and freed from gravity, flames behave in strange and beautiful ways. They burn at cooler temperatures, in unfamiliar shapes and are powered by unusual chemistry.

But the reason NASA is starting fires in orbit goes beyond mere aesthetics. It is chasing a deeper understanding of fire itself. Studying combustion in microgravity is beginning to enhance our ability to harness its power down here on solid ground. That could bring huge benefits through flames that emit less polluting gas or allow engines to run more efficiently.

Up in flames

Humans have been entranced by fire for almost as long as we have existed. Archaeological remains suggest that our ancestors were controlling fire 1 million years ago. Doing so was a crucial precursor to the invention of cooking, which allowed us to get more calories out of our food and reduced the infection risk from bacteria. Some researchers think this could have changed the course of human evolution itself.

Flames were no less compelling once we had figured out some of the science behind them. In 1848, in a series of public demonstration lectures, Michael Faraday explored the chemistry of combustion and respiration using nothing more than a candle flame. They proved wildly popular.

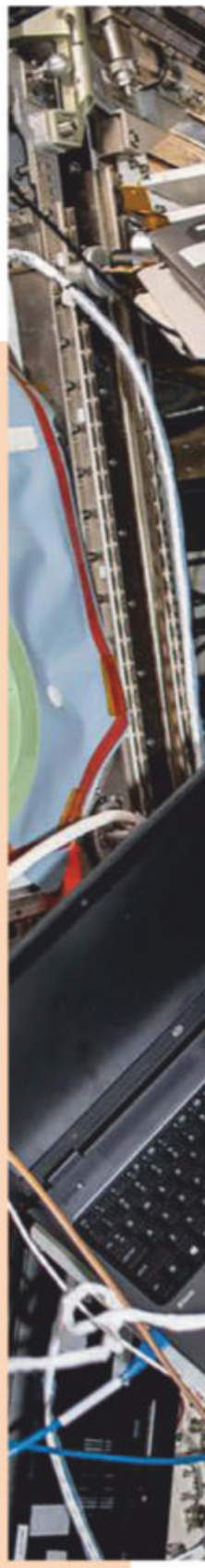
Fire is a chemical reaction in which the atoms in molecules of a fuel and oxygen get rearranged into carbon dioxide and water. But behind the apparently simple transformation is dizzying complexity. The burning of fuels happens via a welter of intermediate chemical compounds, many of them highly unstable and imperfectly understood.

Getting a detailed grasp of what is going on is tough because combustion is sensitive to movements of hot gases. These movements are driven by convection currents: the upward flow of hotter, less dense air and the sinking of cooler air. The flame itself both drives and is affected by these currents. This circle of cause and effect "is one of the key reasons that the problem is so challenging", says combustion scientist Paul Ronney at the University of Southern California.

There is good reason to pick at the problem, though. We may have taken great strides with renewable energy, but about 85 per cent of the energy we generate globally still comes from burning fossil fuels. Better understanding how these fuels burn could have huge pay-offs, like helping us extract heat more efficiently and avoiding unburned, wasted fuel. This would also mean that less pollution – such as carbon monoxide and soot, which are a result of incomplete combustion – is produced. Because so much of our energy comes from burning conventional fuels, "even small improvements in efficiency can be significant", says Dennis Stocker at the Glenn Research Center.

The reason studying fire in space is so attractive is that, with almost no gravity, there are no convection currents to complicate things. With the circle of cause and effect removed, a deeper grasp of what's really going on in a flame should be possible.

There is a way to see what happens to something in microgravity without leaving Earth: drop it. The Glenn Research Center has two drop towers, essentially long pipes in which experiments can free fall for a few seconds. These were originally used decades



"The experiments revealed something distinctly unexpected: fires in space can go out twice"

ISS/NASA

Astronaut Jessica Meir services the equipment used to light fires in space

ago to test how components of spacecraft would perform in low gravity. Since then, researchers have allowed burning droplets of methanol to fall down the tubes and used cameras and other instruments incorporated into the dropped load to record the results. A few seconds doesn't give you long, but the drop towers enabled NASA to conduct precursor experiments with fire before doing them in orbit.

No more teardrops

The agency first ignited fires in space in the 1990s aboard space shuttles. But it was with experiments on the ISS that the research really got started. These tests showed that a flame in microgravity looks very strange. It burns in the shape of a half-sphere instead of the familiar teardrop and it doesn't glow bright yellow but has a dimmer, blue colour (see photo, page 45). The colour difference is thanks to the lack of convective draught wafting fresh oxygen into the flame. Oxygen can then only get into the flame by diffusion, in which gases move slowly from areas of higher to lower concentration. This keeps the temperature lower and means less soot is produced – it is the incandescent heat of soot particles that creates the yellow colour of some flames on Earth.

In 2009, NASA began the Flame Extinguishing Experiment (FLEX), which involved igniting small droplets of liquid fuels such as methanol and heptane aboard the ISS. The experiments are prepared on Earth in an apparatus about the size of a washing-machine drum that is shipped into orbit and operated remotely from the ground. Astronauts aren't much involved, apart from carrying out routine procedures like cleaning. These experiments showed that burning fuel droplets must be within a certain size range to stay alight. Too small, below a millimetre or so, and oxygen can't diffuse into the flame quickly enough. Too big, and too much heat is radiated for the flame to stay hot enough.

That much was expected. But a few years later, the experiments revealed ›

Fire starters

The idea of a fire raging on the International Space Station (ISS), or on a future vessel voyaging through interplanetary space, is frightening. But in space, air doesn't move around in convection currents as it does on Earth because, with there being virtually no gravity, warmer, less dense air won't rise. Without convection, fires aren't fed so quickly with fresh air. They are less intense and spread more slowly than fires on Earth.

