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New Scientist

WEEKLY 7 March 2020

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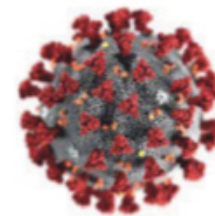
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Cover image: Pasioka/Getty Images

Data points from Johns Hopkins University, 3 March 2020

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Parallel problems

Our fight against climate change offers useful lessons for tackling the coronavirus

WE ARE facing a global emergency, and politicians who appear to not believe in science are putting us all at risk.

That this statement applies equally to coronavirus (see our special report, starting overleaf) and climate change says something about the era in which we live. Our response to the ever-widening outbreak has surprising parallels with our efforts to tackle global warming, though at accelerated speed. There are some transferable lessons.

First, we must listen to scientists. There have been reports of public health officials in the US being told not to speak to the media without first clearing it with the White House. This is a mistake. As with climate change, open discussion of the risks and uncertainties is the only way forward.

Likewise, science alone can't guide

our response. In the coming weeks, politicians will face difficult decisions over whether to restrict people's movements, perhaps even locking down cities as happened in Wuhan, China, where the covid-19 outbreak began. They will need to weigh the social and

"We must calibrate our caution to the outbreak, neither denying the issue nor giving up in despair"

financial fallout against the public health risk. Many people can't afford to self-isolate without pay for two weeks, so should governments pay them to stay at home? A virologist can't answer that.

As climate change rises up the agenda, people increasingly look for advice on how they can help mitigate the crisis,

whether it be flying less, recycling or reducing meat intake. The role of individual action in this fight is still being debated, but with the coronavirus, it is clear that handwashing will help protect your own health, and that of others.

In fact, as the virus spreads, we may need to take more drastic action, such as preparing food supplies to allow us to self-isolate. Younger, healthier people in particular should see this as a civic duty. Although they may only develop mild symptoms if they become infected, they risk passing the virus to people who are much less likely to be so lucky.

This isn't a call to panic buy or begin prepping a bunker. As with climate change, we must calibrate our caution, neither denying the issue nor giving up in despair. The virus can be beaten – but at what cost will depend on our response. ■

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DAVID RYDER/GETTY IMAGES

A number of cases of covid-19 have been linked to a nursing home in Kirkland, Washington

On Tuesday, the UK government published a 27-page document setting out the UK's response to the virus. The report warned that a coronavirus outbreak could lead to school closures, police dropping low-priority cases and the National Health Service delaying non-urgent care.

The document acknowledges the potential impact on businesses. "In a stretching scenario, it is possible that up to one fifth of employees may be absent from work during peak weeks," it says.

The UK government's response is focused on containment and planning for delaying and mitigating the outbreak.

UK officials hope to delay the peak of the virus until the warmer spring and summer months when health services are less busy.

If the disease becomes established, mitigation measures will be introduced. These could include police concentrating only on serious crimes and maintaining public order if faced with a significant loss of officers and staff, and the NHS calling retired staff back to duty.

Local authorities may have to deal with "an increase in deaths", particularly among vulnerable and older people, and the government is considering how to distribute the UK's stockpiles of key medicines and equipment such as protective clothing.

In a sign that the military could be called in to help, the document says there are "well-practised arrangements for defence to provide support to civil authorities if requested".

The number of people in the UK who have tested positive for the virus stood at 51 as *New Scientist* went to press. ■

Covid-19 spreads in US

Multiple outbreaks worldwide have led to countries stepping up their responses. By **Debora MacKenzie** and **Press Association**

WITH cases detected in more than 70 countries, and significant outbreaks not only in China but also in South Korea, Italy and Iran, the novel coronavirus first detected in Wuhan, China, has truly gone global.

This week, it emerged that the covid-19 virus could already be circulating in the US. Similar genetic sequences were detected in viruses from two people who contracted the disease weeks apart.

One comes from a case in Snohomish County, Washington, in which the infected person had no contact with another known case or outbreak location. Despite this, the virus sequence closely matches that in the first infection detected in the US, on 21 January,

in a man in the same county who had visited Wuhan.

Both sequences share a rare single mutation. "This strongly suggests that there has been cryptic transmission in Washington State for the past 6 weeks," tweeted Trevor Bedford at the Fred Hutchinson Cancer Research Center in Seattle.

Testing in the US has been limited. China is doing 1.6 million tests a week, South Korea is testing upwards of 10,000 people a day and the UK had tested about 13,000 suspected cases by 28 February. By then, the US had tested only about 2500 people,

partly because only those with links to China were being tested.

On that day, however, the US Centers for Disease Control and Prevention issued new testing guidelines, to permit testing of potentially locally acquired cases. Three were immediately reported in California, Oregon and Washington, including the latest Snohomish case.

Caitlin Rivers at Johns Hopkins University in Maryland says the US should now test hospitalised patients with severe respiratory disease of unknown cause, to see if they have covid-19. On 3 March, 105 US cases had been confirmed.

The latest coronavirus news online

Keep up to date with the science of the outbreak
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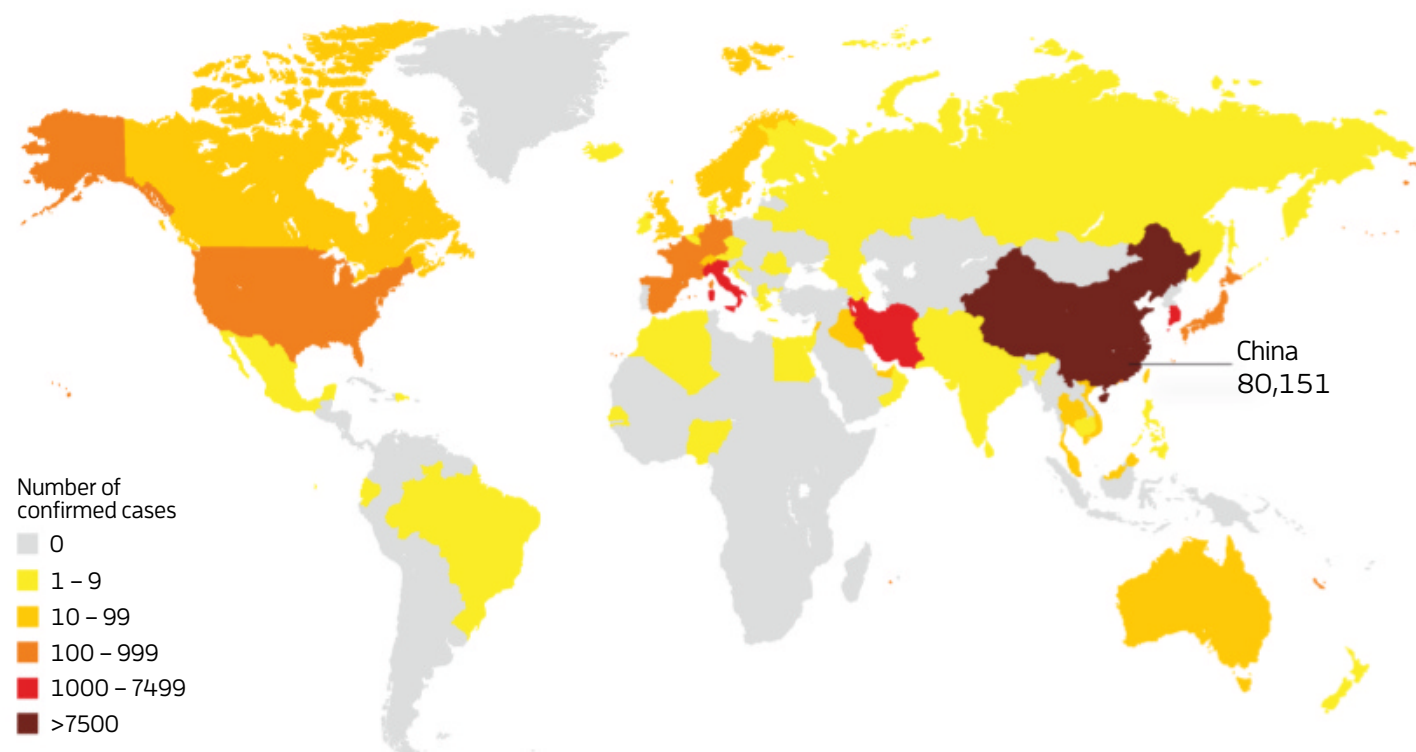
Pandemic readiness

How well prepared are we?

Covid-19 is rapidly spreading around the world during a period when many healthcare systems are already under pressure, reports **Debora MacKenzie**

Coronavirus cases

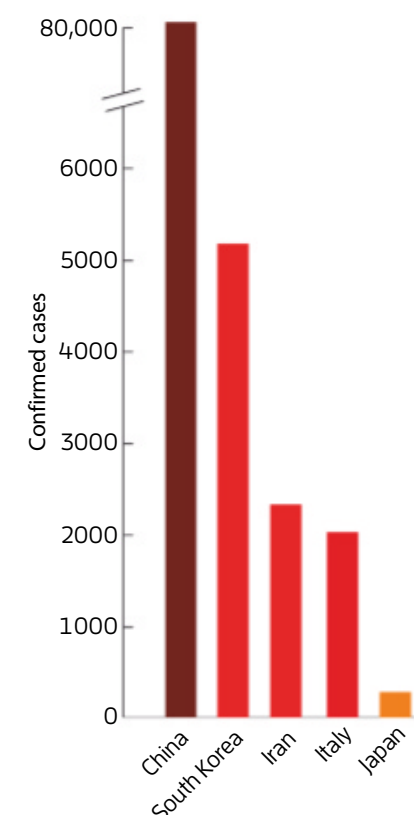
By 3 March, the covid-19 virus had been detected in more than 70 countries



SOURCE: JOHNS HOPKINS UNIVERSITY, 3 MARCH 2020

The largest outbreaks

China still accounts for the majority of covid-19 cases worldwide



LAST week, the World Health Organization raised its assessment of the global risk from the novel coronavirus to Very High – its maximum level. The virus has escaped containment in at least four countries.

But the WHO is eager for nations to keep practising containment measures (see “Why the WHO won’t use the p-word”, right). These can slow the spread of the virus in countries that only have a few cases. But as long as it is circulating somewhere in the world, new cases will continue to crop up in countries even if they have effective containment practices.

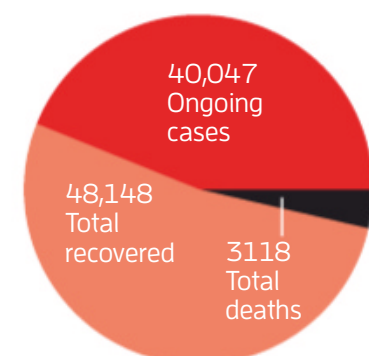
Mike Ryan of the WHO said on 28 February that the goal isn’t to stop the virus spreading, but “to slow its spread so health systems can prepare”. But what will that take? Can countries around the world handle a pandemic? The

short answer is no. “Health systems, north and south, are just not ready,” Ryan said emphatically.

Systems under strain

When the epidemic started in the city of Wuhan, in China’s Hubei province, a rapid build-up of severe cases overwhelmed medical staff. There wasn’t enough medical protective gear

There have been 91,313 confirmed cases of the covid-19 virus so far



SOURCE: JOHNS HOPKINS UNIVERSITY, 3 MARCH 2020

and there were insufficient intensive care beds – along with oxygen and ventilators needed to help people with severe pneumonia breathe – to meet the high demand. It also strained the delivery of ordinary medical care.

Bruce Aylward of the WHO, who led an international mission to study China’s response, noted last week that containment stopped the virus spreading generally and overwhelming healthcare in every Chinese province but Hubei, and mitigation measures aimed at preventing contact between people are driving case numbers down in Hubei. But this isn’t permanent: China is still building hospitals, growing public health capacity and buying more ventilators for when cases rise again, he said.

Countries whose health systems struggle during a bad winter flu season, or which can’t build new

hospitals in days or lock down whole cities, could struggle to repeat China’s success in slowing an outbreak.

In theory, the world has been preparing for a pandemic since concerns about bird flu spiked in 2006. “There has been some progress,” says Tom Inglesby of the Johns Hopkins Center for Health Security in Maryland. “Many governments have done some kind of pandemic planning, improved their labs, set up emergency operations centres and improved surveillance systems.”

Yet progress has been patchy. In 2017, the Coalition for Epidemic Preparedness Innovations was launched to develop vaccines for potentially pandemic viruses, and it has candidates for the covid-19 virus. However, it will take months to develop and test these.

In the meantime, we could do with treatments to help those

who develop severe covid-19. But an effort to set up a similar international project for antiviral drugs failed for lack of investment. Fortunately, some researchers have found possible anti-coronavirals, and these are currently being tested.

Even in advanced economies, the coronavirus is striking at a time when many health systems are under pressure due to ageing populations and increasingly expensive health technologies. Between 2000 and 2017, global health spending grew only slightly faster than economies overall, despite increasing demand.

Health systems that could be strained by a pandemic include those in Australia, the US and the UK, as well as those in many developing economies. According to a 2015 report, 56 countries – rich and poor – cut health expenditure as part of austerity measures after the 2008 financial crisis. Some of the poorest countries have cut public sector wages, affecting public hospitals and healthcare workers.

In the US, emergency capabilities have been dismantled

under president Donald Trump, who shut down the National Security Council's global health unit, which was put in place after the 2014 Ebola crisis, and disbanded the team charged with coordinating government agencies in a pandemic response.

To get better prepared, Inglesby lists where the world needs to invest more money: the development of drugs, vaccines and rapid diagnostics, and their fast mass manufacture and distribution; disease surveillance; building stockpiles of protective equipment; and expanding capacity so that demand for ventilators doesn't outstrip the number of machines available.

An unexpected area that needs more understanding is quarantine. Of the more than 3000 people quarantined aboard the cruise ship Diamond Princess in Yokohama, Japan, after they were exposed to an infected passenger, at least 31 have fallen ill since leaving the ship. But the quarantine period was long enough that anyone infected should already have fallen ill by the end of it.

This suggests that, while most of the 634 cases detected while still on board or when disembarking were infected before quarantine began, the virus must also have spread during quarantine, says Stephen Lauer of Johns Hopkins University. That shouldn't be possible.

Clearly we have work to do. "Hopefully this tragic epidemic will galvanise not only a very strong response to the coronavirus at hand, but will also bring about major positive changes in our level of investment and commitment to pandemic planning going forward," says Inglesby. Until then, it could be a rough ride. ■



"Since the start of the outbreak, my administration has taken the most aggressive action in history to protect our citizens"

Donald Trump

The US president on 2 March

Analysis When is it a pandemic?

Why the WHO won't use the p-word There are no criteria for a pandemic, but covid-19 looks like one, says **Debora MacKenzie**



FEATURE CHINA/BAROCROFT MEDIA VIA GETTY IMAGES

PREPARE for a pandemic, said the World Health Organization, as the global spread of covid-19 began to soar. Yet so far the WHO isn't calling covid-19 a pandemic. Why?

The answer may lie with what kicks into gear when we deploy the p-word. Countries have pandemic plans that are launched when one is declared, but these plans may not be appropriate for covid-19.

There are no global criteria for a pandemic. There used to be for flu, but the WHO abandoned them when it was criticised after declaring a flu pandemic in 2009 that triggered expensive countermeasures in some countries.

That could be one reason the WHO seems anxious to avoid the word pandemic for now. But there is a more important one.

There are two responses to a growing pandemic. The first is containment: as cases appear, you isolate each person then trace and quarantine their contacts. The second is mitigation, such as cancelling mass gatherings. If containment only slows the virus, eventually you get "community spread": people are infected without knowing how they were exposed, so you can't quarantine all contacts. All you can do is try

An isolation ward in a Wuhan hospital for critical covid-19 cases

to slow the epidemic so it won't overload health facilities.

Normal flu skips between people so quickly that containment is a non-starter. Pandemic plans are mostly designed for flu, and they go straight to mitigation. The UK plan suggests containment only if a new pandemic flu isn't yet able to spread as fast as normal.

In this light, statements from the WHO start to make sense. "It's not either/or," said WHO director Tedros Adhanom Ghebreyesus last week. "We must focus on containment while doing everything we can to prepare for a potential pandemic."

Meanwhile, the WHO seems to have a third problem with the p-word. "Using the word pandemic now does not fit the facts but it may certainly cause fear," said Tedros. Asked about the WHO's reluctance to declare a pandemic, a spokesperson said: "It is important to focus on actions and not on words."

True – but words matter. Reluctance to tell the public the truth for fear of causing panic has plagued responses to other disease emergencies, notably BSE in the UK. ■

Briefing

What you need to know

From symptoms and fatality rate to stockpiling and caring for family, **Michael Le Page** and **Jessica Hamzelou** have the answers

AS CONCERN increases worldwide, unscientific information about covid-19 and how to protect yourself is now rife, proliferating on social media and through messaging apps. Here's what we really know about it.

What are the symptoms?

More than 80 per cent of cases appear to be mild-to-moderate. The most common symptoms include fever, dry cough and tiredness, but some people may get just a sore throat or runny nose. Other individuals may not notice symptoms at all, but some go on to develop difficulty breathing and may ultimately experience organ failure.

Who is most at risk?

A report covering 82 deaths linked to covid-19 in Wuhan, China, found that 80 per cent of those who had died were over the age of 60, and three-quarters of these had other disorders that may have made them more vulnerable, including high blood pressure, diabetes, heart disease and cancer (medRxiv, doi.org/dnww).

However, no deaths have been reported in children under 9 years old. A report by the World Health Organization (WHO) and China, based on more than 75,000 cases, found that only 2.4 per cent were in those aged 18 or under (JAMA, doi.org/ggmq43). We don't yet know if children are less likely to catch the virus, or if they don't develop as strong symptoms.

How deadly is the virus?

Most estimates put the fatality rate at somewhere between 1 and 2 per cent of infections. This is higher in older populations. A report covering more than 44,000 cases put the fatality rate at 8 per cent for those in their 70s and 14.8 per cent for people aged



The WHO says there is no need for healthy people to wear face masks

According to the WHO, there is no evidence that pets can get and spread the covid-19 virus, or that it can be passed on via letters, packages or food.

How can I protect myself?