Still, the dangers are immense. A serious fire would raise the internal temperature and the pressure of a spacecraft, and use up precious oxygen. None of this can be quickly balanced by venting or admitting air from outside. And with plenty of electronics about, you might not want to use water fire extinguishers to put it out. The recommended procedure on spacecraft is to smother flames with carbon dioxide extinguishers – but if you use too much, you risk asphyxiation.

To make things worse, we don't really know how fires on spacecraft would play out. All the fires lit in space previously "have been about the size of an index card", says David Urban at NASA's Glenn Research Center in Cleveland, Ohio. "They're not fires you can get particularly frightened of, or that we're really worried about."

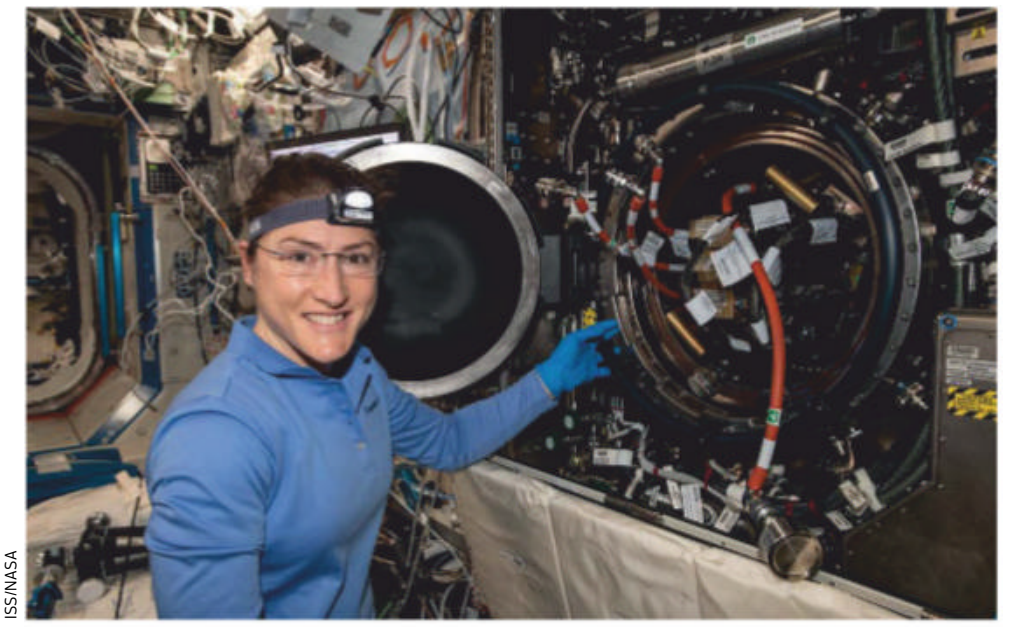
To wise up, NASA is running a project called Saffire in collaboration with the European Space Agency. This involves setting sizeable blazes that might happen in an accident on a spacecraft. It is too dangerous to do this on the ISS, so Cygnus cargo vessels, which ferry supplies to the ISS, are used instead. They are "like FedEx trucks" for space, says Urban. In their normal role, these disposable capsules are filled with ISS waste and allowed to burn up in the atmosphere.

NASA has lit fires in them several times over the past few years. In an experiment in 2017, the Saffire team found that these fires spread three times more slowly than expected based on experiments done in the ISS (see main story). They also seemed to stop growing once they reached a certain size. That might sound welcome, but it may mean smoke detectors on spacecraft need to be more sensitive to provide a useful warning. It may also mean that fires generate more noxious carbon monoxide.

In May, the Saffire team conducted its most ambitious experiment yet, filling a Cygnus capsule with several 50-centimetre-wide swatches of materials to be burned, including a cotton-fibreglass material that mimics clothing, and the plastic used to make the windows of the ISS. The group also tested a filter designed to clean smoke from the air. The results are still being analysed, but Urban says the fires "didn't extinguish as quickly as we thought they would". Two more experiments are planned for October and sometime in 2021.

The biggest fires in space have been lit aboard Cygnus cargo capsules

JEFF WILLIAMS/NASA



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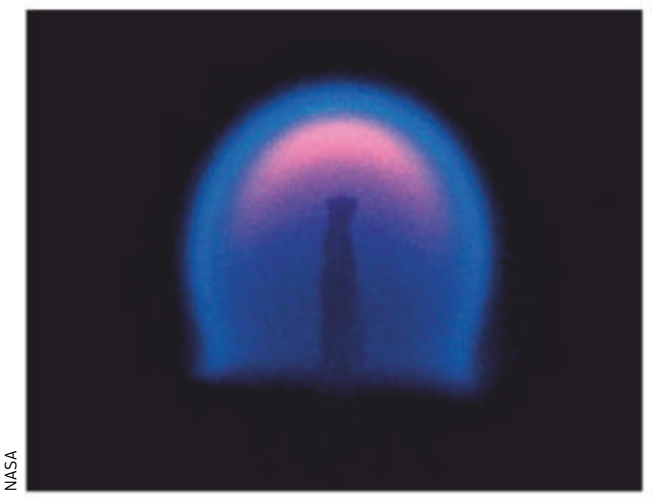

NASA

Astronaut Christina Koch works on the rig used to light fires on the International Space Station (above). Inside it, flames burn in blue half-spheres (left)

something distinctly unexpected: fire in space can go out twice. Droplets would burn until they got too small, at which point the visible flame would vanish. But combustion was still going on, even though it was producing no light. The visible flames burned at between 1200 and 1700°C, yet the invisible flames reached just 200 to 500°C. And whereas the hot flames burned fuel completely into carbon dioxide and water, the cool-flame combustion was incomplete, producing carbon monoxide and formaldehyde among other molecules. "The cool flames were a total surprise," says Ronney. They couldn't appear in drop-tower experiments because they need about a minute to form. "We've been trying to understand them ever since," says Dietrich.

This discovery from far above Earth could help improve an everyday technology: the internal combustion engine. We already knew that low-temperature combustion reactions feature in car engines and that they are responsible for misfires. But Dietrich says they were always viewed as an intermediate step in the ignition of hot flames. The fact that they are sustainable in themselves could be useful in a new generation of diesel engines being explored by companies such as car manufacturer Nissan. These homogeneous charge compression ignition engines burn premixed fuel and air at lower temperatures, creating less of the polluting nitrogen oxides that cause smog and acid rain.

Flame sculpting

To generate power, we burn all the states of matter, not just liquids. Gas-fired power stations provide about 25 per cent of the world's electricity, and NASA hopes that these too might be improved by looking at how gas burns in microgravity.

Investigations began in 2017, with the Advanced Combustion via Microgravity Experiments (ACME). Part of the project is about designing flames that burn more efficiently. In gas flames, sooty particles can form in regions where there isn't enough oxygen for the fuel to burn up properly, so that the carbon-based molecules from the fuel react instead with themselves. The ACME study should help us work out the optimal mixture of gaseous fuel, oxygen and other gases that could be used in a power station to minimise this process – a piece of knowledge that has eluded us on Earth. "Microgravity is a great environment for studying soot formation," says Stocker, who is part of the ACME team. "In normal gravity, all flames tend to look much the same because of the dominance of gravity-induced effects."

ACME will also try using electric fields to sculpt the shape of flames. Some of the molecules produced transiently during combustion are electrically charged ions and so they can be pushed around by an electric field. These flows can sweep up other gaseous components, so that the flames can be guided and deformed. "You can affect the shape of the flames, push them down towards the burner or make them bend in a certain direction," says Stocker. He says this could allow us to control soot formation and engineer flames that burn with less fuel than is usually possible. The lessons from these electric-field studies might ultimately be implemented in gas-fired power stations and other large furnaces, says Stocker, although that would probably be too expensive for a domestic boiler.

Next year, the NASA team will move on to look at how solids burn in microgravity. Here, the focus won't be so squarely on the fundamentals of fire, but on practical hazards. Plenty of spacecraft components are flammable solids and NASA wants to know how they burn so it can mitigate the risks of accidental fires (see "Fire starters", left).

Space-based experiments are sometimes criticised for being frivolous. But NASA's space fires could bring all sorts of benefits here on Earth. In his lectures, Faraday said that "there is no better, there is no more open door by which you can enter into the study of natural philosophy than by considering the physical phenomena of a candle". He probably never imagined quite how far we would take that idea. ▮

Philip Ball is a science writer based in London

Pandemic warnings

Scientists have been warning us about pandemics for years. How can we heed such calls in future, asks **Debora MacKenzie**

PETER REYNOLDS

IN JULY, George Gao, head of the Chinese Center for Disease Control and Prevention, published an alarming paper. He and his colleagues had discovered that a new kind of swine flu was sweeping to dominance in China's pigs and spreading to people. "[It] has all the hallmarks of a candidate pandemic virus," they said. That same month, European virologists also warned of a similarly worrying swine flu in European pigs. We know flu pandemics happen regularly. What if one struck while we are still reeling from covid-19? Can we stop that happening?

Not if the past is any judge. In 2004, US virologists warned about another strain of swine flu; five years later it went pandemic. The warning had been so widely ignored that the pandemic came as a surprise even to many virologists. And swine flu is just the start. In recent years, virologists have warned about potential pandemics from bird flu to coronaviruses like those behind SARS and MERS – warnings that came true with covid-19. In south Asia, the super-deadly Nipah virus is starting to spread between people in respiratory droplets. Few have even heard of it.

There are many potentially pandemic viruses out there, and some are far worse than the one we are currently fighting. Disease experts have been issuing warnings for years, but covid-19 showed how unprepared the world was for an outbreak. One lab in Wuhan even warned of the very viruses that spawned covid-19. No one did anything. If this pandemic is to finally change that, lessons must be learned from how we missed the warning signs this time around.

Let's wind back first to 2003, when humanity was on the verge of another pandemic. The coronavirus that causes SARS had arisen in China the previous year and spread to 26 other countries before a global

"One lab in Wuhan even warned of the very virus that spawned covid-19"

effort, led by the World Health Organization (WHO), ended the outbreak. Initially, the virus was thought to have come from civets, but that proved incorrect. Zheng-Li Shi at the Wuhan Institute of Virology and her colleagues decided to look in bats, which were known to carry many viruses including human pathogens.

In 2005, Shi and Kwok-Yung Yuen at the University of Hong Kong independently discovered hundreds of coronaviruses similar to the one behind SARS in common horseshoe bats in both Hong Kong and in Hubei province, where Wuhan is located and covid-19 later emerged. They also noted "the increasing presence of bats and bat products in food and traditional medicine markets" in China, and called for efforts to "prevent future outbreaks".

Shi's team later began working with EcoHealth Alliance, a US-based research non-profit organisation, to study a large horseshoe bat colony in the Chinese province of Yunnan. In 2013, the researchers reported that some of the coronaviruses they had found in the bats could infect human cells via a protein called ACE2 on the cells' surface – the same infection method used by the virus behind SARS. They called for "pandemic preparedness". And in 2017, when they reported finding viruses that were genetically identical to the SARS coronavirus, they proposed monitoring the viruses there, and at other sites, to avoid future disease emergence.