It is being claimed that all kinds of things can protect you from the covid-19 virus, from vitamins to garlic. There is no evidence to support most of these claims. But there is evidence that moderate exercise, adequate sleep and a healthy diet help keep your immune system in shape generally.

We don't know if smoking raises the risk of people with covid-19 becoming severely ill, but previous studies have shown that smoking increases the risk of being hospitalised if you get flu. Now may be a good time to give up.

It might also be worth booking flu and pneumococcal vaccines, which are already recommended for people over the age of 65 in the UK. These won't prevent infection with the covid-19 virus, but by protecting you from other infections they should ease the burden on health services.

How can I avoid infecting others?

If you are ill and think you might have covid-19, don't go to a doctor or to a hospital – you might infect others. Stay at home and call your local health authority. If you have a fever, cough and difficulty breathing, you should seek medical attention, says the WHO.

If you feel ill but have to go out, wear a face mask. Cover your mouth and nose with a tissue when you cough, and throw it away afterwards. If you don't have a tissue, cough into your bent elbow, not your hand.

80 or over. But the precise figure is difficult to calculate because we can't be sure how many people have caught the virus, says Mark Woolhouse at the University of Edinburgh, UK.

How do people catch the virus?

The covid-19 virus is thought to be transmitted by droplets emitted when people sneeze, cough or even just talk, says David Heymann at the London School of Hygiene and Tropical Medicine.

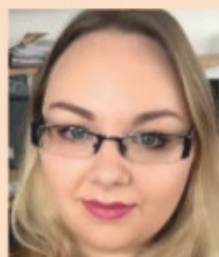
If you are within 2 or 3 metres of an infected person, you can breathe in those droplets directly. The longer you are near them, the greater the risk.

Surfaces can be contaminated by falling droplets, or by people coughing into their hand before pressing a button, say. If you touch a contaminated surface and then touch your eyes, nose or face, you can become infected. Faeces from infected people might also be infectious.

How can I avoid catching the virus?

You can minimise your risk through "social distancing" and good hygiene. Move at least a metre away from anyone who appears ill if you can. Don't shake hands, hug or kiss people as a greeting. Wash your hands often with soap and water, or use an alcohol hand rub, especially after touching surfaces that might be contaminated.

The WHO says there is no need for healthy people to wear face masks, and the US surgeon-general has warned that a rush on buying them could lead to a lack of important supplies for healthcare professionals.



"I'm a virologist, so I know what are on people's hands, so I don't shake hands at the best of times"

Lindsay Broadbent

Research fellow at Queen's University Belfast, UK, on BBC News, 3 March

LINDSAY BROADBENT

We were warned, so why couldn't we prevent it? SARS and MERS gave us ample warning of the risk of new coronaviruses, but we failed to set up sufficient defences, reports **Debora MacKenzie**

There are various viruses circulating in the northern hemisphere right now, and if you come down with norovirus, for example, it is a good idea to stay at home for several days after symptoms finish. This will help reduce the spread of infections that would exacerbate the strain on health services, and make it easier to track those who really have covid-19.

What happens if my family or flatmates get sick?

Now is the time to think about what happens if you or people you care about become ill. "Plan who will check up on who," says Michael Osterholm at the University of Minnesota.

There is a high risk of the virus spreading among people who live together. Ideally, people who are ill should stay in a separate room and use a different bathroom, although this will be difficult in many situations.

If ill people require care, both they and the carer should wear masks, says Heymann. The carer should also wear gloves.

Should I stockpile food or medicine?

There are differing views on this. "I don't think it is necessary, and I certainly don't advise it," says Woolhouse.

Virology blogger Ian Mackay recommends slowly building up a "pandemic stash". "[But] don't buy things you won't eat later, don't hoard and don't buy more than you'll need for a 2 week period," he writes. "We're not talking zombie apocalypse and we very probably won't see power or water interruptions either."

Osterholm says don't try to stock up on your prescription medicine. "You might create a shortage for others who need it," he says. ■

THE world dodged a bullet in 2003 when a global effort contained the SARS coronavirus, after it jumped from bats to humans in China and then spread to 26 countries. We nearly had another close call when MERS, another bat coronavirus, spilled over into people in 2012.

A year later, Chinese scientists found SARS-like viruses in fruit bats that could infect human cells. And in 2016, the World Health Organization put coronaviruses among the top eight known viral threats requiring more research.

So you would think we would have some coronavirus drugs and vaccines by now. But there are none licensed. That is why we are hurriedly testing drugs designed for other viruses to see if they can help, and running expedited trials for experimental vaccines. Why were we so unprepared for a threat we knew about?

After 2003, there was a burst of research, but it was short-lived. "From 2005, it became really difficult to get funding for work



We have vaccines for flu but not for the covid-19 virus yet

on SARS coronavirus," says Rolf Hilgenfeld at the University of Lübeck, Germany.

This was partly because, when SARS disappeared, there was no obvious market waiting for drugs or vaccines to treat it, says David Heymann at the London School of Hygiene and Tropical Medicine. Only big drug companies have the

money and expertise to get drugs or vaccines through human trials, and without a market they can't invest. But Hilgenfeld says agencies that fund research also lost interest, because "prominent virologists believed that SARS coronavirus was a one-time only thing".

Compared with other coronaviruses, SARS had an extensive genetic mutation that prompted some virologists to guess that this was what allowed it to suddenly spread in humans – and that such a mutation was unlikely to happen again. They were right about the second part. The covid-19 virus doesn't have this mutation, but it spreads even better in humans than SARS did.

SARS did inspire some global measures. MERS was rapidly identified in 2012 because the European Union had started funding labs to sequence mystery respiratory viruses. In 2007, a revamped version of the International Health Regulations, a treaty designed to reduce the spread of diseases internationally, required advanced economies to help developing ones improve their capabilities for detecting and controlling disease. But nations mostly invested in global initiatives and "not enough in helping countries take care of themselves", says Heymann. No countries now meet the requirements of the 2007 treaty.

Another problem is getting people other than doctors and scientists on board. After SARS, China set up a network to spot mystery clusters of respiratory disease. It spotted covid-19 in Wuhan – whereupon local officials stifled efforts to raise the alarm.

Public health experts have warned for years that we need to do better. The next new disease might be worse and, unlike covid-19, totally unexpected. ■

Epidemiology

What happened in earlier pandemics?

It wasn't that long ago that the last pandemic struck. In 2009, a flu virus from pigs jumped to people. The first serious cases were identified in Mexico but containment efforts were soon abandoned. The virus went on to infect a quarter of the world's population within a year.

Fortunately its impact was relatively mild. That virus killed only about 1 in 5000 of those it infected. But the covid-19 death rate appears to be around 1 in 100, more in line with the 1918 Spanish flu pandemic.

Almost all those people who survived that infection just over a century ago had normal flu symptoms. But with coronavirus it is different: around 20 per cent of cases fall seriously ill, and many of these people require ventilation to keep them alive until their immune system kills the virus.

If there was a rerun of 1918, in which half the US population was infected within a year, millions might need intensive care in that country alone.

Michael Le Page

Finance

World braces for economic impact

The repercussions for businesses, workers and supply chains could be severe

Adam Vaughan

GLOBAL economic growth could halve this year in a worst-case scenario for the covid-19 outbreak, the Organisation for Economic Co-operation and Development (OECD) said on Monday, as the financial impact of the disease becomes clearer.

At one point last week, \$5 trillion was wiped off share markets globally in their worst week since the 2008 financial crash, although shares had since begun to rebound as *New Scientist* went to press.

The OECD downgraded its global GDP forecast for 2020 from 2.9 per cent to 2.4 per cent, but warned that a more intense and longer-lasting outbreak might restrict growth to just 1.5 per cent.

A pandemic lasting six months could knock \$1.1 trillion off the expected growth of global GDP, according to a report by UK research firm Oxford Economics.

Consumers will spend less, people will be unable to work, travel and tourism will drop sharply and investment will fall, said the firm, which based its analysis on past outbreaks including SARS and swine flu.

“\$1.1 trillion would be much less than the financial crash impact, the world economy would still be growing. Our forecast is 2.3 per cent GDP growth,” says Ben May at Oxford Economics.

Calculating the economic damage so far is hampered by a lack of data, he says. Figures for industrial activity emerge slowly and efforts to extrapolate from what is happening in China are made harder by the changing timings of Chinese New Year – the initial outbreak in Wuhan coincided with the annual holiday.

However, there is evidence from some sectors, such as travel and tourism. Thailand, which normally gets just over a quarter of its visitors from China, saw



numbers down 70 per cent in the first 10 days of February, compared with that period in 2019.

“Clearly there will be big impacts on tourism, which we are seeing,” says May. “You will also see weaker trade, which will lead to supply chain issues. Some businesses will be fine, others badly affected.”

Airlines anticipate that demand will drop 4.7 per cent this year, which would be the first overall decline in global air travel since the 2008 crash. Around \$29 billion is expected to be wiped off airlines’

global revenues this year, with those in Asia-Pacific most affected, said trade body the International Air Transport Association.

Car firms have seen demand hit, says David Bailey at the University of Birmingham, UK, who notes that companies like Jaguar Land Rover have said they aren’t currently selling any cars in China. “We might even see global car sales decrease this year for the first time in many years,” says Bailey.

Although car manufacturers use a “just-in-time” production model, meaning parts arrive at a factory shortly before they are needed rather than being stored on site, those in the UK source relatively few components from Asia, less than 10 per cent.

However, they could still face disruption, as shown by Jaguar Land Rover flying parts from China to the UK in suitcases. If and when production restarts in Chinese factories that have currently downed tools, there will still be a delay to restoring supply chains because parts take six to seven weeks to reach Europe.

The effect on the UK economy remains to be seen, but health secretary Matt Hancock has told

We are starting to feel the financial effects of the covid-19 outbreak

firms to issue sick pay to staff who self-isolate from the virus on National Health Service advice.

Sickness from the outbreak could cost the UK billions, a Department of Health report suggests. Though only illustrative, the 2011 analysis of a potential flu pandemic found that GDP would take a £28 billion hit if half of employees had to be absent from work.

Depending on how long a pandemic lasts, the economic fallout for some could be lethal. Aaron Reeves at the University of Oxford, who was part of a team that found the financial crash was linked to an extra 10,000 suicides in Europe and North America, says the recent stock market fall could result in additional suicides.

\$5 trillion
Amount wiped off global share markets last week

“There is a real chance this leads to rises in unemployment in the next three to six months,” he says. “We would expect some mental health implications, and the hard edge of that is suicide.”

It would be surprising if a coronavirus pandemic led to as many suicides as the 2008 crash, but the number is still likely to be significant, says Reeves.

How bad the effect is will depend on where the economic damage lands: countries with stronger social welfare provisions mitigate the knock-on impact on suicides, he says. ■

Need a listening ear? UK Samaritans: 116123 (samaritans.org). Visit bit.ly/SuicideHelplines for hotlines and websites for other countries.



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Mental health

Compulsive robot could improve the way we treat OCD

David Adam

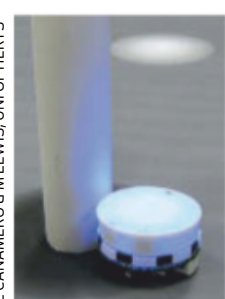
A ROBOT that mimics obsessive-compulsive disorder (OCD) could help us understand the condition.

OCD involves obsessive worrying that compels people to carry out rituals like repeated handwashing, and generates anxiety if they can't complete these compulsions.

Researchers recreated this in a robot they programmed to achieve three goals: "eat", avoid bumping into things and "groom". The robot eats by touching light patches on the floor, replenishing its energy. It grooms by going to, and bumping into, a solid post – a behaviour that causes damage and runs down its energy if performed excessively.

To recreate a compulsive drive, the robot's target grooming level was set beyond what it could achieve, prompting the robot to run out of energy 95 per cent of the time (*Computational Psychiatry*, doi.org/dnmw).

Treatment for OCD often involves exposing someone to the things that trigger their obsessive thoughts and



The OCD robot can be programmed to compulsively bump into a post

preventing them from responding. In future, showing people with OCD how the robot might improve may help them accept such stressful treatment, says Naomi Fineberg at the University of Cambridge, one of the robot team.

As someone with OCD, I am concerned the robot's quirks might reinforce the idea that the condition is all down to weird behaviours, instead of distressing, obsessive thoughts. We have been studying people for years, though, so maybe robots do have a role. ■

Quantum technology

Surprise contender enters the quantum computing race

Leah Crane



Honeywell's trapped-ion quantum computer

trapped ions – charged particles held in place by precise electromagnetic fields – as its qubits. Many other quantum computing players, such as Google and IBM, instead use superconducting qubits, which are based on supercooled electrical circuits. Superconducting qubits are easier to mass-produce and can run calculations faster, but trapped ions tend to be more accurate and they have longer-lasting quantum states.

Honeywell has also made an ambitious promise: the firm plans to add additional qubits to its computer each year for the next five years, increasing its quantum volume by a factor of 10 each time. "This is not a science project for us," says Uttley. "We're doing this because we believe we can make that step to value creation with a useful quantum computer."

It isn't yet clear how Honeywell's computer will compare with those already available, says Scott Aaronson at the University of Texas at Austin. Several other companies already have quantum computers, and some have had a years-long head start, he says.

Thanks to its longer-lasting trapped-ion qubits, Honeywell does have one thing that the other firms don't, says Uttley. "We can stop the calculation, take one qubit, ask 'what are you right now, are you a 1 or a 0?' and change the rest of the calculation based on that answer," says Uttley. "It's like putting an 'if' statement in an algorithm, and it's something that's unique to us." ■

A COMPANY known for its control systems for homes, businesses and planes has built a quantum computer. US-based firm Honeywell says it has big plans for the quantum future.

"You would have never suspected Honeywell was doing this," says Tony Uttley, president of Honeywell Quantum Solutions. The company has been working on its plans for a decade, he says.

On 3 March, the firm announced that customers will be able to access its quantum computer over the internet within the next three months. Like all the quantum computers currently available, it will probably be used to more easily solve problems that involve huge amounts of data, such as optimising aeroplane routes. It isn't expected to outperform ordinary computers yet.

Honeywell measures its computer's efficacy using a metric coined by IBM called quantum volume. This takes into account the number of quantum bits – or qubits – the computer has, their error rate,

how long the system can spend calculating before the qubits stop working and a few other key properties.

IBM's System Q One, its first commercial device, has a quantum volume of 16, which the firm claims makes it the world's most powerful quantum computer. According to Uttley, Honeywell's new computer had a quantum volume of 16 when the company began testing it in January, but he says the firm expects it to reach a quantum volume of up to 64 when the computer becomes available for commercial use.

16

The quantum volume of Honeywell's new computer

While IBM's computer used 20 qubits to reach a quantum volume of 16, Honeywell's uses only four. This indicates that Honeywell's qubits are longer-lasting with fewer errors than IBM's, but this kind of system can be difficult to scale up.

Honeywell's computer uses

Binge watching isn't as bad as we thought

It has been said that streaming 30 minutes of Netflix releases as much carbon as a short car ride, but this isn't true, says **Michael Le Page**

EVERY time you search the internet or stream a video, a computer in a data centre somewhere in the world spins into action. With rising internet use, there have been fears that this is driving a big increase in energy consumption, undermining efforts to limit climate change.

The good news is that, according to the most detailed study to date, the energy use of data centres rose by just 6 per cent between 2010 and 2018, despite a 550 per cent hike in demand. Dramatic efficiency improvements have almost cancelled out the big increase in use, according to Arman Shehabi at the Lawrence Berkeley National Laboratory in California and his colleagues (*Science*, doi.org/ggm3sk).

That isn't all. Video streaming in particular has been singled out as a major driver of rising energy use, with several media outlets reporting that the emissions generated by watching 30 minutes of Netflix are the same as driving almost 4 miles.

This claim is based on figures for global streaming in a 2019 report by French think tank the Shift Project. But according to an analysis by George Kamiya at the International Energy

Agency published by CarbonBrief last week, errors in those figures mean emissions from viewing Netflix were overestimated by 30 to 60 times.

So does this mean we can stop worrying about the climate impact of internet traffic and, in particular, streaming videos? Not quite.

The main conclusion of the Shift Project report was that transmitting and viewing online videos generates 300 million tonnes of carbon dioxide

Love is Blind was one of the most-watched shows on Netflix this week in the UK



a year (mtCO₂), or nearly 1 per cent of global emissions, as *New Scientist* reported (although we didn't mention the unlikely driving claim).

Kamiya's analysis applies only to Netflix, but he thinks the Shift Project did overestimate the overall emissions from streaming video. "I haven't done any estimates of the global emissions from all streaming video," he says. "This would require quite a bit more analysis."

One author of the Shift Project report, Maxime Efoui-Hess, says his team welcomes an open discussion and will contact Kamiya to talk about the differences in numbers. Kamiya makes the same recommendations for reducing emissions as the report did, Efoui-Hess points out, so these won't change.

An independent study by Chris Preist at the University of Bristol, UK, estimated that YouTube alone generates 10 mtCO₂ a year, and he says nothing in Shehabi's or Kamiya's work undermines this conclusion.

According to the Shift Project, YouTube accounts for less than a fifth of total streaming emissions. If that is correct, overall emissions due to streaming based on Preist's research

would still be more than 50 mtCO₂ a year – a lot less than 300 mtCO₂, but still substantial.

While big efficiency gains appear to have limited the rise in energy use by data centres, we can't assume this will continue, says Shehabi. The centres may have already implemented all the easy wins.

Meanwhile, Anders Andrae, an efficiency researcher for Chinese technology firm Huawei, thinks Shehabi's team has got it wrong. He is sticking with his forecasts of huge rises in electricity demand due to growing internet and computer use.

Resolving these conflicting numbers won't be easy. We have limited information on the data industry, as companies disclose little. All studies are essentially educated guesstimates.

Another complication is that rising energy use in this sector might sometimes lower demand in others. For instance, demand for streaming video might shoot up this year if millions of people are forced to stay at home because of the coronavirus outbreak. But if they are doing this instead of driving or flying to places, overall carbon emissions will fall. ■

Space

Satellites dock together for historic repair mission

FOR the first time ever, two private satellites have latched on to one another in orbit around Earth as part of a rescue mission.

This technique should give a flagging spacecraft five more years of operation, and could be used in the future to repair and service satellites in space.