Meanwhile, in 2015, Shi and Ralph Baric ›

Shoot the messenger

Zheng-li Shi at the Wuhan Institute of Virology in China has been warning about the risk we face from coronaviruses in bats for years. Yet in April, US president Donald Trump accused her lab of being the source of covid-19, based on nothing more than its location in the city where the pandemic began. Conspiracy theorists quickly asked how a virus Shi's lab discovered far away in the Chinese province of Yunnan could emerge in Wuhan, if not from the lab. In fact, Shi reported very similar viruses in bats near Wuhan in 2005.

In July, US disease experts including David Morens at the National Institute of Allergy and Infectious Diseases argued that the virus couldn't have originated in Shi's lab because it meets the same containment standards as US labs and the virus matches none that the lab has sequenced and published. They dismissed even more firmly the possibility that covid-19 is caused by an artificial virus created in the Wuhan lab – not least, they said, because virologists didn't then know enough about coronaviruses to have designed it.

Despite this, the US National Institutes of Health terminated funding for the US research non-profit organisation the EcoHealth Alliance to work with Shi to find out how many more bat coronaviruses are potential human pathogens. In July, seven prominent disease experts in the US and UK called the cancellation political and "a flagrant example of shooting the messenger".

at the University of North Carolina had reported that another SARS-like coronavirus from the Yunnan bat colony was able to replicate in cells from the human airway without the need for any further mutations. In 2016, Baric found that the virus made mice ill, and called it "pre-pandemic" and "poised for human emergence".

Still nobody paid much attention. That remained the case even last year when, in a review of this research, Shi highlighted the risk posed by China's huge diversity of bats and bat viruses, together with their proximity to large human populations and a thriving market in wildlife products. "It is highly likely that future SARS- or MERS-like coronavirus outbreaks will originate from bats, and there is an increased probability that this will occur in China," she wrote. Later that year, her team found that bat coronaviruses were occasionally jumping to people in Yunnan. The researchers urged that efforts be made to "maintain the barriers between natural reservoirs and human society".

Too little, too late

In January, with covid-19 raging in Wuhan, Shi's lab reported that the coronavirus behind it was 96.2 per cent identical to one of the Yunnan viruses. Even though the work identified the source of the pandemic and confirmed the researchers' repeated warnings, it attracted unsubstantiated accusations that the lab was the source of the outbreak (see "Shoot the messenger", left).

At least some measures were finally taken to prevent more viruses jumping from bats to people. In February, China banned trading in wild animal products for food, even though there isn't much evidence for early suspicions that the virus initially infected humans at a market that sold wildlife.

So far, however, few restrictions have been placed on traditional Chinese medicine, another source of infection that Yuen and Shi had warned about in 2005. Of particular concern is Ye Ming Sha, or night brightness sand, which contains dried, powdered bat faeces, including from horseshoe bats. It is used to treat eye problems. That creates a particularly high risk, because coronaviruses are found in bat faeces and eyes have lots of the ACE2 protein that the covid-19 virus uses to infect cells. This year, bat faeces was removed from the Chinese pharmacopoeia, the list of approved medicinal ingredients, but it may still be available to buy.

We can't say we weren't warned. The virus behind covid-19 "emerged essentially as predicted", wrote a group led by David Morens of the US National Institute of Allergy and Infectious Diseases in *The American Journal of Tropical Medicine and Hygiene* in July. "Our prolonged deafness now exacts a tragic price." If this continues, the group added, we are in for replays.

Why did the warnings go unheeded? "Potential threats are ignored in favour of current problems," says Tom Monath, a prominent virologist and vaccine developer. He also notes that scientists are accused of crying wolf about pandemics if emerging viruses are successfully controlled or haven't – yet – gone rogue. "We need new structures," says Morens. "We raise the alarm, but it's no one's responsibility to make sure things happen."

"We really need a functioning biological threat preparedness committee whose recommendations are acted upon," says

> "Preventive measures look like a bargain now we know how costly a pandemic can be"

DE AGOSTINI VIA GETTY IMAGES

Horseshoe bats (left) carry many potential human pathogens and excrete coronaviruses in their faeces (below), which is used in traditional Chinese medicine

Laura Kramer at the State University of New York at Albany. "This takes money – and scientists who are free to speak their mind without repercussions."

Caitlin Rivers at Johns Hopkins University believes the US should create a centre for epidemic forecasting and analytics, to develop real-time predictive epidemic models, like weather forecasts. However, Morens says that one country acting alone isn't enough because pandemics can emerge anywhere, putting everyone at risk.

Besides predicting and preparing for pandemics, we need to actively watch for them. Yet scientists are rewarded for discovering viruses, not for keeping tabs on them. The world lacks field studies and surveillance in "hotspots" where viruses could emerge. Peter Daszak at EcoHealth Alliance wants an international research programme to look for threatening viruses in animals and people. It would also work with people and industries – from the wildlife trade to lumbering – to stop risky activities. That would include avoiding biodiversity loss, such as deforestation, which throws people and bats together.

Such a plan would need substantial government funding, but it looks like a bargain now we know how costly a pandemic can be. Andy Dobson at Princeton University and his colleagues calculate that spending between $22 billion and $31 billion a year for 10 years to halve global deforestation rates, monitor diseases in people and livestock, and control the sale of wild animal products would amount to 2 per cent of the cost of the covid-19 pandemic – less if you count the carbon dioxide savings.

FLETCHER & BAYLIS/SCIENCE PHOTO LIBRARY

Meanwhile, there is too little research into countermeasures such as drugs, diagnostics and vaccines. The WHO tries. In 2016, it devised a road map for research and development to counter eight priority viruses, including SARS-like coronaviruses and Nipah virus. But the organisation doesn't have the money to ensure anything happens, so little has progressed.

A hard sell

Public money will be needed to develop vaccines for diseases that don't yet exist, which could be hard for politicians to sell to voters. The private companies that develop most drugs and vaccines can't invest without certainty of a profit. Even with some funding from health charities and private organisations, governments must pay.

All of this cries out for a global mechanism for sharing the planning, surveillance and cost of pandemic preparedness. We don't have that, but in March the G20 group of the world's biggest economies promised to organise it. We do have a treaty, the International Health Regulations (IHR), that requires countries to declare worrying outbreaks.

Yet, as we saw with covid-19, declarations may not be accurate, and the WHO has no right to check facts on the ground. Under treaties on weapons of mass destruction, countries cede some sovereignty to international agencies to verify their declared weapons. A beefed-up IHR might similarly mandate international inspectors to verify a country's declarations about disease in the global interest.

We have learned the hard way that pandemics, too, cause mass destruction. Governments need a plan to anticipate and stop outbreaks, instead of frantically trying to respond after diseases go global. We have been warned. Now it is time to act. ▮

Debora MacKenzie is the author of *Covid-19 - The pandemic that never should have happened, and how to stop the next one*

Fellowships for Postdoctoral Scholars

WOODS HOLE **OCEANOGRAPHIC** INSTITUTION

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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

Maker Stargazing at home

Spotting satellites

There are hundreds of SpaceX satellites in the sky. A successful sighting just requires a bit of luck, writes **Abigail Beall**

Abigail Beall gazes at the stars from her home in Leeds, UK. She is the author of *The Art of Urban Astronomy* @abbybeall

What you need

The Find Starlink website or something similar
A spot of sky viewed away from light pollution

OUR skies are filling up with satellites. Starting in May 2019, the firm SpaceX has deployed around 700 Starlink satellites into Earth orbit over 11 launches. SpaceX plans to deploy 12,000, and perhaps later 42,000, satellites with the aim of providing internet access to the entire world.

These satellites have the potential to change the way that the night sky looks. For comparison, there are only around 2600 satellites currently orbiting Earth. These days, spotting a few satellites in the sky is still an exciting activity.

The Starlink orbits vary and change at the last minute, so it is difficult to predict too far in advance when they will be visible. But as there are so many of them, the chances of seeing one are high.

Most satellites orbit at an altitude of 1000 kilometres, but Starlink satellites orbit at just 550 kilometres, making them more visible compared with others of the same size. This has been a problem for astronomers attempting to take photos of the night sky, as the satellites have shown up as intrusive bright streaks (see photo). As of the ninth launch, the Starlink satellites have had sunshades, making them slightly less visible.

There are many online tools available to predict when you might get a glimpse of a Starlink satellite. One, called Find Starlink, takes your location and tells you what time and where in the sky to look. Even with the help of a tool it can still be a game of chance, though, but if you try a few times, you will eventually see something.

DENISE TAYLOR/GETTY IMAGES

To get the best chance of seeing a Starlink satellite, or a few of them that follow each other relatively closely, pick a clear night. Try to get away from light pollution by going to a park or an open field, for example. Let your vision adjust to the darkness, then keep an eye out for moving sources of light in the sky. Satellites are only visible when they reflect sunlight back to Earth. Because of this, the best time to look is just after sunset or just before sunrise, when sunlight is still reflecting off the satellites but it is dark enough to see them.

If you can't tell whether what you are looking at is a satellite or something else, there are a few simple rules to tell the difference. If a point of light is steady and not moving compared with everything else, it is a star. If it is a bright light moving slowly compared with the stars, it is a planet. If it is a bright flash moving extremely quickly across the sky in seconds, it is a meteor.

Satellites lie somewhere in between. They are steady points of light that move across the sky in minutes. Planes also move at this speed, but they have flashing red lights that give them away.