The first spacecraft, called IS-901, is a communications satellite that was launched by

Intelsat in 2001 and is now running out of fuel. The second, called the Mission Extension Vehicle-1 (MEV-1), was developed by Northrop Grumman and is designed to attach to other satellites and take over, controlling their orbits and the direction in which they point. It was launched in October and reached IS-901 on 25 February.

When the two spacecraft came together, MEV-1 connected with IS-901. It is now performing diagnostic tests before the combined double-satellite moves from the higher orbit in which this manoeuvre took place back down

to a lower orbit, where it is planned to operate for another five years.

Intelsat is the first customer to be serviced by MEV-1, but if all goes well, it won't be the only one. These two satellites will stick together for five years, and then MEV-1 will return IS-901 to a "graveyard" orbit out of the way of working satellites and move on to a new partner.

Another similar satellite, called MEV-2, is scheduled for launch later

"Thousands of dead satellites in orbit could prove problematic for space flight in the future"

this year, and Northrop Grumman has said that it plans to develop and deploy a whole fleet of service satellites.

This could be a helpful step in dealing with Earth's space junk problem – the thousands of dead satellites in orbit that could prove problematic for space flight in the future.

If satellites can be made to last longer and moved around even after they are broken or out of fuel, it could mitigate the problem or even let us bring down the old junk that has been up there for years. ■

Leah Crane

Archaeology

Denisovan tools unearthed

Extinct hominins made refined tools and possibly also jewellery

Colin Barras

EXCAVATIONS at Denisova cave in Siberia have uncovered almost 80,000 stone artefacts that extinct humans left over a 150,000-year period. Collectively, they reveal how technology developed by Denisovans may have evolved through the Stone Age.

Ancient human remains in Denisova cave are extremely rare, but artefacts are not. Maxim Kozlikin at the Russian Academy of Sciences in Moscow and his team have now studied 37,000 tools from the cave's east chamber.

The oldest artefacts were in dirt layers more than 200,000 years old, according to a method called optical dating. They show that the cave's inhabitants used the relatively sophisticated Levallois technique, which involves carefully chipping at a stone to remove flat flakes with sharp edges to be used as tools.

By about 150,000 years ago, the people using Denisova cave shifted towards producing narrow, parallel-sided stone blades, some about 3 centimetres wide and 10 centimetres long (*Quaternary International*, doi.org/dnmj). This marks a move towards tools that could be used with more precision,

as scrapers for woodworking or as chisels for engraving stone.

The cave inhabitants had begun making finer quality stone blades and chisels by 60,000 years ago – and about 10,000 years later, they may have been using the tools to make jewellery, including bone beads, a bracelet made out of polished green rock and what has been described as an ivory tiara.

"The stone industry shows a

Thousands of stone tools have been uncovered in Denisova cave in Siberia



SHUNKOV, M.V., ET AL.

gradual evolutionary development," says Kozlikin. It also shows continuity. For instance, tools from each period his team studied were made using stone from the same river beds.

Partly because of this, Kozlikin and his team argue that the tools were all made by Denisovans. They say this is backed up by evidence of Denisovans occupying the cave through these periods. This includes DNA recovered from 200,000-year-old layers, and remains found in layers about 100,000 and 60,000 years old.

But Bence Viola at the University of Toronto in Canada advises caution. We also know from human remains and DNA in the cave's sediment that Neanderthals were present there sporadically around 190,000 to 100,000 years ago. They may have made some of the tools, he says.

Denisovans probably behaved a lot like Neanderthals and made similar tools, says Viola, "which is exactly why it's so hard to tell which assemblage was produced by whom". He also doubts that Denisovans made the jewellery 50,000 years ago, particularly since a 45,000-year-old bone from a site 1500 kilometres to the north-west shows that our species may have been present in the area.

But 1500 kilometres is a large distance: Kozlikin thinks we can't rule out the possibility that Denisovans made the ornaments.

"I would like to think that we have become more open-minded in the past few years to the idea that species other than our own were also capable of creating Palaeolithic art – in this case in the form of jewellery," says Genevieve von Petzinger at the University of Victoria in Canada. ■

Astronomy

Earth's new moon is a mini marvel the size of a car

OUR planet might have a tiny new moon. It is probably between 1.9 and 3.5 metres across, about the size of a car, making it no match for Earth's main satellite. It circles our planet about once every 47 days on a wide, oval-shaped orbit, mostly far outside the larger moon's path.

On 19 February, astronomers at the Catalina Sky Survey in Arizona spotted the newcomer as a dim

object moving quickly. Over the next few days, researchers at six more observatories around the world watched the object, designated 2020 CD3, and calculated its orbit, confirming that it has been gravitationally bound to Earth for about three years.

An announcement posted by the Minor Planet Center, which monitors small bodies in space, states that "no link to a known artificial object has been found", implying that it is probably an asteroid caught by Earth's gravity as it passed by.

This is just the second asteroid known to have been captured by our planet as a mini-moon – the first, 2006 RH120, hung around between September 2006 and June 2007 before escaping.

2020 CD3's orbit isn't stable, so it will eventually be flung away from Earth. "It is heading away from the Earth-moon system as we speak,"

"The mini-moon circles our planet about once every 47 days on a wide, oval-shaped orbit"

says Grigori Fedorets at Queen's University Belfast in the UK, and it looks likely it will escape in April.

However, there are several different simulations of its trajectory and they don't all agree. We will need more observations to accurately predict the fate of our mini-moon and even to confirm that it is definitely a temporary moon and not a piece of artificial space debris. "Our international team is continuously working to constrain a better solution," says Fedorets. ■ Leah Crane

Microbiology

Secret of silver's antimicrobial powers revealed

Chris Baraniuk

SILVER seems to help prevent harmful bacteria from spreading by disrupting how they move around.

The precious metal has long been used to stop the transmission of bacteria – for example, in the filters of some medical face masks and in the antibacterial coatings used on the International Space Station. But until now, we didn't fully understand why it has a sanitising effect.

To find out, researchers at the University of Arkansas exposed *E. coli* to small doses of positively charged silver ions, which are toxic to bacteria. They then used a powerful microscope to watch what happened to the bacteria's flagella – the whip-like motors that bacteria use to move around.

Exposing the bacteria to silver ions stalled their flagella, causing the cells to “become much, much slower”, says Yong Wang, one of the researchers on the team. These bacteria also changed direction more, so they spent less time moving in a line than non-exposed bacteria (bioRxiv, doi.org/dnj6).

Silver has been used for decades to stain flagella to make them easier to see under the microscope, says Jim Thomas at the University of Sheffield in the UK. But this is probably the first time its effect on flagella has been studied, he says.

David Coil at the University of California, Davis, says silver won't always have this effect because not all bacteria have flagella. But silver stops microbes in other ways too – for instance, in higher doses, it can damage cell walls and cause bacteria to explode.

Stopping bacteria from moving as easily makes it harder for them to escape and therefore become resistant to silver's effects, says Thomas. “Treatments that work through multiple pathways or targets are much more difficult for bacteria,” he says. ■

Astronomy

Galaxy's black hole may have helped life start

Leah Crane

THE supermassive black hole at the centre of the Milky Way may have been crucial to the evolution of life in our galaxy.

These days, the black hole, known as Sagittarius A*, is relatively calm. But there are hints that it may have been much more active millions of years ago, swallowing down matter and spewing out high-energy radiation, including large amounts of X-rays.

Xian Chen at Peking University in Beijing, China, and his colleagues simulated how these X-rays would affect the abundance of chemicals crucial to the evolution of life: water and organic molecules such as methanol.

When high-energy photons, like those of X-rays, hit molecules, they can knock off electrons. The resulting molecules – and the free electrons – tend to be more likely to latch on to other atoms or molecules, so this

interaction can start a cascade of chemical reactions.

The result can be ever larger molecules, eventually generating the complex compounds required for life to evolve. “Ultimately, maybe after billions of years, this little energy from a little photon created close to a supermassive black hole becomes part of a life,” says Chen.

The researchers found that even as far away as 26,000 light years from Sagittarius A*, which is about the distance Earth sits from it, many organic molecules would be present at much higher levels if the black hole was once active than if it never was. This effect could remain for millions of years after the activity ends, they calculated (arxiv.org/abs/2002.03086).

“Right now, the black hole is starved, but it's possible that a few million years ago it was shining up to 100 million times brighter,” says Avi Loeb at Harvard University. “It could have influenced the material that made the sun, the building blocks of life that we find on Earth.”

It is important to take this sort of temporary event into consideration when thinking about the necessary conditions for life to develop, says Loeb. Because this kind of radiation can also be extremely harmful to planets too close to the black hole, blowing away their atmospheres and sterilising their surfaces, there might be

26,000

Light years from the black hole Sagittarius A* to Earth

a fine line for planets to walk in terms of where in the galaxy they could host life.

Finding this line is still hard because we don't know exactly what conditions are required for life. “So far, we have established the link between the activity of the supermassive black hole and the formation of some basic building blocks of organic and prebiotic molecules,” says Chen. “But from building blocks to a full-fledged life is a long way, and there are still many missing pieces.” ■

The black hole at the centre of the Milky Way was once more active



Microbiome

E. coli strain linked to cancer

Microbes in our guts seem to be responsible for some disorders, like bowel cancer

Clare Wilson

SOME bowel cancers seem to be caused by bacteria, with one microbe triggering a distinct type of mutation in our DNA seen in up to one in 10 cases of colon cancer.

"It's the first bacteria ever shown to change DNA and be carcinogenic," says Hans Clevers of the Hubrecht Institute in Utrecht, the Netherlands.

Colon cancers are usually seen as stemming from random genetic mutations, with smoking and an unhealthy diet raising the risk. But more recently, suspicions have grown about certain gut bacteria, including a strain of *E. coli* that produces a substance that can damage our DNA.

This strain, called *pks⁺ E. coli*, is more common in the faeces of people who have had colon cancer, but it was unclear if it causes the tumours or just grows better in the guts of people who had already developed cancer.

To investigate, Clevers and his team injected this strain into tiny clumps of human cells, known as organoids, in a dish over five months. They found that the microbe triggers distinct patterns of DNA damage: of the four "letters" of the DNA code, the

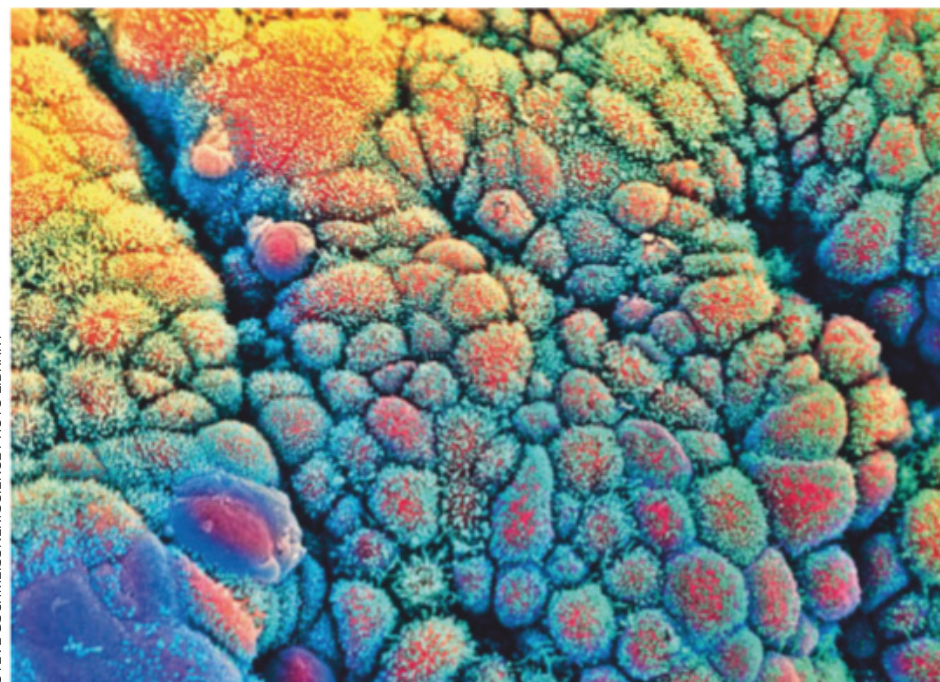
mutations happen at a particular two-letter combination.

The group then looked at two previous studies in which the genes of nearly 6000 tumours, mostly from the colon, had been sequenced. Between 5 and 10 per cent of people with colon cancer had this same mutation pattern, but it wasn't there in the other tumours (*Nature*, doi.org/ggmtkr). "We feel that's very strong evidence that these bacteria are indeed the cause of the cancers in those patients," says Clevers.

"I won't say this is the clincher, but this takes a very strong step forward," says Cynthia Sears of Johns Hopkins University in Maryland.

If confirmed, people could get rid of the cancer-causing bacteria with antibiotics and then take probiotic capsules of a safe *E. coli* strain to stop the dangerous one from returning, says Clevers.

An electron micrograph showing cancer cells in the intestine



STEVE GSCHEISSNER/SCIENCE PHOTO LIBRARY

In a separate study, another group has shown that a lack of certain bacteria may cause ulcerative colitis, where the immune system seems to attack the gut, leading to inflammation.

Aida Habtezion at Stanford University in California and her colleagues found that people with this condition have less diverse gut bacteria and lack a particular class of biochemicals in their faeces called secondary bile acids.

These compounds are made by a type of microbe that people with ulcerative colitis are without. "That really stood out," says Habtezion.

Her team gave the bile acids to mice with a similar condition to ulcerative colitis and found their gut inflammation lessened (*Cell Host & Microbe*, doi.org/dnmv).

The group has now started a trial of one of the bile acids in 15 people with ulcerative colitis to see if it reduces their symptoms. Results are due next year.

The researchers have been able to move quickly into human tests as the bile acid is already used as an oral medicine for liver disease. But to be most effective, Habtezion believes it should be delivered into the colon through an enema. ■

Anthropology

Aboriginal people hunted kangaroos with dingoes

AS RECENTLY as 110 years ago, Aboriginal Australian hunters enlisted help from an unlikely source. They used dingoes, difficult-to-train canines halfway between wolves and dogs, to help trap and kill kangaroos and emus.

We know from historical accounts that people sometimes collected wild dingo puppies to keep as pets.

However, some of those same historical records suggest that the animals were too disobedient to serve much practical purpose on hunts.

"Their eagerness to pursue usually caused the prey to become aware of the danger and flee early," says Loukas Kounououlos at the University of Sydney.

But Kounououlos and Melanie Fillios at the University of New England in Australia have now found evidence that indigenous hunters took advantage of this,

using dingoes to help flush out large kangaroos and emus towards concealed groups of hunters armed with weapons (*Journal of Anthropological Archaeology*, doi.org/dnmc).

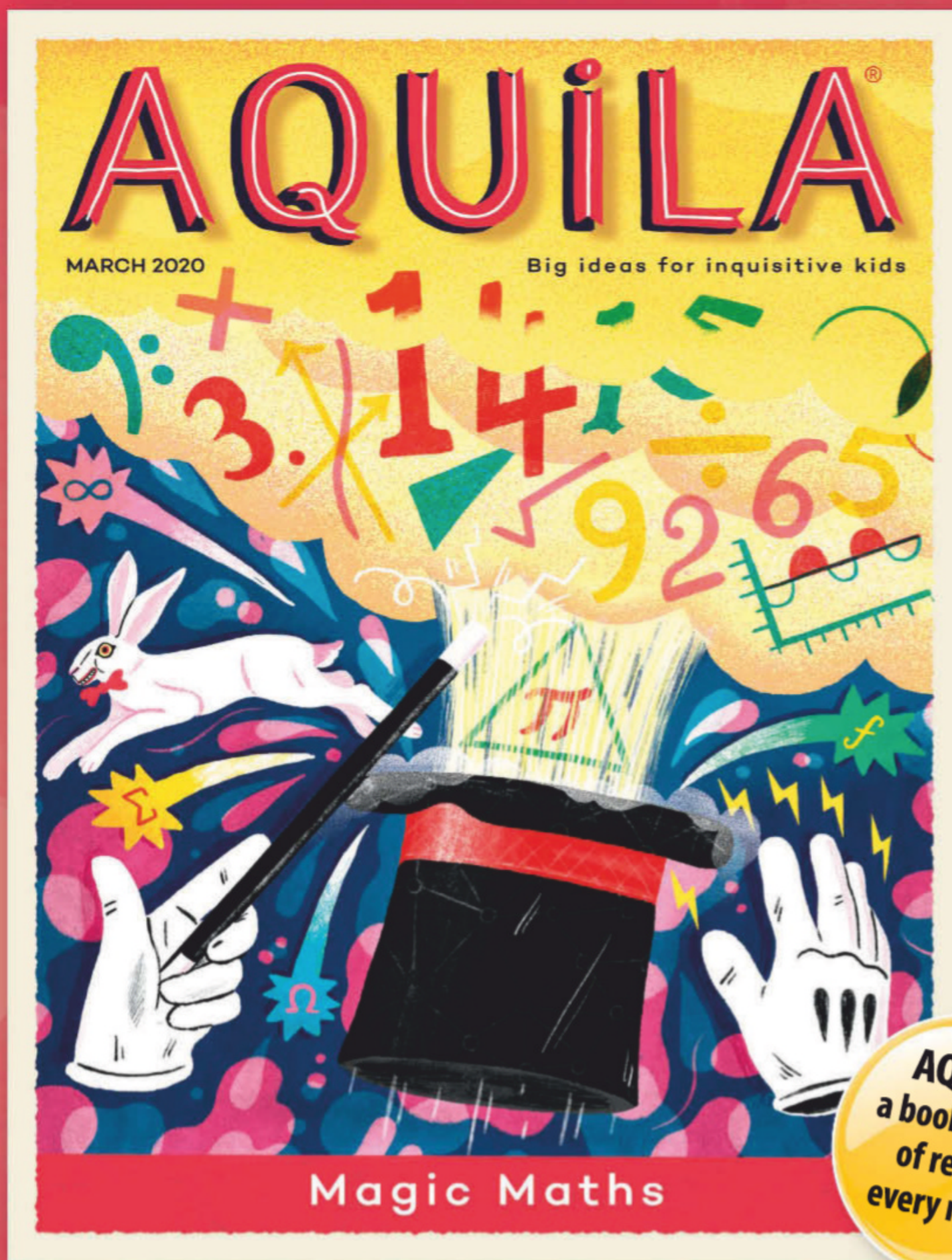
Naturalist Thomas Ward outlined the practice in northern Australia in the 1900s. "Kangaroo and wallaby are... driven into a crowd with the

"Their eagerness to pursue caused prey to flee, and indigenous hunters took advantage of this"

aid of the semi-tame dingo dogs," he wrote, adding that a few emu were caught this way too.