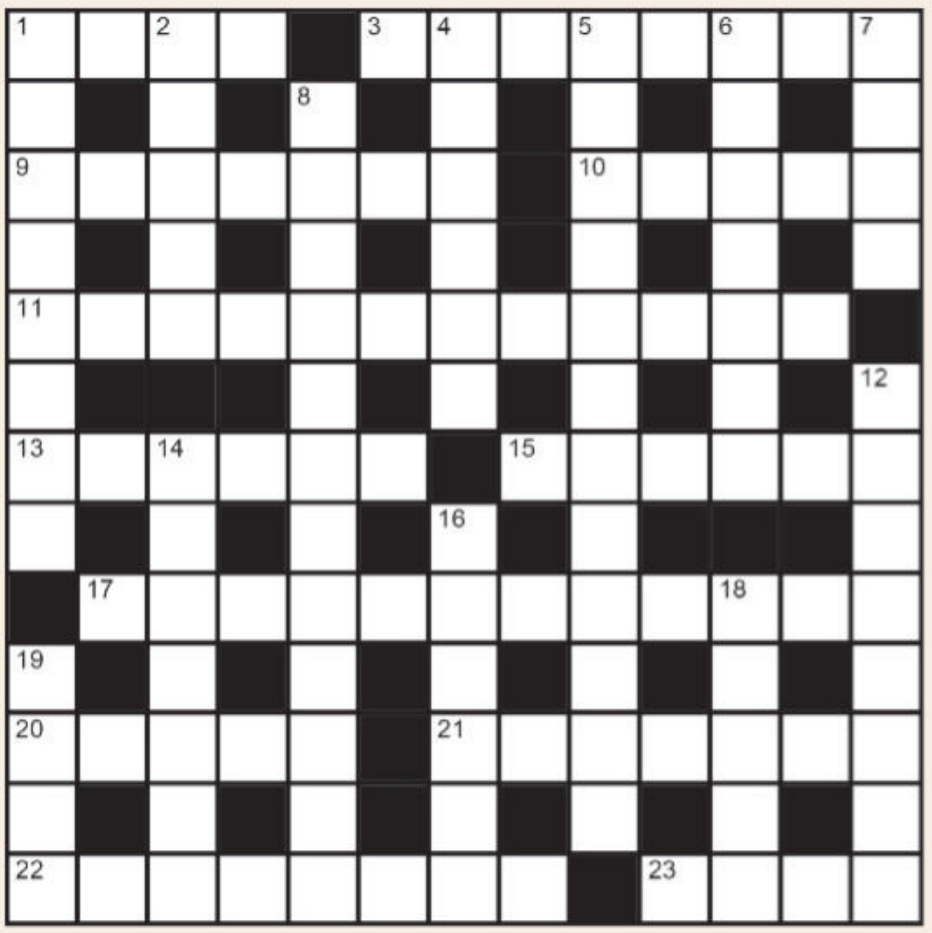
Stargazing apps will be able to show you the location of the planets, stars and big satellites like the International Space Station. But smaller satellites, like the Starlink ones, won't appear.

Maker projects are posted each week at newscientist.com/maker

Next week

Science of gardening

Cryptic crossword #40 *Set by Wingding*



Scribble zone

Answers and the next quick crossword next week

ACROSS

1 Vegetable with time to become decayed matter (4)
3 Soft grains somewhat heated in competition between sellers (5,3)
9 Field of maths encompassing 30 per cent of algorithms, Euler's number and underwear (7)
10 See 15
11 Assess unheaded wall chart with single hormone (12)
13 Important-sounding star (6)
15/10 Scientist – Einstein and Hoyle, perhaps? – with no means of getting attention audibly (6,5)
17 It weakens bones, so poster is too confusing (12)
20 Bull, look at flower (5)
21 Terbinafine beginning to disrupt fungus (7)
22 Good day? I'm unsure... I made some cheese (8)
23 Containers break when toppled (4)

DOWN

1 Ghost of elephant, as many would admit (8)
2 Even Galen gains support (5)
4 Rising star, picking up carbon and energy, undergoes chemical change (6)
5 Manipulate set who might be given a placebo (7,5)
6 You and I shorten two-part online meeting (7)
7 Internet bully loses head in a spin (4)
8 Salute boozer that's brewing as cold as possible (8,4)
12 Homecoming king sues heartless synod for damages (8)
14 Virus reproduction number on rise at alleged site of alien landing (7)
16 Body fluid placed in maths problem (6)
18 Setter gets into seat in capital (5)
19 Insect goes 30 days without nitrogen (4)

Quick quiz #69

1 Which pirate-turned-navigator was said to be the first to circle the globe three times?

2 Individuals in which family of bivalves are often referred to as the "termites of the sea"?

3 A urethral syringe found in Blackbeard's flagship contained traces of which metal?

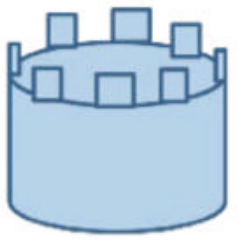
4 Scurvy is caused by a lack of vitamin C, which is essential for making what protein?

5 The tattooed Zenetan pirates feature in which sci-fi series?

Answers on page 55

Puzzle *set by Katie Steckles*

#77 Sir Prancelot's archers



Sir Prancelot employs nine of the finest archers in the shire to defend his castle, dispatching them to a turret that has eight gaps in its battlements. Prancelot has numbered his archers 1 to 9 so he doesn't have to remember their names. The castle is under attack and Prancelot sends his messenger to check on things. "Sire, there is an archer in each gap, but no sign of the ninth – they must be taking a nap." "What? Which one is napping?" "I don't know - but if it helps, I noticed that each neighbouring pair of archers adds up to a prime number." Prancelot sighed. "That doesn't answer my question – go and look again!" The messenger runs out and returns with more news. "The archers have taken up defence formation, every other one around the tower has knelt down, and I noticed that the sum of the four standing archers was the same as the sum of the four kneeling ones. Does that help?"

Which archer is napping? And in what two ways might the turret archers be arranged?

Answer next week

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For more information and to register your place visit newscientist.com/subsevent

Wayward waves

If waves are caused by wind action on the sea surface, then why do they always appear to roll towards a beach?

Stephen Johnson
Eugene, Oregon, US
Ocean waves are created by three forces: wind, seismic events and the gravitational pull of the moon and sun. However, the vast majority of the waves you see at the seashore are created by wind blowing against the ocean surface.

Their size is determined by the wind strength plus the length of time it blows for and the distance it travels over the water. There is a maximum wave height for any given wind strength. From this maximum point, waves will diminish with distance if the wind abates, but can travel for thousands of miles.

As waves are created, they move in the opposite direction to the wind source. If this was all that happened, they would hit beaches at almost any angle. However, as waves move into shallower water that is less than half as deep as their wavelength, they begin to be modified by the bottom of the ocean and are slowed. In addition, the wavefront aligns itself with the contours of the bottom, generally resulting in a turn towards the shore.

This process of wave refraction is why they mostly break in a line along the shore. Since ocean bottoms are all unique, there are many waves that hit the beach slightly off parallel, as can easily be seen in many locations.

Eric Kvaalen
Les Essarts-le-Roi, France
A sea can have waves going in different directions at the same time. If the wind is coming from the shore, it won't create real waves until a long way out. There will just be very small waves going away from the shore, and they will grow bigger the further they go so long as the wind holds.

Waves created hundreds or thousands of miles away by a wind coming towards us will continue all the way to our shore, even if the wind near us is blowing in the other direction. So there are almost always waves coming ashore, no matter what the wind direction is.

Waves don't necessarily come directly towards shore – they can arrive at an angle. But when the water gets shallow, they refract towards the shore, so they seem to be more straight on than they really are.

David Singer
Manchester, UK
Waves appear to roll towards the beach rather than away from it because those moving away have much less energy than those rolling in. A sloping shore absorbs much of the incoming wave energy, as well as scrambling the returning waves so they are hard to see.

Chris Daniel
Glan Conwy, UK
The phenomenon of waves breaking parallel or nearly parallel to the shore is due to refraction, and is analogous to the refraction of light as it passes from one medium to another.

As the wave travels, water molecules at the surface move in a circular motion with a diameter equal to the height of the wave. The size of this circular motion decreases the further the water molecules are below the surface, and is no longer felt at a depth called the wave base.

When the distance to the sea floor is less than the wave base, the speed of the wave will slow due to friction at the sea's bottom and the wavelength will decrease. Parts of the wave still in deeper water will continue to travel faster, causing the wave as a whole to bend towards the shore, creating the refraction effect. In this way, waves tend to wrap around the contours of a typically indented coastline.

The shapes of coastlines and offshore sandbars can generate impressive waves through the refraction process, by focusing wave energy into breakers that occur reliably in certain weather conditions. These can be popular with surfers.

Richard Mellish
London, UK
In the open sea, waves can travel in any direction. There may even be a superposition of waves moving in different directions. Yet waves can only arrive at a beach if a part of their velocity is towards the beach.

Graham Cox
Hothfield, Kent, UK
Offshore winds that blow from the coast out to sea can never create waves that roll back towards the beach. Waves generated by wind or earthquakes can travel thousands of miles before they dissipate from the friction of water molecules and attenuation. So, on the majority of days, waves roll onto beaches because they consist of one or many waves from elsewhere, intermingled. Only in sheltered beaches after days of calm does this not happen and no waves occur. Where waves meet vertical walls of rock or concrete, they can bounce out to sea.

Waves have a direction despite being entirely created by water molecules rising and falling together. The physics of how wind can generate those vertical and forward motions should be explained by someone with more expertise than me!

Victor Stanwick
New York City, US
I can offer one partial answer: waves reaching beaches on the west coast of Africa appear to be moving away from beaches on the east coast of the Americas.

IPPEI NAOI/GETTY IMAGES

Does Earth's rotation affect how quickly clouds seem to move?

This week's new questions

Cloud control **On a still day, clouds move slowly across the sky. How much of this is due to Earth's rotation? Do clouds seem to move faster at the equator? *Philip Welsby**, Edinburgh, UK***

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

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Tom Gauld
for New Scientist

Sea settlers

Hydrothermal vents teem with life on a lifeless seabed. How are they colonised?

Mike Follows
Sutton Coldfield, West Midlands, UK

Hydrothermal vents occur at hotspots on the ocean floor, often at mid-ocean ridges where two oceanic plates are moving apart.

Vents in the deep ocean are beyond the reach of sunlight yet support a diverse ecosystem and appear like oases in a desert. Creatures living in this environment obtain their energy via chemosynthesis from the chemicals dissolved in the vents instead of the photosynthesis that is essential to life on Earth's surface. The discovery that ecosystems can be hosted by these vents increases the likelihood of extra-terrestrial life, even within our solar system – in the water beneath the ice of Jupiter's moon Europa, for example.

Giant tube worms (*Riftia pachyptila*) and other animals around hydrothermal vents reproduce by releasing eggs and sperm into the water. These fuse and develop into microscopic larvae – the equivalent of seeds – that are dispersed by ocean currents. Hot water from the vents forms buoyant plumes that cool as they mix with the surrounding water and become neutrally buoyant about 200 metres above the ocean floor. Local currents then carry this water over long distances.

The larvae carry enough food reserves to survive a journey of several weeks. If they arrive at another suitable vent before they starve, they could start a new colony. The same species can be absent from closer vents but present at more distant ones, which may be because of differences in the depth, pressure, temperature or chemistry at different vents.

This colonising mechanism is reminiscent of the mass spawning events on tropical coral reefs. It is also like panspermia, the idea that life came to Earth aboard an asteroid, which was championed by scientists like Svante Arrhenius and Fred Hoyle. They believed that the seeds of life pervade the universe and, when they land on a habitable planet, life flourishes.

Other scientists doubt that life has an extraterrestrial origin. There is an increasing body of opinion that alkaline hydrothermal vents like those found at the Lost City site in the mid-Atlantic Ocean might be where life on Earth began.

In 1993, before alkaline vents were discovered, geochemist Michael Russell predicted that life could harness the energy created when electrical charges are separated. Acids have more hydrogen ions – or protons – than alkalis, so separating an acid from an alkali leads to a separation of charges, just like in a battery.