We don't know which indigenous group Ward was referring to, but Kounououlos says a similar account in the 1840s by explorer John Ainsworth suggests the Bundjalung people of eastern Australia used dingoes on kangaroo hunts. And in 1831, Isaac Scott Nind described similar hunts that were conducted by the Mineng Noongar people of south-western Australia. ■

Colin Barras



IN THIS ISSUE Children can delve into the magical world of numbers to discover how maths is an innate part of the world we live in. We investigate **Pythagoras'** theories about musical and **universal harmony** and the 'magic' **number patterns** that appear to rule the natural world. PLUS: cook marshmallows using the power of a **parabola!**

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Richard Robinson, Brighton Science Festival

Solar system

More secrets of the moon's hidden face are revealed

WE NOW know what lurks below the far side of the moon, thanks to data from China's Yutu-2 rover.

For more than a year it has been exploring the South Pole–Aitken basin, the oldest and largest impact crater on the moon, sending back photos and videos of the surface. Now we have the findings of its high-frequency, ground-penetrating radar, which researchers used to peer 40 metres below the surface.

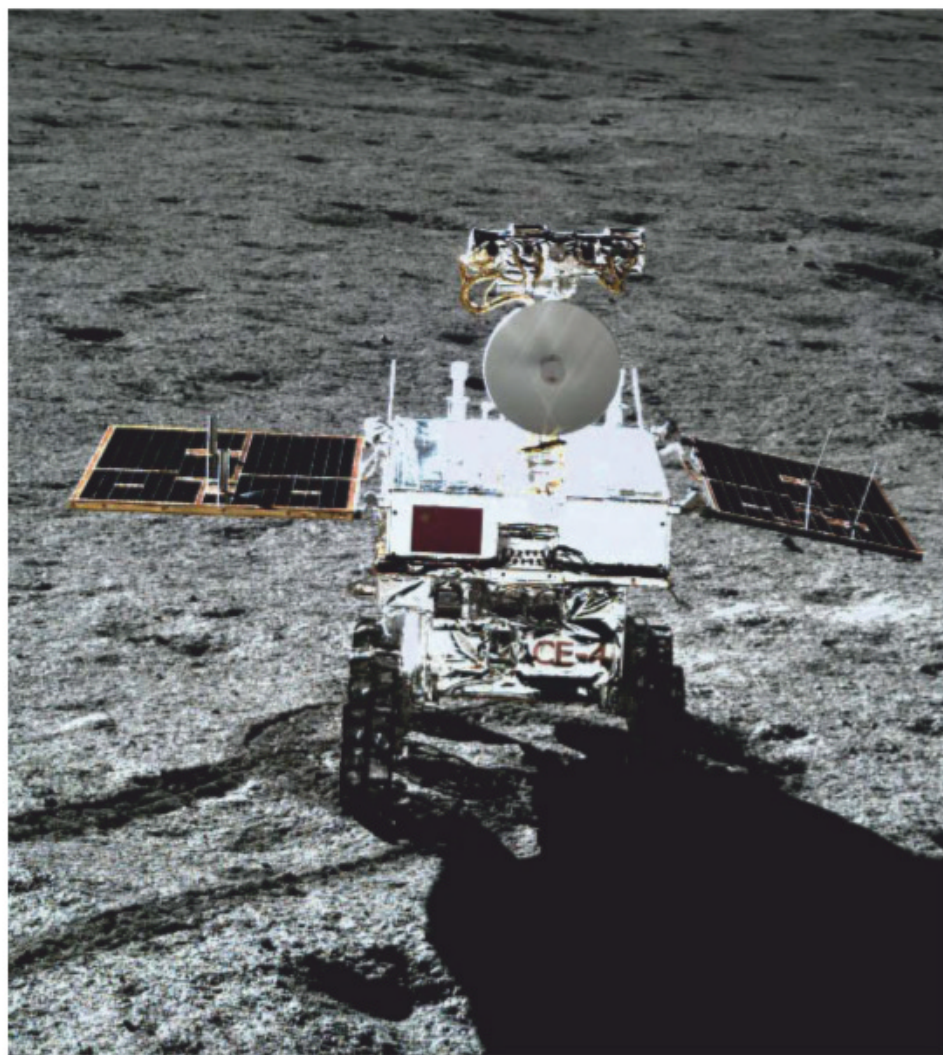
The top layer – extending to about 12 metres down – appears to be mostly fine dust. The particles probably formed as small meteorite collisions and radiation from the sun gradually degraded the top soil, says Yan Su at the Chinese Academy of Sciences in Beijing, who was part of the team that analysed the data.

Between 12 and 24 metres deep, the soil is coarser and has large

rocks embedded in it. The rocks are probably leftover debris from when large asteroids and meteorites smashed into the moon's surface, says Su.

The layer below this, which extends to the radar's penetration limit of 40 metres, is composed of alternating layers of coarse and fine soil (*Science Advances*, doi.org/dnmx). The coarse layers are probably leftover debris from impacts, while the finer material probably formed via gradual weathering during the periods between each impact, says Su.

Yutu-2 (pictured) is still roaming the far side of the moon, and may be able to tell us more about what lies beneath by using low-frequency, ground-penetrating radar, which can see several hundred metres down, says Su. **Alice Klein**



CNSA VIA CNS/AFP

Animal behaviour

Gulls prefer food touched by humans

GULLS prefer to approach food that has been handled by people, suggesting that the birds may use our cues to find a meal.

Madeleine Goumas at the University of Exeter, UK, says the idea for her research came from seeing how gulls acted around humans. “Are they just looking for food, or are they noticing what people are doing and picking up on their cues?” she says.

Goumas and her colleagues did an experiment in which she approached 38 herring gulls (*Larus argentatus*) on the UK's Cornish coast with two buckets, each with a wrapped flapjack inside. Standing about 8 metres from each bird, Goumas removed the flapjacks from the buckets and placed them at an equal distance from her.

She then picked up one of the flapjacks and pretended to eat it for 20 seconds, before putting it back

down, still wrapped, and moving away. Some gulls ignored her, but of the 24 that picked up a flapjack, 19 chose the one Goumas handled.

Goumas then repeated the experiment with blue sponges the same size and shape as the flapjacks. This time there was no significant difference in which one the birds went for (*Royal Society Open Science*, doi.org/dnnb).

The team can't say for sure whether the gulls were able to differentiate between the food and the sponges, but Goumas speculates that the differing results may be due to the birds understanding that items in shiny plastic wrapping are more likely to be food-related.

“The findings suggest that herring gulls have learned that handled food is likely to be a good resource. Given how quickly they may be disturbed when feeding in an urban setting, this is a smart strategy,” says Mark Fellowes at the University of Reading, UK.

Jason Arunn Murugesu

Locomotion

How feet made the leap to bipedalism

WE HAVE new clues to how our feet got their stiffness, which enables us to walk and run upright.

The arches in the human foot are key to this trait. Other primates have flatter, more flexible feet that can bend more than ours. Humans have two distinct arches in the middle of the foot: the medial longitudinal arch (MLA) that runs from the ball to the heel, and the transverse tarsal arch (TTA) near

the ball of the foot, that runs from one side of the foot to the other.

The TTA was thought to be more involved in supporting the foot and the MLA in stiffening it. But Madhusudhan Venkadesan at Yale University and his colleagues looked at the TTA and found that it is much more involved in stiffness than previously thought.

Using two feet from body donors, they found that cutting the tissues that run along the TTA decreased the stiffness of one foot by 44 per cent and the other by 54 per cent. This is a bigger drop than the 23 per cent difference in stiffness when they cut the MLA (*Nature*, doi.org/dnm9).

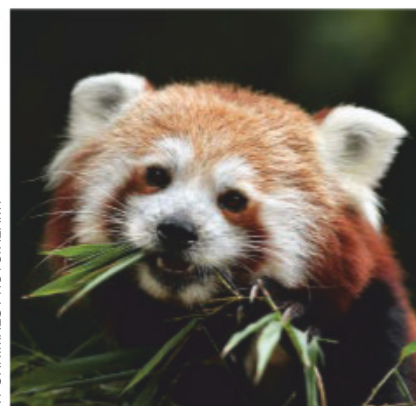
The finding sheds light on how ancient humans may have walked upright despite having flat feet lacking a distinct MLA. The team used fossils to find that *Homo naledi*, which could walk on two legs, had a human-like foot but a flat MLA. However, its TTA was similar to that in our feet, which may have compensated. **Gege Li**



WESTEND61/GETTY



Really brief



VPC ANIMALS PHOTO/ALAMY

Red pandas may be two species

The Chinese red panda and the Himalayan red panda (pictured) may be separate species, not sub-species as we thought. A genetic analysis suggests they diverged from one another 200,000 years ago (*Science Advances*, doi.org/dnmk). Differences in their fur colour and tail rings back this up.

Both sides of brain process songs

We deal with the lyrics and melody of a song using different sides of the brain. Researchers played songs to 49 people while their brains were scanned with functional MRI. This showed the left hemisphere processes lyrics and the right hemisphere the melody (*Science*, doi.org/dnnw).

Fish using VR help us study perception

Exposing zebrafish to virtual reality has allowed researchers to study their perception as they swam and interacted with virtual fish. When what they saw didn't match the way they were trying to go, the fish moved their tails faster to correct for it (*Nature Methods*, DOI: 10.1038/s41592-020-0759-2).

Opioid crisis

US overdose deaths worse than thought

MANY more people in the US may have died from opioids in the past two decades than were reported, according to a new analysis of unclassified drug deaths.

Elaine Hill and her colleagues at the University of Rochester, New York, were examining data on drug overdose deaths when they realised that 22 per cent of such cases reported between 1999 and 2016 were listed on death certificates as overdoses without

specifying the substance involved.

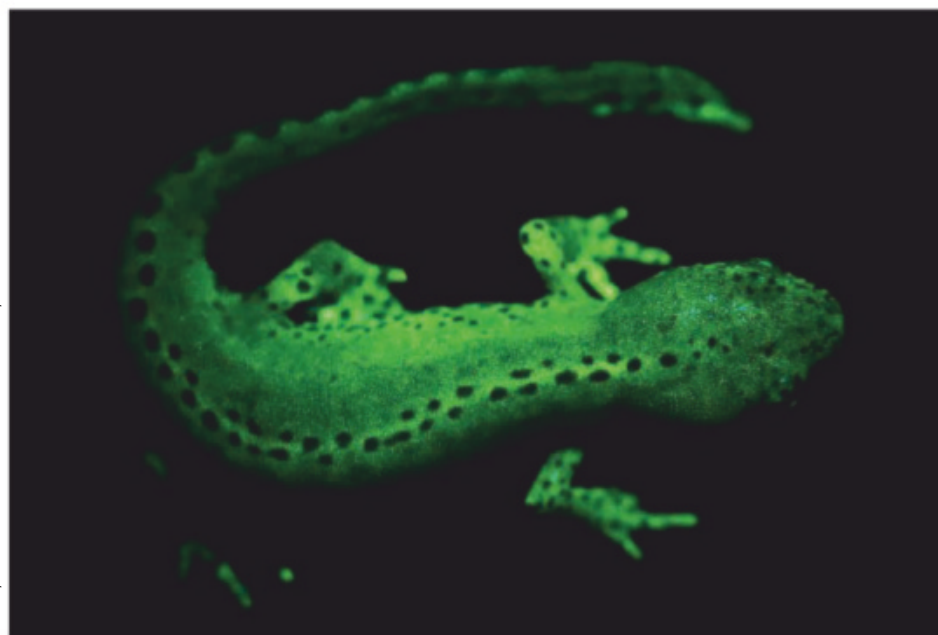
The team tried to estimate what percentage of these were due to opioids by analysing medical reports and coroners' reports. First, the researchers used machine-learning algorithms to analyse deaths that had been recorded as being due to opioid overdose. They were able to identify common factors that could signify the involvement of opioids, such as descriptions of long-term pain and arthritis.

Using this information, the team estimates that 72 per cent of the unclassified overdose deaths

involved opioids. This finding suggests that 99,160 more people in the US have died from opioid overdoses than previously thought, an underestimate of 28 per cent. According to these new results, a total of more than 450,000 people in the US have died from an opioid overdose since 1999.

According to the analysis, some states under-reported opioid overdose deaths far more than others. Pennsylvania and Delaware performed the worst in this regard (*Addiction*, doi.org/dnnd). **JAM**

Zoology



J LAMB, M DAVIS/ST CLOUD STATE UNIVERSITY, MINNESOTA

Amphibians have a hidden power – they can glow green

MANY species of salamander and frog are naturally fluorescent, glowing green under certain wavelengths of light, although why they have this trait isn't yet clear.

Biofluorescence occurs when light hits a living organism and is absorbed and re-emitted at a different wavelength, like when white teeth glow blue under UV light. We know that many sea creatures are fluorescent, but we hadn't studied it in amphibians.

Jennifer Lamb and Matthew Davis at St. Cloud State University in Minnesota examined individuals from 32 different species of amphibian, mostly frogs and

salamanders, to figure out if they would fluoresce under blue light. Every single species did: most lit up green, like the alpine newt (pictured) while a few were a bit more yellow (*Scientific Reports*, doi.org/dnm5).

Most of the fluorescence seemed to come from pigments in the skin of the animals, but some also came from mucus excretions or even bones. It isn't yet clear exactly what purpose the fluorescence serves, says Lamb. It could help warn off predators, similar to the brightly coloured markings on some animals, or maybe it could help individual amphibians identify one another. **Leah Crane**

Evolution

Earliest ever animal to lose its legs

A WORM-LIKE creature from 518 million years ago is the oldest animal known to have lost body parts it no longer needed – in this case its back legs.

Facivermis yunnanicus was around in the Cambrian period. It was under 10 centimetres long and had five pairs of spiny legs on its front half and a swollen rear end.

However, we have been unsure what type of animal it was. To find out more about its lineage, Richard Howard at the University of Exeter, UK, and his team looked at fossils of *F. yunnanicus* from China.

They discovered that some were accompanied by a tube, which the species evidently made and then lived inside. This implies that it was a type of filter feeder, similar to some modern tube worms, that would have anchored its tube to a surface and caught fragments of food with its front limbs (*Current Biology*, doi.org/dnnf).

Its closest relatives had long and feathery appendages for catching food, but they still had rear legs to anchor themselves in place.

F. yunnanicus went a step further in evolutionary terms and dispensed with the rear limbs. "It's just lost its back legs altogether and built a tube to live in," says Howard. **Michael Marshall**

Big tech

Taxing times

The ability to shift online profits to low-tax nations has made tech firms hugely profitable. Should that change, asks **Chris Stokel-Walker**

THE tech giants have taken over the world, but now governments are trying to claw some of it back. Global leaders are discussing new rules on taxing some of the planet's most valuable firms, but reaching agreement on how to divide the digital spoils won't be easy.

It has been clear for some time that these firms seem to pay less tax than might be expected given their revenues. Take the UK, where in 2018, Facebook achieved a record £1.6 billion in revenue, but paid just £28 million in corporation tax, around 1.75 per cent of the total. The same year, Google paid nearly £67 million in tax, but reported £1.4 billion of UK revenue. Apple made £1.2 billion in UK revenue last year, but paid just £3.8 million in tax.

It is a similar picture in many other countries. It is smart business and entirely legal for multinational companies to funnel profits through low-tax countries, but many argue that it robs nations of vital income.

"The multinational tax system doesn't work properly," says Neil Ross of industry body techUK. "We know global tax rules haven't kept up with the way the modern economy works, particularly when it comes to the digital economy, which is international by default."

France is leading the charge. Last year, it levied an additional 3 per cent rate of tax on about 30 tech firms worldwide. The tax retroactively charged companies for income earned in France during the 2018-19 tax year.

The French finance ministry declined to say exactly how much the tax raised, saying it hasn't yet calculated the figure, but spokesperson Mélanie Voin told *New Scientist* it was several hundred million euros.



CHESNOT/GETTY IMAGES

Many tech firms have huge revenues, but small tax bills

3%

Additional tax on income of large tech firms in France

"We know global tax rules haven't kept up with the way the modern economy works"

France had initially called for a European Union-wide tech tax, but these efforts were stymied by opposition from Ireland, Finland and Sweden, says Voin, in large part because they benefit from the status quo. For example, many tech firms choose to base their European operations in Ireland because its corporation tax rate of 12.5 per cent is much lower than the EU average of 21 per cent.

"For us, it's a matter of fairness," says Voin. "It's something people want in France. There's a perception that there are companies not paying a lot of taxes, whereas they're making a lot of profits, and individuals feel that they are taxed much more."

Countries like Austria, Italy, Spain and the UK have also introduced or are proposing to introduce similar taxes.

But the French plans started a spat with the US, where many big tech firms are based. US president Donald Trump threatened to impose import tariffs on French goods in retaliation.

Both sides stepped back from the brink at a meeting of the World Economic Forum in Davos, Switzerland, in January 2020, agreeing to consider a plan put forward by the Organisation for Economic Co-operation and Development (OECD) for a global digital services tax that would increase tax bills across the tech sector by about 4 per cent, or \$100 billion.

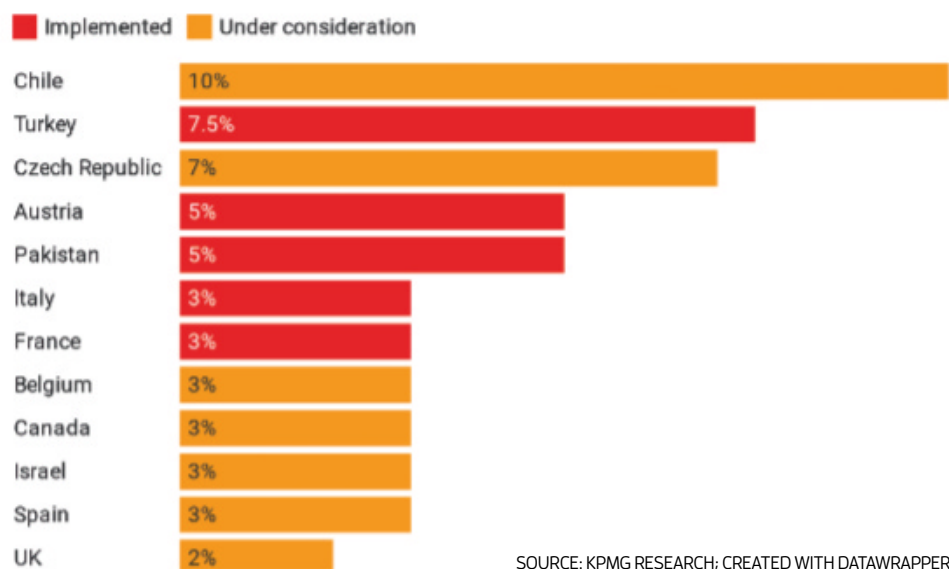
Global debate

International finance ministers met in Saudi Arabia on 22 and 23 February for a G20 summit to debate the plan, which has two pillars. The first would give governments some taxing rights for any sales made in their country, redressing the issue that big tech firms can shift profits to nations where tax is low by accounting online sales to customers in one country as being made in another.

The second ensures a minimum level of tax internationally, avoiding a race to the bottom as countries reduce their taxes to encourage firms to shift their profits there. The agreement would harmonise tax rates across 137 countries supporting the OECD plan. This wouldn't install the OECD as the global tax authority, but it would replace existing national-level tax rules and standards, allowing each country's tax authority to levy and collect the agreed amount of tax.

"Both pillars would go a long way towards addressing the challenges posed by the increasing digitalisation of the economy,"

A number of countries have started or are considering a new tax rate on tech firm revenues



says Pascal Saint-Amans, director of the OECD Centre for Tax Policy and Administration.

Google says its overall tax rate has been 23 per cent for the past decade, similar to the average statutory rate across OECD countries, but the OECD thinks it and firms like it should be paying more. Tech giants have profit margins of about 20 per cent compared with the global average of 8 per cent for listed companies, according to the OECD. It says these excess profits should be distributed to the markets where those goods are sold, rather than being kept in their home jurisdiction, generally the US or China.

Not everyone shares this view. "Countries sense that [big tech firms] are making a lot of money in terms of revenue but also profit in jurisdictions in which they do not pay a certain 'fair share' of tax," says Matthias Bauer of the European Centre for International Political Economy, a free-trade think tank based in Brussels that is opposed to the notion of introducing tech taxes.

Bauer argues that the companies often fingered as the

worst tax avoiders still contribute to the countries they operate in: they add employment, investment through data centres or logistics and warehouse facilities, and pay out salaries that are taxed through income tax. "If you tax away the capacity of the companies to do this, you lower the impact of their activities," he says.

At the G20 meeting, the US cautioned against the OECD plan, while European nations were

French finance minister Bruno Le Maire talked tax at a recent G20 summit



generally in favour. If they don't reach an agreement by the end of the year, countries that have already put forward proposals for so-called digital services taxes are likely to reinstate or implement their own unilateral taxes anyway.

Michael Devereux at the University of Oxford believes the latter is the most probable option for politicians. "I think they've made enormous progress given where they started and the difficulties of doing it, but they've got a very tight timescale," he says. The next OECD meeting on the tech tax will take place in Berlin in July, where the participants hope to thrash out the key policy features of a global solution and sign a political agreement that would be delivered to G20 heads of state in November 2020.

Like and share

The bosses of big tech firms are recognising that something has to change. "I understand that there's frustration about how tech companies are taxed in Europe. We also want tax reform and I'm glad the OECD is looking at this," Facebook CEO Mark Zuckerberg said last month. In January, Apple boss Tim Cook said that he "desperately" wanted the tax system to be "fair". Facebook and Alphabet, the parent company of Google, both declined to comment for this story. Apple didn't respond to requests for comment.

It makes sense for tech executives to throw their support behind the OECD scheme. "It's in their interest and from a tax certainty perspective, it's definitely better for them to have one international solution," says Voin. "The economy has changed, and the fiscal principles haven't changed." If the OECD gets its way, they soon will. ■

Working hypothesis

Sorting the week's supernovae from the absolute zeros



▲ Big explosions

Astronomers have discovered the biggest explosion we have ever seen, to the delight of pyromaniacs everywhere.

▲ Oldest man

Bob Weighton has become the world's oldest living man at the spry age of 111. Congratulations!

▲ iPhones

Hands off, bad guys! Film director Rian Johnson says Apple won't let villains be seen using its tech on screen.

▼ Heathrow

Plans to build a new runway at London's Heathrow airport have been ruled unlawful as UK politicians overlooked the Paris climate deal. Planes are bad for climate change, who knew?!

▼ Corona beer

A widely shared survey suggests people in the US won't drink Corona beer because of coronavirus concerns. But perhaps it is just that 38 per cent of people don't like the beer.



TOP: JAKEOLIMB/GETTY IMAGES; BOTTOM: CORONA

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The columnist

Graham Lawton on giving up his much-loved car **p24**

Letters

There's a very fine line between life and death **p26**

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The pink manta ray lurking in the Great Barrier Reef **p28**

Culture

The incredible superpowers of the desert ant **p30**

Culture columnist

Sally Adee delves into a sci-fi tale of a world without trees **p32**

Comment

A long overdue ban

In an attempt to stem the spread of coronavirus, China has shut its wildlife markets for good. It is a welcome move, says **Adam Vaughan**



Adam Vaughan is chief reporter at New Scientist. Follow him @adamvaughan_uk



TEAMS in China are racing to solve the mystery of which wild animal at a Wuhan food market was the source of the coronavirus that leapt into people. Snakes, pangolins or bats? We just don't know yet.

What is clear is how seriously China is now clamping down on the trade in wildlife. Last week, the country's highest authorities enacted a permanent ban. "It is forbidden to hunt, trade and transport terrestrial wild animals that grow and reproduce naturally in the wild for the purpose of food," says the new law.

My instinct was to applaud the news. For decades, campaigners have been calling for an end to

wildlife markets in China, where animals, including those that are sick or disease-laden, are kept caged, often in poor conditions and near to people. Animal welfare is reason enough to ban them. The markets were also home to the huge under-the-counter trade in illegal fare, such as shark fins.

However, there are risks that prohibiting the markets could drive the trade underground, making the situation worse.

After the outbreak of the SARS coronavirus, which also came from animals, in 2002, legal markets were suspended, but people still bought wildlife on the black market and the virus still spread, said David Heymann

at the London School of Hygiene and Tropical Medicine at a briefing last week.

Related research backs his warning. A 2018 study led by Yin Li at the China Animal Health and Epidemiology Center found that bans by Chinese authorities on live bird markets amid the 2013 bird flu outbreak led to the spread of that virus to uninfected areas.

The problem was that different provinces implemented bans at different times, meaning poultry prices would be dented in one area, motivating traders to move infected animals elsewhere. "This type of behaviour is regularly seen in many outbreaks and is also a significant problem in the

containment of African swine fever," says Chris Walzer at the Wildlife Conservation Society, a US-based charity.

Fortunately, the new ban is different. While it has loopholes (it only covers wildlife traded for food, not for medicine or research), it is immediate, permanent and China-wide. If done well, it could limit the economic incentives that have seen some partial bans fail.

Matt Lowton at the Zoological Society of London says that it may also kick-start a generational change, as children won't grow up with the wild animal trade.

The backdrop to all this is that the legal markets were never well-regulated. Richard Thomas at wildlife trade monitoring group TRAFFIC shared a photo with me of a wildlife market where civets, which helped spread SARS to humans, sit caged next to biscuits for human consumption.

Walzer says the ban, like any ban, is likely to encourage criminal activity. But any short-term local spread of viruses that results from such activity will have a small impact in the context of overall gains, he says.

And let's not forget about the big picture. Banning wildlife markets in China permanently won't end the illegal trade, but will reduce it. If done well, the ban looks like that rarest of things: a faint silver lining amid the coronavirus crisis. ■

No planet B

None for the road It has been a long time coming, but I am finally giving up my car. Though it is going to be painful, you should consider doing it too, 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

Dishoom, the cookbook: both a collection of excellent Bombay recipes and an evocative portrait of the city.

What I'm watching

The new series of the BBC's genius black comedy Inside No. 9.

What I'm working on

Secret projects...

This column appears monthly. Up next week: Annalee Newitz

LAST weekend, I said goodbye to another dear old friend. We had 12 fine years together but our relationship was becoming dysfunctional. Unwanted emissions and serious health issues were the final straw, leaving me with no choice but to make a trip to the knacker's yard.

I am now car-free for the first time in 20 years, and it feels strange. When I gave up meat, I did so mainly for environmental reasons, and I didn't miss it at all. I would like to say the same about my car, but I can't. It was first and foremost a financial decision: keeping the old banger on the road was getting too expensive.

But doing the right thing for the wrong reasons is still doing the right thing. I now have a chance to rethink how I move myself and my family around, and can try to find a more environmentally benign means of transport. However, this has turned out to be less straightforward than I had originally imagined.

Going car-free is, I suspect, a lifestyle change that many of us are going to make over the next few years, as car ownership becomes increasingly unnecessary, expensive and socially unacceptable.

Earlier this month, the UK government announced that the scheduled 2040 ban on new petrol, diesel and hybrid cars will be brought forward to 2035 or earlier, lest its net-zero target disappears in a puff of exhaust smoke – not to mention the issue of air pollution.

I was also chafing at increasingly restrictive parking and congestion charges, low-emission zones, maintenance costs, insurance premiums and vehicle taxes. All of these gradually disincentivised me from owning a car, and I suspect

the same is true for others too.

Anecdotally, the exodus is already happening. The dealer who bought my car said business was good – lots of people are offloading their vehicles and choosing not to buy a new one. On my way to the dealership, I found that my local petrol station had closed down, the third to vanish from my area in as many years. Car-sharing schemes and electric vehicle-charging points are springing up in their place.

Nonetheless, actually hitting the brakes is hard. Cars are very, very convenient. I am lucky that I live in London with its decent

“I thought I was unsentimental about the car, but when I left it in that desolate parking lot, I welled up a bit”

public transport, improving cycling infrastructure and swarms of cabs and car-share schemes. I can't imagine trying to go car-free in the countryside, or even in the northern city where I grew up.

There is also an emotional side to contend with. I am no petrolhead and thought I was unsentimental about the car, but when I left it in that desolate parking lot, I welled up a tiny bit. Remember that summer when we drove to the west coast of Ireland?

Now she is gone, I am free to see other cars. I still need to get around. But how? I already cycle to work and use public transport when appropriate. But there are some occasions when a car seems to be the only way.

I won't buy one: I have joined a car-share scheme and will use taxis more often. I will hire a car if I need to drive a long distance. But then I am still travelling in fossil-

fuelled cars. Just like when I quit meat and ended up eating more cheese, I fear I may have swapped one environmental sin for another.

I also shudder to think about the ultimate fate of my car. I have just offloaded more than a tonne of metal, plastic, rubber, fabric, electronics, grease, oil and petrol that will eventually end up in landfill. There are millions of similarly decrepit vehicles in the UK alone that will have to go somewhere.

Maybe I am overthinking it. According to Charlie Wilson, a climate scientist at the UK's Tyndall Centre for Climate Change Research, getting rid of a private car is definitely a positive step towards carbon neutrality.

He points to research by the OECD's International Transportation Forum. “They showed that moving from a private vehicle fleet to a shared vehicle fleet can dramatically cut the number of vehicles you need to deliver the mobility that we need and want. You can pretty much remove congestion at a stroke, and if that vehicle fleet is electrified, you can also reduce CO₂ emissions close to zero.” So in other words, if you are wavering over your car, go on – just get rid of it. Or maybe wait a bit longer for the policy landscape to change: reportedly, the city of Coventry will soon offer people who scrap their cars £3000 in transport vouchers.

In case you were wondering, I got £50 for mine. My wife suggested that we spend it on a tree, to atone in part for its lifetime emissions (though there was so much moss and algae growing on the bodywork that it was almost offsetting them already). OK, I said, let's take a trip down to the garden centre. Have you seen the car keys? ■

28 March 2020

INSTANT EXPERT: THE NATURE OF REALITY

Congress Hall, London

What is reality? What is it made of?
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something more? How does human
consciousness fit in – and do we actually
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Anil Seth, professor of Cognitive and
Computational Neuroscience, University
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Editor's pick

Can we model decision-making in single cells?

15 February, p 34

From Paul G. Ellis,
Chichester, West Sussex, UK

Speaking to Richard Webb, Sean Carroll wonders whether bacteria have decision-making power or agency. Arguably, the earliest known "decision-making" in the burgeoning tree of life occurs with chemotaxis: single-celled life forms propelling themselves in response to a chemical stimulus, for example towards sources of nutrients.

Webb later quotes researcher Larissa Albantakis, who argues that the apparently deliberative quality of our agency sets it apart from this: it "is not just reflexes". But bacterial chemotaxis is more than a single reflex action. It is a response to an environment that results in the selection, over alternatives, of one near-optimum direction to move in.

Information scientist Susanne Still says that agents follow rules that must fulfil certain criteria, including some element of memory storage and recall. Evolutionary processes constitute a memory function and provide this feedback, but over generations rather than within an individual cell.

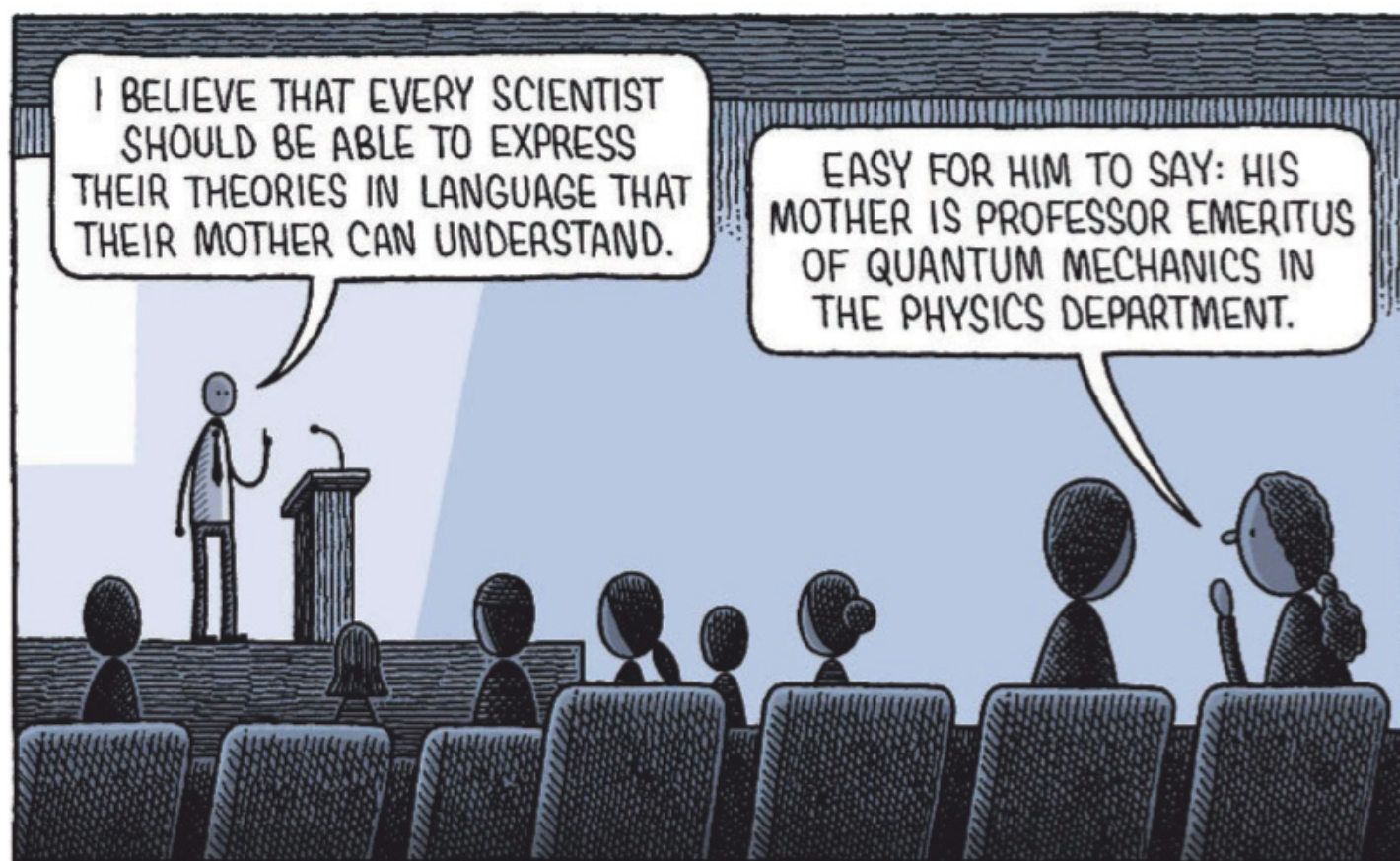
So could focusing on a primitive form of agency – the ability to select one optimal direction from many – in a system as simple as a single cell help determine whether agency can, in principle, be explained in purely physico-chemical terms?

How can evolution happen without external reality?

1 February, p 39

From Paul Mealing,
Melbourne, Australia

Your collection of articles on reality was informative. Most provocative was Alison George reporting Donald Hoffman's claim that nothing we perceive resembles reality and we are "born with a virtual reality headset on". He says evolution gave us this to simplify things so we had "what



TOM GAULD for NEW SCIENTIST

we need to play the game of life", and that what we perceive is an abstract data structure that represents something that "doesn't even exist in space and time". The implication that evolution therefore doesn't occur in space and time creates problems for me. Hoffman goes on to say that evolution has shaped us to see things that we have to take seriously, to see what we need to stay alive, but that "does not, logically, permit us to say that we're seeing the truth".

But evolution occurs by natural selection, which requires an environment for biological agents to interact with. Assuming that we are born with such a VR headset, the "data structure" it creates must surely closely resemble the external environment it interacts with in space and time – otherwise we wouldn't survive.