This could occur when alkaline water inside a vent is separated by porous rock from the more acidic seawater of the ancient oceans outside. This may have been the precursor of the proton pump that acts across biological membranes in cells and allows respiration to take place. ▮

Answers

Quick quiz #69 *Answers*

1 William Dampier. He was also a keen naturalist and hydrographer

2 Shipworms (Teredinidae)

3 Mercury, a common treatment for syphilis at the time

4 Collagen

5 *Farscape*

Quick Crossword #66 *Answers*

ACROSS **8** Free, **9** Automation, **10** Mucous, **11** Methanol, **12** Edge, **13** Lactic acid, **17** Fern, **18** Brown, **19** Dane, **20** Woodpecker, **22** Cyst, **23** Ethernet, **27** Psyche, **28** Supersonic, **29** Nerd

DOWN **1** Ground zero, **2** DeLorean, **3** Fat-soluble, **4** STEM, **5** Emit, **6** Strata, **7** *Homo*, **14** Clock, **15** *Innerspace*, **16** Ionosphere, **19** Decaying, **21** Diesel, **24** True, **25** NASA, **26** Tune

#76 Four hipppos *Solution*

Starting with the lightest, call the hippos A, B, C and D. A+B must be 2.23 tonnes, A+C = 2.35 and B+D = 2.85. But we don't know if it is A+D or B+C that weigh 2.48, so there are two solutions for the weights of the hippos: 0.93/1.30/1.42/1.55 and 1.05/1.18/1.30/1.67.

However in the first of these, A+C+D add to 3.90 tonnes and wouldn't break the scales. In the second, A+C+D add to 4.02 tonnes. So the smallest hippo weighs 1.05 tonnes.

Build that accelerator!

Few exhortations ignite such wearisome passion as those to "build that wall" from the man otherwise reliable sources inform us is US President. Now physicist David G. Hitlin floats an alternative on the arXiv physics preprint server. It could, he suggests, "provide the desired deterrence capability without reallocation of Defense Department funds, the use of alligators, the separation of children and parents, or the need to shoot anyone in the leg".

Hitlin notes the Mexico-US border has some very long, very straight bits. Particle physicists have a yen for very long, very straight things, in the form of the linear particle colliders they use to bash things together at ever higher energies to recreate the earliest conditions of the universe/devour huge amounts of cash/consume the world in a black hole (tick as applicable, multiple answers possible).

Deciding where to site such a thing, or who should fund it, has been the subject of much unresolved argy-bargy. Licking his lips and mouthing the word "synergy" with the enthusiasm of a business consultant, Hitlin suggests building a linear collider along part of the southern US border.

To serve its dual purpose of border defence fortification and international particle research facility, the Very Big International Linear Collider or Trump ILC, names floated by Hitlin, would be built above ground, with two arms each 150 kilometres long.

It would be more in keeping with Trump's original plan for a concrete wall, rather than the latest version to be built of "beautiful steel slats". But the increased cost need not be a problem. "The Mexican government would likely be more willing to fund this structure as part of an international scientific consortium than to pay for the current single-function wall," Hitlin writes.

Hitlin observes that a precedent exists in a proposal from physics Nobel laureate Leon Lederman in the 1970s to convert some of the straighter bits of the New York Subway network into a particle accelerator to help out with a black hole in the city's finances. He also points out that an accelerator of the length of the Very Big ILC would have to take account of the curvature of Earth, a concept that some of the wall's more fervent supporters may have some difficulty with.

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

Icon slippage

Our reverie on the beautiful walls of our stationery cupboard office is interrupted by a smartphone on the end of a telescopic selfie stick extending its way through the door. A socially distant colleague – nothing to do with the pandemic, 'twas ever thus – is sharing their screen.

On it is a message in a well-known messaging app about an upcoming trip – such things excite us uncommonly these days – accompanied by an emphasising pictogram of a suitcase on wheels.

Feedback is no fan of wheelie suitcases since they ceased being the sole preserve of airline employees: our ankles were once nearly removed by one deployed like a rapier missile in a famous London department store. The point of interest, however, is that the push notification preview showed the bag icon slanted and blue, while in the message itself it was upright and black.

Even odder (and we applaud our colleague for their investigative verve in pinning this down), the icon actually sent by their correspondent was of an old-school suitcase with a simple strap handle. Much more pleasing all round, IOHO, but in sum Feedback is perplexed, and not a little alarmed. With so much of the emotional, umm, baggage of our messaging now invested in these little pictograms, the news that we cannot rely on them to reflect our true intent shocks our small world. Further instances of such icon slippage to the usual address.

Got an itch?

Reader Steve Powell notes an alarming report from the BBC news website: "Local officials in Florida have approved the release of 750 million mosquitoes that have been genetically modified to reduce local populations."

Feedback nods sagely. Anyone who ventures, as we did recently, to the glorious northern latitudes of Scotland in summer will be aware of a similar, long-running experiment: the control of tourist populations through the annual release of the highland midge. Yes, you told us not to scratch it, and we are trying not to.

Ig Nobel cause

Talking of insects: as Feedback shuffles to press this week, the 30th annual Ig Nobel prize ceremony – for "research that makes people laugh, and then think" – is due to take place in the hallowed portals of the internet, rather than the usual cloisters of Harvard University.

This year's theme is "Bugs" – we see what they did there. Promised delights include a new opera, *Dream, Little Cockroach*, about a cockroach that (nods to Franz Kafka and Ian McEwan) wakes up to discover it has metamorphosed into a gross human.

An advance copy of the libretto has fallen into Feedback's clammy hands. It includes a rousing Act 3 finale of Nobel prizewinners singing *La Cucaracha*. Artistes engaged include Andre Geim, the only researcher to have won both a Nobel (for co-discovering graphene) and an Ig Nobel (for using magnets to levitate a frog). It promises to be quite a show. We'll bring you a full review next week. ▮

New Scientist
Newsletter

Launchpad

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