The importance of naming our parts correctly

11 January, p 30

From Alan Moskwa,
Adelaide, South Australia
Clare Wilson says that educating people about sexual health is

more important than policing their language to prevent them referring to the vulva as the vagina. Yet that is akin to calling the lips the throat.

Such errors can lead to serious misunderstandings. One of my patients was convinced he had rectal cancer. In reality, he had a skin cancer just outside his anus. I couldn't convince him otherwise.

Fictitious women are more equal on Wikipedia

8 February, p 46

From Krista Nelson,
Rokeby, Tasmania, Australia
I am amazed that some Wikipedia editors deem female scientists to be "not notable enough for inclusion". Many characters from anime films have their own pages, even supporting characters.

The meaning of life is simpler than it seems

Letters, 11 January

From Colin Walls,
Sidmouth, Devon, UK
People are intrigued by the Canadian frogs that freeze in winter and thaw out in summer.

Are they alive or not? It sounds like a deep philosophical question, but it isn't.

"Life" is a collective noun for things that are living. Things transition from being dead to alive all the time. Every time you breathe in, atoms that were dead are incorporated in your body and begin to live. When you breathe out, atoms that were living are sent into the atmosphere and are now dead. Life isn't a substance: it is an activity.

So are the frozen frogs active? No. Therefore they aren't living. When you thaw them out, are they active? Yes, so they are living. As every detective story teaches you, it is the time of death that is important. Whether something is alive or not can only be answered with reference to a time. This is the meaning of "life".

Don't forget the role of the body's thermostat

18 January, p 13

From Richard Burton, Glasgow, UK
Average human body temperature has fallen in the US since the 1860s, reports Michael Marshall. Julie Parsonnet, one of the team

that analysed data from more than 677,000 measurements, says the most likely explanation is that immune systems have become less active because we get fewer infections, leading to a reduction in inflammation and therefore heat production.

This seems unlikely to be the explanation. The body's heat production very much depends on physical activity, which varies enormously from moment to moment in individuals and also from person to person.

Body temperature is far steadier, being mainly controlled by the brain's hypothalamus, which acts somewhat like the thermostat of a central-heating system. The paper you report doesn't mention this.

A more likely explanation of the gradual temperature fall lies in a steady change in the average setting of the thermostat. This is raised to higher temperatures during fever.

Two further, and in some sense opposing, considerations are that ill people are often less active, which would imply that the reduction in infection means more heat production, and that work has tended to become more sedentary over the years, which implies less heat production.

This military invention is music to my ears

18 January, p 14

From Peter Asher,
Malibu, California, US

You report that arm heaters that keep hands warm without gloves are being developed by the US Army. Let me assure the researchers that there is a large non-military community to whom this invention would be of incalculable benefit: musicians.

At any outdoor gig in cool weather – or even in TV studios that keep the temperature low – one sees multiple hand-warming devices and much rubbing and blowing of hands among the band or orchestra.

I don't know of a single colleague who wouldn't welcome

the proposed arm-warming device with great enthusiasm. You quote a reduction of dexterity loss by 50 per cent and of finger-strength loss by 90 per cent in those wearing it. Whatever instrument one plays, that would make a gigantic difference to the performer and thus to the quality of the music.

Beware the consequences of these good intentions

Letters, 1 February

From John Elton, Lidingö, Sweden

Alain William proposes a unit of environmental impact, the Thunberg. Though designed to achieve desirable outcomes, this seems to have much of the charm of China's Social Credit System (17 October 2015, p 22).

Likewise, Stewart Reddaway suggests that passenger aircraft should limit the number of premium seats (also in Letters, 1 February). This measure to achieve an environmental goal could also lead us to a dystopia in which, among other things, environmental problems would be impossible to solve. In this case, ask yourself a simple question: who gets the few remaining premium seats?

Science denial tactics are on a hiding to nothing

1 February, p 11

From William Hughes-Games,
Waipara, New Zealand

Michael Marshall reports on fears that a conference on scientific reproducibility has a hidden agenda to create doubt about climate change and hence support the fossil fuel industry. If so, its organisers are fighting a rearguard action to try to delay their retreat.

Wind and solar is now less expensive than coal. Add the economic success of the Australian

mega-battery (15 July 2017, p 6), which I understand was on track to produce revenue equal to almost a third of its capital costs after a year of operation, and the writing is on the wall.

Economics is a more powerful motivator than street protests and outraged articles. The icing on the cake is that when you install a tranche of solar panels or wind turbines, it immediately goes into operation, providing revenue to fund the next installation. A coal-powered generator, in contrast, has to be completed before producing any revenue.

Do trees feed bacteria that make rain fall?

2 November 2019, p 40

From Sandy Henderson,
Dunblane, Stirling, UK

Fred Pearce says large areas of tropical forest promote more rainfall than previously thought. I recall that clouds contain tiny organisms. Trees emit complex chemicals – could these be the feedstock for aerial bacteria?

It might be that what the trees emit not only feeds such bacteria, but stimulates them to help provoke rainfall. Cloud seeding with aircraft to produce rain has had limited success, but bacteria and the trees that may feed them would have had many millions of years to improve the process. I wonder how far the links go and how sophisticated they are – and whether we can imitate the processes to relieve drought.

Papuan peoples could have sailed to Australia

25 January, p 38

From John Morris, Avoca Beach,
New South Wales, Australia

There is obviously some question about how the earliest settlers crossed seaways en route

to northern Australia. In the 1950s, I was a surveyor in Papua. Coastal peoples there made large dugout canoes and joined three of them together to form *lakatois* well before European settlement.

These canoes were dug out using stone axes and adzes. They had V-shaped sails woven from local materials. They couldn't tack, but sailed well before the wind. Crossing the Gulf of Papua with this method would have been relatively easy, provided you picked the right season.

There is no reason why people 50,000 or more years ago couldn't have built similar craft and easily travelled in a westerly direction.

We need dark matter and energy, whatever they are

Letters, 8 February

From Mike Bell,

Woolacombe, Devon, UK

Paul Leek says dark matter and dark energy are "imaginary constructs" and links them with the big bang theory.

It is my understanding that dark matter is postulated because galaxies are observed to be spinning too fast for the gravity of the observable matter, as required by Einstein's theory of general relativity, to hold galaxies together.

This has little to do with big bang theory. Galaxies do exist, so dark matter must exist, unless Einstein was wrong.

Dark energy is put forward to explain why the observed expansion of the universe is accelerating, when general relativity would expect it to be decelerating. Big bang theory is irrelevant. ■

For the record

■ The chart in the online version of our article on stress shows negative effects of stress that people experienced over their lifetimes (bit.ly/NS-stress).

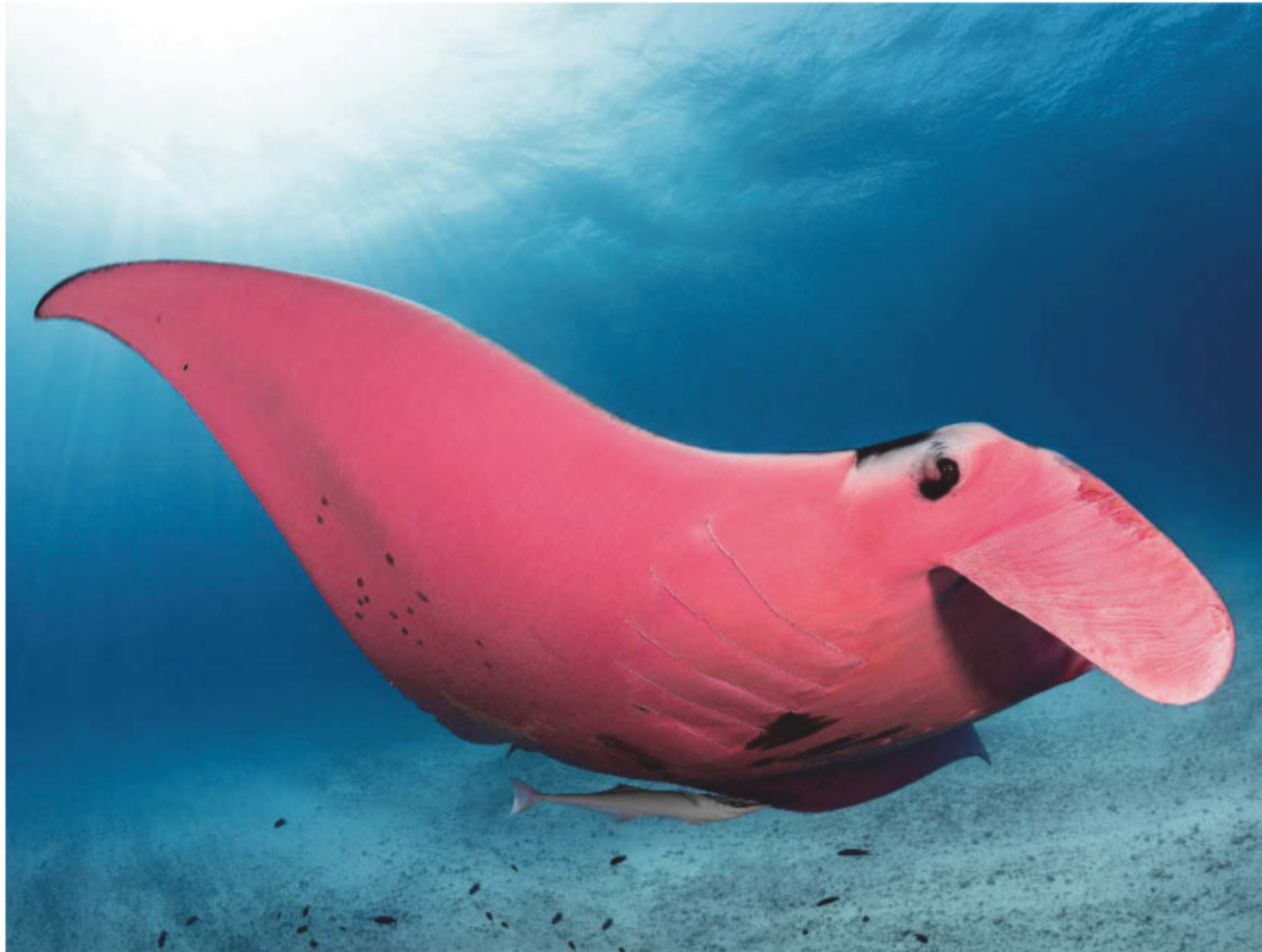
■ None of the substances found in commercial xylene is especially toxic, but they may be precursors of toxic chemicals (25 January, p 11).



Want to get in touch?

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Clouseau returns



Photographer Kristian Laine
Agency Magnus News Agency

THIS reef manta ray (*Mobula alfredi*) has stolen hearts all over the world. Seldom photographed since its discovery in 2015, the pink fish recently went viral when photographer Kristian Laine captured it swimming through the Great Barrier Reef near Lady Elliot Island, off the coast of Queensland, Australia.

Laine didn't realise at the time that he had seen the only known pink manta ray in the world, affectionately dubbed Inspector Clouseau after the protagonist of the *Pink Panther* franchise.

He told the website ScienceAlert that he had never heard of a pink manta when he first saw it, and initially thought his camera wasn't working properly. The more than 3-metre-long manta ray elicited a similar reaction when it was first photographed by Ryan Jeffrey, a regular diver off Lady Elliot Island.

Scientists aren't certain what gives Clouseau the pink hue on its underside. Project Manta, a research group at the University of Queensland, took a skin sample from the fish in 2016 and decided its colour wasn't caused by diet or infection. The most likely explanation is that its pink hue is due to a genetic mutation in a protein that expresses the pigment melanin.

Many fish have this mutation, but it usually results in albinism. Guy Stevens, CEO of conservation group Manta Trust, has speculated that Clouseau's existence suggests there may be manta rays of other unusual colours out there. ■

Jason Arunn Murugesu

This ant has superpowers

The amazing desert ant runs at breakneck speeds and uses the sun, wind and magnetic fields to navigate featureless deserts, discovers **Alun Anderson**



Book

**Desert Navigator:
The journey of an ant**
Rüdiger Wehner
Harvard University Press

“CATAGLYPHIS is only an ant, but truly what an ant,” writes Rüdiger Wehner in the prologue to *Desert Navigator*. A chapter into his new book, I also came under the spell of this long-legged “racehorse of the insect world” and the staggering navigational skills that emerge from the 500,000 neurons in its brain, which weighs less than a tenth of a milligram.

As a young biologist, Wehner fell for them when he visited a Tunisian salt pan and saw one pick up a dead insect and sprint 100 metres across the featureless desert to its inconspicuous nest hole. How did the ant know where to go? Fifty years later, thanks to Wehner, now director emeritus of the Institute of Zoology at the University of Zurich, Switzerland, and the researchers he inspired, we have many of the answers, laid out in this grand book.

As Wehner realised early on, *Cataglyphis* is a “model organism” for studying animal navigation. The ants run about on flat, open surfaces, so it is easy to track them and explore their talents. The secrets revealed in five decades of research are extraordinary.

One of the first surprises is that these ants can do what human navigators call “dead reckoning”: keeping a continuous tally of both direction and distance covered so that they can always compute the direction of home.

As their compass, the ants use

the polarisation pattern of the sky, as well as Earth’s magnetic field and the desert wind. Gauging distance is done with a “pedometer” – the ant counts its steps – and by sensing the “optic flow”, or relative motion, of the ground beneath it as it runs.

If the desert contains landmarks, such as rocks, the ants are superb at using them for navigation too. When an ant leaves the nest, Wehner describes how it faces back towards the entrance and pauses to take “snapshots” of its surroundings. Later, it compares those snapshots with the current view to spot the way home.

Wehner explains many more fascinating ant skills before he moves on to his pioneering studies on the harder question of how the ant integrates all that

information with its memory to decide where to go. This is the frontier where field studies meet computational modelling, robotics and neuroscience.

So far, research seems to settle one long-running debate: the ants don’t form a mental “map” of their

“These insects do what we call dead reckoning, tallying direction and distance so they always know the way home”

surroundings as many researchers have argued. Although they are superb navigators, they keep things simple. They never actually know where they are but only where to go. If that sounds confusing, it is a little like what

you might do on a stroll from a hotel in an unfamiliar city. You may not know where you are, but you can find your way home by remembering things like: “I turned left at a big supermarket.”

Desert Navigator is written in a concise and serious style. You will need to give time to its many explanatory diagrams, but the rewards are insights into “the process of thought that leads to the solution”, and the ingenuity of the experiments that Wehner and others have devised to work out how the ants do their thing.

For example, to show that the insects were counting steps to estimate distance, tiny stilts were glued to their legs to lengthen their stride. Sure enough, they changed their distance estimates. And to show that the ants really sense optic flow, a runway was built in the desert with a moving pattern of stripes beneath it. That, too, altered their perception of how far they had run.

You will end the book as a fan of *Cataglyphis*, for the creature is more than just a navigator. Early in life, the ants nurse the brood, then become “excavators”, and finally, after initial timid trips, they sprint off from the cool of the nest into the ferocious desert heat to forage.

Outside, their achievements are amazing. They can move fast, covering up to 110 body lengths a second; in human terms, about 600 kilometres per hour. They must dodge danger everywhere. Robber flies attack from the air, jumping spiders from the surface and tiger beetles from below ground. A forager is usually dead within five to seven days, even though the ants live for months in a lab. But food must be found. What a life and, yes, what an ant. ■

Alun Anderson is an editor emeritus of *New Scientist*



COURTESY OF RÜDIGER WEHNER

***Cataglyphis* takes “snapshots” of landmarks to help it locate its nest**

Why people try wellness

In debunking the alternative health industry, *The Dream* offers plenty of empathy for those caught up in it, finds **Wendy J. Fox**



ARTISTEER/GETTY IMAGES



Podcast

The Dream – Season 2 Jane Marie and Dann Gallucci

WELLNESS is a booming industry encompassing everything from fitness and personal care to crystals meant to interact with a person's "energy field".

Season 2 of podcast *The Dream* attempts to separate science from pseudoscience by delving into the scams, the regulation of vitamins and supplements, and why people find wellness so compelling.

Season 1 took a similar approach in addressing the predatory nature of multi-level marketing schemes.

Many of the products and services mentioned in the new season are straightforward enough to debunk. Herbal sex supplements that supposedly mimic Viagra actually have Viagra in them.

An intra-vaginal jade egg, purported to balance hormones, led to the lifestyle brand Goop being fined \$145,000 for making unsubstantiated claims. And, while taking adaptogens – herbs and other plants that theoretically adapt to the needs of the body – probably

won't do anything to harm you, there isn't much evidence to show they will help either.

As producer Jane Marie narrates with collaborator Dann Gallucci, her cynicism is palpable, even though she has tried out many wellness "treatments" for herself.

Each episode explores a different aspect of the industry, including how inaccurate claims persist in part because of a lack of oversight.

For example, in the US, although the Food and Drug Administration monitors herbs and supplements, manufacturers don't need FDA

"The shady parts of the wellness industry capitalise on our concerns about health or ageing"

approval before going to market. Marketers also don't have to explain how supplements can interfere with prescribed medications.

At times, the podcast can be a little clunky, such as when Marie says she is going to get ear seeds – seeds that are placed on specific parts of the ear, using similar principles to acupuncture –

US firms don't have to state how supplements can interfere with medications

and Gallucci responds in a very scripted way: "What are ear seeds?"

But what *The Dream* does particularly well is offer empathy. Probably most of us, at some point, have had concerns about health or ageing. The shady parts of the wellness industry capitalise on these and on a distrust of the medical establishment among people who haven't always been treated well by it.

In the opening episode, for example, Marie interviews her cousin, whose painful endometriosis was virtually ignored by doctors – which raises the question of why wouldn't someone, if their healthcare professional won't treat them with medication or another intervention, try out essential oils like Marie's cousin did? Or why wouldn't someone for whom conventional antidepressants were unsuccessful look for alternatives?

Indeed, discussion of health and wellness can be fraught with our personal opinions or biases. Marie addresses this by bringing on expert guests, including a theoretical physicist (interviewed because many wellness products use words like "quantum"), a science journalist and vitamin researcher, and an obstetrician-gynaecologist, to keep the conversation out of the realm of just anecdote.

In pushing past her own dismissiveness, Marie creates a narrative that incorporates lived experiences and actual science. It is this model of inquiry – accessible to both sceptics and believers – that keeps listeners tuning in. ■

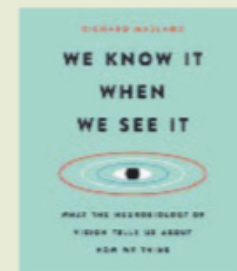
Wendy J. Fox is a writer based in Colorado. Her latest book is *If the Ice Had Held*

Don't miss



Watch

Westworld, on HBO, Sky Atlantic and Now TV from mid-March, breaks out of its blood-drenched amusement park and into a future Los Angeles for season 3, following the rebellion of some very articulate, spiritually inclined robots.



Read

We Know it When We See It (Basic Books) has Harvard neurobiologist Richard Masland – who died late last year – explaining why, of all our senses, it is vision that reveals so much about how we perceive, learn about and remember the world.



Listen

Murmurs, produced by BBC Sounds, is a series of podcast dramas about cracks in reality that exploits the weird, disembodied business of having voices come at you from out of thin air. Episode one features a time-travelling soldier.

The science fiction column

All is dust Earth's trees are dead, except for a few Douglas firs on a tiny island off Vancouver. Through their rings, we learn what happened in an unsettling epic that combines sci-fi, mystery and an exposé of capitalism, finds **Sally Adee**



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



BJORN FORENIUS/GETTY IMAGES

Greenwood Island is the last refuge after the global tree apocalypse

and Hugh C. O'Connell in an essay in *Speculative Finance/Speculative Fiction*: "It's too big to see... and it seems nearly unapproachable."

In *Greenwood*, Christie shows this playing out in individual lives and societies, revealing how we justify converting the natural world into a slag of money and profit.

The story's "rings" represent "apocalyptic" years – mostly economically induced. From 2038, the story moves to 2008, the most recent global economic crash, and then to 1974, and economic stagnation so bad few believed in recovery. Closer to the tree's centre is 1934, as the Great Depression hits Toronto. "It's as though an artillery shell has gone off, loaded not with gunpowder but with despair and squalor," thinks Everett Greenwood, the other key figure through whose life the novel's events radiate.

What stands out is how the people who lived through those years couldn't conceive of life returning to normal. In every ring, the characters face what must be the final apocalypse, in many guises and at many scales. And yet the world always survives, scarcity and plenty recorded in the rings.

Returning to the apocalypse of 2038, Jake ponders if her era will be the last. "Or have all ages believed this? That life can't possibly go on and that these are the end times? Still, things did go on. And on..."

This is hardly reassuring for those of us racked by climate anxiety. The rings of the trees are a testament to the fact that life has always continued. But in *Greenwood*'s 2038, there are few trees left to keep that record. The only real record is debt. ■



Book

Greenwood
Michael Christie
Scribe

Sally also recommends...

Book

Stolen: How to save the world from financialisation

Grace Blakeley

Crisp analysis of how we got to the current human, climactic, political and economic emergency.

Journal

Speculative Finance/Speculative Fiction

Edited by David M. Higgins and Hugh C. O'Connell

A special spring 2019 issue of CR: The New Centennial Review that discusses finance in fiction.

IT IS 2038. A creeping fungus has eaten Earth's trees. Forget ecological heartbreak: now there is nothing to stop vast dust storms scouring skin, invading lungs, asphyxiating the unprotected with a new disease called rib retch, named after the cough that snaps ribs. Unless, that is, you are one of the 0.0001 per cent in air-filtered towers, or their lucky serfs.

The collapse of ecosystems was followed by that of the global economy. Only the world's debt has survived.

Greenwood Island is the last refuge, a leafy oasis off the Vancouver coast that somehow escaped the "Great Withering". Inevitably, it is now a wellness retreat for the super-rich.

Jacinda "Jake" Greenwood was a top ecologist before the tree apocalypse. In a near-hopeless effort to repay her staggering student loan, she now works as a tour guide helping social media stars take good selfies with 1000-year-old Douglas firs. It becomes evident she might have some claim on this last sanctuary.

Thus begins Michael Christie's

Greenwood, an epic, ambitious quilt of themes, stitched together by the compelling arc of the family that may culminate with Jake. The narrative is arranged in concentric circles going back in time to evoke the rings we use to date trees. It is a clever conceit, uniting historical mystery, sci-fi and a psychological exposé of capitalism.

"In every ring, the characters face what must be the final apocalypse – and yet the world survives"

This last is a new theme in speculative fiction as writers increasingly tune into "financialisation". The term describes how finance has relentlessly insinuated itself into our lives, making debtors of us all, through student loans, mortgages, interest on credit cards or instruments even now being devised.

The threat that financialisation poses is analogous to global warming, write David M. Higgins

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LIKE the crumbling turrets of a fairy-tale castle, three spires emerge from a greenish haze, their tops spraying out blue streamers of light. Bright stars shine through the gaseous crenellations, outlines framed in stark yellow. The image in which they feature may seem like a work of pure fantasy, but this misty fortress is very real. It is an area of the Eagle Nebula called the Pillars of Creation, a massive stellar nursery 4 light years across and 7000 light years away.

It is a photograph that shows us hundreds of stars being born from clouds of dust and gas produced in the final explosions of a previous stellar generation. It certainly puts our own puny solar system into perspective. Small wonder, then, that today you can find it adorning everything from shower curtains to phone cases, astronomy's equivalent of Van Gogh's *Sunflowers*. But it prompts a vexing question. If I were to board a spaceship, and travel for long enough to be at the right spot at the right time, could I see its beauty with my own eyes?

The answer is no. With the naked eye, the technicolour majesty of the Pillars of Creation fades into an indistinct red blur. Many of our most iconic cosmological images are produced by telescopes that can capture more light than the human eye ever could, and at wavelengths that are invisible to us. Transforming the hidden wonders of the night sky into such stunning visuals isn't simple. It takes a lot of technology, a lot of time and a little creative licence.

The first problem is knowing where to look. For millennia, astronomy was purely about what we could see. First with the naked eye and then with the help of primitive telescopes, astronomers observed moons,

Capturing the beauty of the cosmos takes a little photographic sleight of hand, reveals **Leah Crane**

spotted planets and catalogued stars. These distant objects gave off light, and we were able to pick out these tiny pinpricks in the darkness. Then, in the early 20th century, we realised the darkness wasn't actually dark at all. It was awash with light, only in forms we couldn't see.

We now know that astronomical objects give off light with a vast range of wavelengths spanning the electromagnetic spectrum. Black holes burn with gamma rays, whose wavelengths are billionths of a millimetre long, while stars give off microwave radiation, whose wavelengths can stretch up to a metre. Almost of all this richness is hidden from us. Our limited eyes can see wavelengths of between about 380 and 740 nanometres, a pitifully narrow window onto the cosmos.

It isn't only our natural insensitivity to the wider spectrum that holds us back. Much of what happens in the universe takes place on timescales or at distances that eyes could never deal with, or behind clouds that visible light can't penetrate. With the help of telescopes that extend our vision deep through time and space and across many different kinds of light, we have made the invisible visible (see diagram, page 36).

The instrument that transformed how this was done was the Hubble Space Telescope. If you have ever gazed slack-jawed at a picture of deep space, chances are it was taken by Hubble. Launched in April 1990, it was perhaps the most transformative instrument astronomy had seen.

Thirty years later, it is still there. About the size of a lorry, it orbits some 540 kilometres from Earth. Four main cameras take images in ultraviolet, visible and near-infrared wavelengths, allowing us to peer at objects billions of light years away in previously unimaginable ➤

“AT THE BEGINNING, EVERY SINGLE PICTURE WE TOOK WITH HUBBLE WAS THE CLEAREST VIEW HUMANITY HAD SEEN OF THAT OBJECT TO DATE”

detail. “At the beginning, every single picture we took with Hubble was the clearest view humanity had seen of that object to date,” says Paul Scowen at Arizona State University. “So every time we took a picture with Hubble, it was jaw-dropping.”

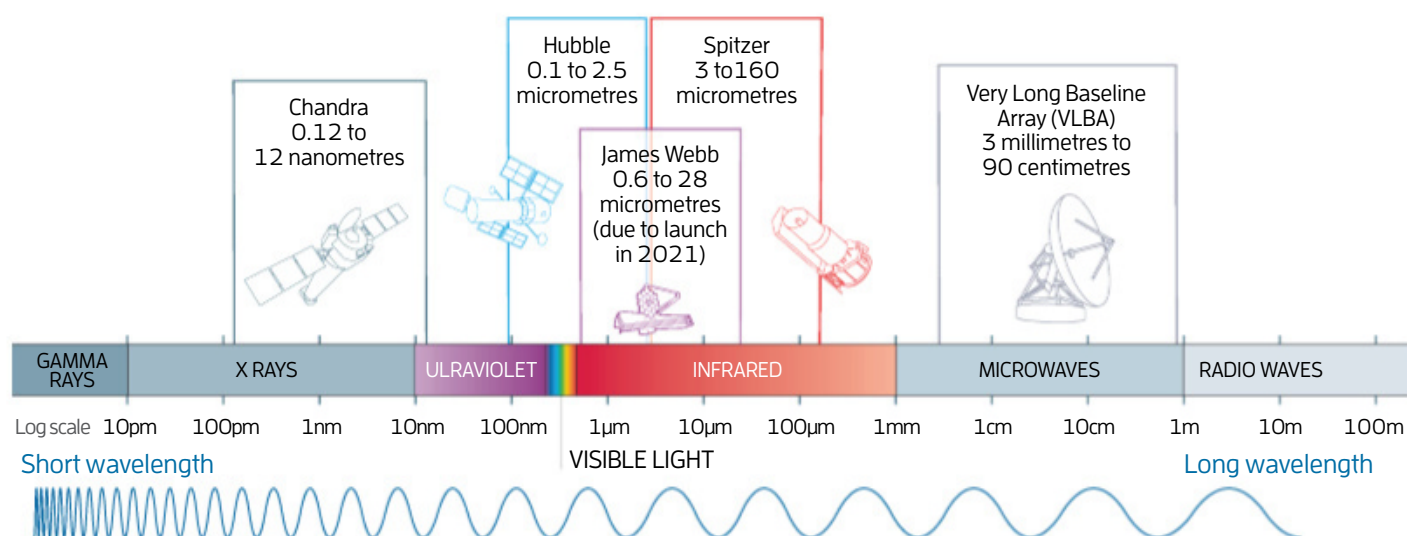
Many of its images are justly iconic – like those inset on these pages. But taking beautiful pictures was never Hubble’s core remit. Most of its images were captured to answer scientific questions. The original Pillars of Creation image, for example, was taken in 1995 to examine how newborn stars interact with their hazy environment. “The colour picture is a nice afterthought, but the science is really done on the statistics and the photon counts and intensities from the actual data,” says Lisa Frattare, who processed Hubble images for 20 years.

For one thing, all its pictures start in black and white, regardless of what colours a human eye might be able to see in the object itself. “Hubble’s cameras are black and white detectors,” says Zolt Levay, who developed some of the first programs to translate Hubble data into images while at the US Space Telescope Science Institute in Baltimore, Maryland, which manages Hubble. That isn’t an aesthetic choice. “Producing [...] colour in the detector actually increases the noise and lowers the resolution,” he says.

Astronomers can choose what filters they want to be placed in front of Hubble’s detectors before they take their images. These act like

Seeing the invisible

The ability of telescopes to see light from across the electromagnetic spectrum enables them to expand our horizons

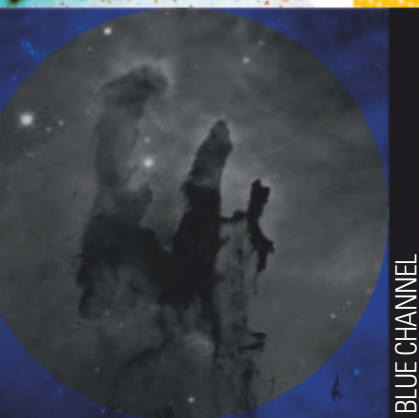




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BLUE CHANNEL



GREEN CHANNEL



RED CHANNEL

This iconic image of the Eagle Nebula was taken by the Hubble Space Telescope 20 years after first capturing it in 1995. The three visible structures are known as the Pillars of Creation, showing dust accumulating into stars 7000 light years away. Molecules of hydrogen, oxygen and sulphur are present, all of which can emit distinct wavelengths of light.

The three smaller images show the emission at three of these distinct wavelengths. It was these that Hubble actually captured, but only in black and white. To form the dramatic main picture, each of these monochrome scenes was assigned a colour to match their relative positions on the electromagnetic spectrum and then combined.

The top one shows only the light emitted by an ionised form of oxygen at a wavelength of about 502 nanometres. Because this is the shortest wavelength of the three, it was coloured blue. The middle picture shows emission from hydrogen and nitrogen atoms at a wavelength of about 657 nanometres – it was coloured green. The bottom of the three small images shows light from an ionised form of sulphur at about 673 nanometres. Being the longest of the wavelengths, this was assigned the colour red.

With the naked eye, you wouldn't see anything like the final picture. Instead, it would appear a much less interesting blurry red. That is because two of the three main wavelengths of light that it emits fall in the red part of the spectrum.

EAGLE NEBULA

NASA, ESA/HUBBLE AND
THE HUBBLE HERITAGE TEAM

stained glass, allowing only certain colours of light through. Sometimes they are fairly broad, allowing all red, green or blue light in. At other times, they are very specific, letting small sections of the spectrum pass, so that only light emitted by particular elements gets through.

Which filters you use depends on what you're trying to learn about the object. For example, if looking for young, hot stars, you might want to use a filter that captures their distinctive blue light. Or, if you want to see clouds of hydrogen gas, you would use a very narrow-band filter that lets through only the particular red wavelength of the light they emit.

That means that the people processing the image from the raw data don't usually have any choice as to what filters have been used. "Those filters don't necessarily correspond to what the colours would look like to our eye," says Levay. Because the human eye combines all the colours, we never see light one wavelength at a time. And because Hubble can see colours we can't, it might take images in a range of ultraviolet wavelengths that would be invisible to our eyes.

Generally, though, regardless of the filters, the people doing image processing use the same mapping that our eyes and brains do: visible light with the highest wavelength is red, green is in the middle and blue has the shortest wavelength. As an RGB computer screen shows, superposing images in those three colours is enough to produce any shade. That is why, after the output from each filter is coloured red, green or blue, combining them can produce a dazzling final image.

"There's this misconception that we're making things up, or we're just 'photoshopping' the image and creating data where there isn't data and assigning colours however we want to," says Joseph DePasquale, senior science visuals developer at the Space Telescope Science Institute. "But almost always, the longest wavelengths in the image are coloured red and the shortest are coloured blue. Those colours have a physical meaning."

That makes processed images easier to interpret: the areas emitting high-energy light are bluer, both in nature and in the picture. For example, in images of galaxies, star-forming regions tend to be shown in blue, whereas dusty areas are more reddish.

"You can think about a weather map on the nightly news – there's a red temperature for the hotter temperatures and blue for the cooler temperatures, and the viewer will get an immediate snapshot of what's going on," says astronomer Kim Kowal Arcand, who makes images with data from NASA's Chandra X-ray Observatory, another space telescope. "We're trying to recreate some of that with astronomical data."

In order for that cosmic weather map to mean anything, the colours have to be well separated – a temperature map where everything is in similar shades of orange doesn't convey a lot. Sometimes that means that using the light's true colour just doesn't work.

The Pillars of Creation, for example, contain molecules of hydrogen, oxygen, nitrogen and sulphur, all emitting light in the visible part of the spectrum. But these wavelengths, while distinct, are too close together for our eyes to tell apart. "If you make a colour composite image ➤

where you stick to what colour those things actually are, you get a muddy image that's mostly red," says DePasquale. "But if you take that image and change the colours a little bit you get a really beautiful image, and it also reveals a lot of information that you lose if you colour it according to the actual wavelengths."

In the pillars image, blue was assigned to oxygen, red to sulphur and green to hydrogen and nitrogen. That allows the viewer to understand the scale and depth of the towering clouds of gas and dust while drawing out scientifically interesting features that might not otherwise be visible. For example, the way that high-energy light hitting the clouds causes delicate streams of gas to evaporate at the top of the pillars.

Most of the time, colour decisions are made for the sake of science and clarity. Sometimes, though, tweaks have to be made in the name of aesthetics too. "We're trying to straddle the line and make something that's pleasing and still totally scientifically accurate," says Arcand.

She cites the example of an image of the area surrounding a black hole as it devoured the dust and gas around it. The image only had a single filter, so her team presented two versions to a focus group: one in blue, and one in red. Before they knew what the image depicted, the group liked each image equally, but once they knew that it was hot material falling into a black hole the vast majority preferred the red one – in everyday life, red means hot, so the subject of the image was more intuitive. "There are already connotations of what colour means here on Earth, so we try to keep those in mind," Arcand says.

The Event Horizon Telescope (EHT) team used a similar tenet when putting together the famous image of the black hole at the centre of the galaxy M87, the first ever direct image of a black hole's shadow. "There is nothing in our data that has to do with colour," says Michael Johnson at the Harvard-Smithsonian Center for Astrophysics in Massachusetts, who coordinated the EHT's imaging efforts. "All that we do measure is how much light is coming from each part of the image."

The image could have been green and purple instead of orange, but that version was confusing and unpleasant to look at, Johnson says. "It is kind of jarring to pick colour schemes that don't correspond to intuitive notions of heat." When straying away from a simple red-green-blue colour scheme, the most important

NASA, ESA, N. SMITH (UNIVERSITY OF ARIZONA) AND J. MORSE (BOLDLYGO INSTITUTE)



"FOR A LOT OF THESE OBJECTS,
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ETA CARINAE

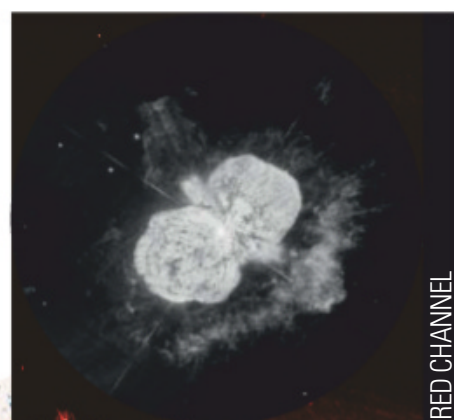
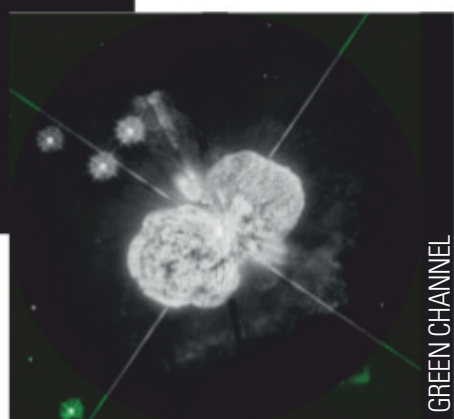
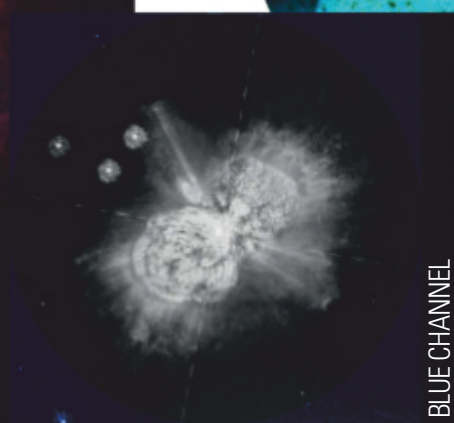
Eta Carinae, shown here in a picture from the Hubble Space Telescope, is one of the biggest stars in our galaxy. In the 1840s, it was seen erupting, blasting out what we now know are two enormous lobes of hot gas and dust. Even now, nearly two centuries later, there is still a lot of energy bouncing around, so Hubble used filters chosen for their ability to catch higher-energy ultraviolet light.

The three smaller images below

the main one show the different wavelengths of light that Hubble collected. To create the main image, these were allotted visible colours and combined. The top one used a filter to capture light from a form of magnesium emitted at a wavelength of about 280 nanometres. For image processing purposes this was coloured blue. In the middle is a filter that allowed in a wider range of ultraviolet light with slightly higher

wavelengths, which was coloured green for the combined final image. At the bottom is light from nitrogen at about 658 nanometres. This was given a red tinge.

Combining these for the dramatic final image produces a picture that allows our eyes to see what would be invisible – warm magnesium gas between Eta Carinae's bright bubbles of material and the filaments of nitrogen that surrounds them.



thing is to make sure the viewers can still tell what's going on.

After all, that is the beauty of the enormous observatories used for this type of work: they show us things in the cosmos that we could never otherwise see. "For a lot of these objects, even if you were in a spaceship going by them, you just couldn't see them because they're impossibly dim or they only emit in the infrared," says amateur image processor Judy Schmidt. "It's not fake, it's absolutely real, but your eyes can't see it."

That's especially true for pictures that incorporate data from beyond the visible spectrum of light. Many of the famous space images you might see today combine shots from Hubble and other orbiting observatories like Chandra or Spitzer. These cram as much data as possible into a single image, adding up X-ray or infrared light that we would never otherwise be able to see, or providing extra information about colour that can't be captured in a single frame.

"If you flew to the Crab Nebula and looked at it with your human eyes, it would never look as good as it does through Hubble or the other great observatories," says Arcand. "Our eyes are kind of sad and puny – our imagination and technological inventiveness go far beyond what our eyes can do."

That is true in terms of filters applied to the whole image, but also on a smaller scale. Sometimes, bringing an image to its full potential means making certain areas of the picture brighter or darker – dodging and burning, as darkroom photographers call these processes.

"By doing those local adjustments, we're actually making information visible in the data that's not otherwise visible," says Levay. "To my mind, it's a more honest representation of the data." For example, in an image of a spiral galaxy, the centre is often far brighter than the arms, so it needs to be darkened in order to show details of both in the same image.

Almost all images get some level of manipulation simply because of the mechanics of the telescope. "The universe speaks to you in whispers, but there are also these loud bits that you don't want," says Schmidt. Those bits can be cosmic rays or other charged particles, which hit the telescope's detectors and fill them with unwanted light, or satellites flying between a telescope and the target object, and they are edited out so they don't distract from the actual science.

All these adjustments turn the zeroes and ones that come down from the space telescopes into images that are legible not just to scientists and computer programs, but to anyone who looks at them. "If you think of it as a language that you can't understand, we translate it into something that we can understand and see," says DePasquale.

"I think of all this as a kind of nature photography," says Levay. "Why is it important to do this stuff? Because it shows us what the universe is." ■



Leah Crane is a space reporter at New Scientist. She tweets @downhereonearth



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Penny Sarchet

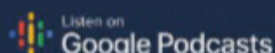
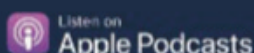


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Undercover with online extremists



Julia Ebner (pictured left) infiltrated the hidden forums where extremists hang out. Her experiences reveal how shady groups hijack social media and video games to spread hate, she tells **Helen Thomson**

ON 15 March 2019, 51 people were killed in two consecutive shootings at mosques in Christchurch, New Zealand. The first of the attacks was live-streamed on Facebook for 17 minutes. But social media wasn't only used on the day. It is thought that the accused gunman was radicalised online by far-right extremists before immersing himself in an internet subculture of white supremacist ideology. In short, his journey from personal trainer to gunman was fuelled by social media.

It is an increasingly familiar phenomenon and few people understand it better than Julia Ebner, a counter-extremism expert at the Institute for Strategic Dialogue in London, UK. Over the past decade, she has seen digital

technology transform almost every aspect of how radical groups work. She has watched extremists use digital platforms, from anonymous message board 8chan and instant messaging app Telegram to YouTube and Facebook, to disseminate their ideologies, recruit and radicalise new members, and inspire them to carry out violent attacks.

A couple of years ago, Ebner realised that the best way to understand online extremists is to infiltrate their hidden forums. She went undercover, joining dozens of groups, from white nationalists to radical misogynists, to see from the inside how they operate – and how to counter them. Ebner has documented her experiences in her book *Going Dark: The secret social lives of extremists*. ➤

Helen Thomson: How easy is it to find the hidden forums where extremist groups hang out?

Julia Ebner: It can be difficult. You might discover a link on YouTube that sends you to a fringe platform, and then another link and another. It's hard to find the newest platform that these groups are using – one will be shut down and another two created. Gab has become the most important alternative to Twitter for the far right. The platform frames itself as a free speech safe haven, so has become the go-to place for many extremists. I'd say it's a radicalisation accelerator.

Sometimes extremists might be using encrypted groups in apps like Telegram or WhatsApp, so you need the exact link to join. And then there is often a recruitment procedure involving a video interview on Skype before you can join any discussions.

How do you go about infiltrating these hidden networks?

It's a long process of building up an online persona. With the alt-right group Generation Identity, I was a member of some of their online forums and I found out about a UK branch they wanted to create. It was an interesting opportunity to see what they were planning. I reached out to their members and had to go through several stages of interviews to get into the inner circle. It was helpful to be able to name drop other members I was in touch with through different channels, so they got the feeling I was already part of the network. I learned the language they used and their insider references.

What did you hope to gain from going undercover?

I wanted to have enough information to take more proactive action to prevent attacks or interrupt intimidation campaigns, because that is what is being planned in these hidden forums. The security services are lagging behind. They are reactive in their approach. The Christchurch mosque shootings in New Zealand were a good example. I thought it was necessary to keep a closer eye on these platforms from the inside, but what's possible to do in the normal ethical framework of an academic institution is a bit tricky.

How did you get around those restrictions?

I did it outside my day job and imposed my own morals. Once inside a group, I wouldn't actively translate materials or help widen the spread of its campaigns, for instance. But sometimes I needed to use methods of deception and adopt fake identities to

“The alt-right often recruit new members by appealing to their love of online games”

get access. I usually pretended to be a naive newcomer so I didn't have to communicate any racist or extremist views and I forwarded anything important onto the security services.

Was infiltrating these groups dangerous?

The biggest fear I had throughout was people finding out my real identity or my address, because these groups know how to intimidate you and your family. It's called “doxing” and it starts with a form of crowdsourced intelligence gathering. Far-right activists are shockingly good at gathering information from different parts of the internet and putting the pieces together. Once they have enough personal information they usually decide to publish it and tag the victim in the post to intimidate them.

Did you ever find yourself being persuaded by any of these group's ideals?

When I investigated jihadism and white nationalism, I was prepared enough to understand their arguments and the radicalisation process, so it wasn't difficult to distance myself. But I was taken by surprise by the anti-feminist groups I infiltrated. I made the mistake of spending a lot of time with “Traditional Wives” while I was in a weak position, going through a relationship crisis of my own. For the first time I could feel myself being drawn in. The people in these groups were touching on topics that I could identify with, they were more relevant to me. They weren't talking about racism or discrimination, but the challenges of being a woman in the modern world. It showed me how anyone could be drawn into extremist movements if it happens at the right time.

At one point in your new book, you show how one guy used Facebook, YouTube and Telegram to orchestrate a (foiled) attack in Singapore from thousands of kilometres away. But hasn't online



communication in some ways also made it easier to track and stop extremists?

It's something that the extremists themselves discuss a lot. They need to be found in order to recruit new members, but they also need to hide from activists and authorities. Extremists use lots of different channels, which makes them hard to track. Sometimes they use existing platforms, sometimes they build their own. They have this whole digital ecosystem, which has revolutionised the ways they can communicate, build alternative news, share conspiracy theories and plan activities.

In the early 2000s, there were online forums that jihadists and white supremacists made use of and that could be monitored, but now this cross-platform approach has made it easier for extremist groups to go below the radar of the security services.

Aside from techniques to avoid authorities, what did you learn about how extremists work?

My time in the networks that radicalised the Christchurch suspect taught me about the importance of community, belonging and subculture as motivators and drivers of radicalisation – even in online spaces. A blend of hate speech, pop culture and dark satire



White nationalists create strong bonds online

NURPHOTO/PA IMAGES

marks these far-right virtual networks, which allows for a very subtle indoctrination and radicalisation. While most of the network's users would never meet in real life, they create strong bonds based on their own invented vocabulary, symbols and insider jokes. It was also shocking to see how easily the line between what's a game and what's real gets blurred. They use gamification a lot.

What is gamification and how is it used by extremists?

The alt-right realised they could recruit new members by appealing to their love of online

games. They would use recruiting procedures that had video game elements, so you can climb up the ranking in a group by getting points when you do a particularly good job, like launching a hate campaign, leading a trolling army online or creating a viral tweet. Some people join just because they are interested in the gaming dimension of it and through that they are introduced to these extreme ideologies. I saw very young people becoming members of extremist groups in this way. Groups also produce modifications of existing computer games, where you can switch sides and play for the Nazis, for instance, or that allow a person to shoot only Muslim characters.

Why can't we just shut down all these groups as soon as we know they exist?

The whole digital sphere is so splintered, with so many subcultures that are so diverse, that there's not one approach for all. Some groups are really violent and need to be reported so that their online platforms can be removed. But there is a grey zone where extremists operate on the legal borders of what's acceptable communication and behaviour, and there we need a more nuanced approach.

“Anyone could be drawn into extremist movements if it happens at the right time”

For example, extremists usually know the violence incitement and anti-hate speech laws in their countries fairly well and try to circumvent them by using twisted extremist symbols or camouflaging violent messages behind satirical visuals. They also know that the police tend to only investigate concrete threats, not abstract ones. Extremists might write “About time someone shoots this traitor” or “I'd love to see your head hanging from a tree” instead of “I'll shoot her” or “I'll cut off your head”.

It's also difficult because of varying laws in different countries. For instance, if the UK bans a group, Twitter must block its content in the UK, but it is still accessible from other countries. So British people could use a virtual private network (VPN) to access it and circumvent these laws. There's a big need for international cooperation in the digital sphere.

What can we do to combat extremist groups online, then?

The most important thing is to make sure that platforms don't amplify content that is extreme, that produces fear or anger or that triggers the most extreme comments, which is what they do right now.

The algorithms of most online platforms are designed to maximise the time users spend there, so most business models boil down to an endless competition for human attention. This means that content which captures our attention is amplified and usually this happens to be the most extreme, most emotive or most violent posts and videos. Extremists therefore have an inherent advantage when they try to spread content that instils fear, generates anger or incites violence. Experimenting with a neutral account on YouTube demonstrates this: one is very likely to end up in an extremist echo chamber after 24 hours. If one starts with a video on jogging this might just mean finding oneself with videos on extreme sports. But for political or patriotic videos it might well be violent white supremacy.

It's a business model that distorts public perception. It gives small groups this megaphone and amplifies these really fringe views. These companies need a lot more pressure to change, because they won't do it proactively. ■



Helen Thomson is a consultant for *New Scientist* and author of *Unthinkable: An extraordinary journey through the world's strangest brains*

An evolution in cancer treatment

Rapid adaptation has helped cancer resist our best treatments. Now it may be the key to toppling the disease. **Clare Wilson** reports

SHE doesn't dwell on it, but 82-year-old Lydia Knott knows what will happen to her after death. Her body will be taken to a laboratory for an unusual post-mortem.

It won't be to find the cause of her demise. Knott was diagnosed with lung cancer five years ago. After surgery to remove part of her lung, she is now doing well: "Fine for an 82-year-old, I can't complain." But if the disease returns and kills her, Knott wants doctors to learn more about her cancer through a "warm autopsy", so-called because it happens soon after someone dies.

Within 24 hours, a team would remove up to 80 tissue samples and preserve them using liquid nitrogen. One of the aims is to fathom cancer's surprising ability to evolve. The same forces that shape the tree of life also drive tumours to spawn and spread, generating a vast genetic diversity of cancer cells within a single person.

Now, thanks to recent leaps in genetic sequencing, the hope is that we can trace a cancer's evolutionary journey and create powerful treatments using this information. "We may actually have the technology to cure many cancers – we just haven't been using the right strategy," says Robert Gatenby at the Moffitt Cancer Center in Tampa, Florida.

We might even be able to stop tumours developing in the first place, but it won't be

easy. "We are battling natural selection, one of the fundamental laws of the universe," says Charles Swanton at the Francis Crick Institute in London, co-leader of the study that Knott has signed up to. "But I think this is our best shot."

A step ahead

We have known since the 1970s that tumours arise when a mutation occurs in one of the genes within a cell that control its reproduction. Our cells are continually replicating themselves – even in healthy tissues – by growing and splitting in two, to replenish those that have worn out.

This process is controlled by hundreds of genes so that cells divide at the right place and time. If a cell has a mutation in one of these genes – perhaps through exposure to cigarette smoke or ultraviolet rays or just bad luck – it may start multiplying faster, its progeny outcompeting healthy cells.

Even if the immune system attacks these cancer cells, their ability to evolve may thwart our body's attempt to destroy them. There are parallels between the way predators shape the evolution of prey populations and how immune system cells kill the most vulnerable tumour cells, says Mel Greaves at the Institute of Cancer Research in London. Cancer cells that

evolve immune system resistance can thrive. "It's survival of the fittest. It's not happening in a jungle or a pond – it's a prostate or a breast. But it's a Darwinian process."

This knowledge hasn't yet influenced the mostly crude and brutal way we treat cancer, which is sometimes described as slash, burn and poison, referring to surgery, radiotherapy and chemotherapy. These approaches can work if the cancer is caught early enough, which generally means before it has spread. But chemotherapy and radiotherapy work by killing all quickly dividing cells, which means they also damage the skin, gut and immune system, causing side effects such as hair loss, sickness and vulnerability to infections.

More recently, targeted therapies have been touted as the next big thing. These work by blocking molecules on cancer cells that are specific to them, so tend to have fewer side effects on healthy tissue. This requires testing someone's cancer to identify the mutations involved, so is painted as the ultimate in personalised medicine.

We often see media coverage when one of these new treatments reaches the clinic, but the reality is they usually extend people's lives by only a few months. That is because their developers failed to consider cancer evolution, says Swanton. A targeted treatment kills all cancer cells that carry a certain molecule – but any that don't have that molecule survive. It therefore "selects for" growth of cells that are resistant to it, so within a few months, tumour cells without that molecule are more numerous, and the treatment no longer works. The cancer has developed drug resistance.

Doctors have long been aware that targeted therapies don't usually extend people's lives for long, but it is only recently that we have been able to genetically chart how resistance ►



evolves. In a 2012 study, Swanton's team sequenced multiple samples from four people's kidney cancers, and found the cells diverged over time – the way different animal species branched off from each other over millions of years. "It's not linear evolution, it's branching evolution," says Swanton.

Within each person, two-thirds of the mutations weren't shared across all their tumour cells. This showed that it could be misleading to take one small sample from a cancer to predict which targeted therapy to use. "Depending on where you put your biopsy needle, you're going to get different results," says Swanton.

Since then, several other studies have launched with the goal of drawing up detailed evolutionary trees for individual cancers, exploiting our new DNA sequencing capacity. The largest is the one that has recruited Knott. However, the only way to get enough tumour samples from each person is to collect them after death, otherwise it would be too destructive, says Mariam Jamal-Hanjani at the Francis Crick Institute, who co-leads the study along with Swanton.

The team is working with hospitals around the UK to find 500 people with many different types of cancer. While some doctors are hesitant, says Jamal-Hanjani, "almost always, these patients are incredibly willing to donate their bodies knowing it will benefit others". As Knott says: "I want to help other people and it seemed to be a logical next step. And when you're gone, you're gone."

The 2012 kidney cancer paper was seen as bad news for targeted therapies, but it also showed that within each person, about a third of the mutations were present in all the tumour samples they took. These mutations must have arisen when the tumour was small, before its cells had diverged much, and are sometimes called "trunk mutations", meaning they are in the stem of the evolutionary tree, not its branches. Any therapies targeting trunk mutations should in theory kill all cancer cells and so be less likely to trigger resistance.

Swanton thinks that the best way of doing this is by weaponising the patient's immune system. People with cancer usually have some immune cells active against their tumour – but most target branch mutations. If someone's immune cells could be directed at their trunk mutations, this could be enough to get rid of all the malignant cells from their body.

Swanton has co-founded a firm called Achilles Therapeutics, which is due to start two small trials of this strategy this year in lung and skin cancer. When people have their tumour

"Targeting certain tumour mutations should in theory kill all cancer cells"

New therapies will help immune system T-cells better target tumours

cut out, the firm will sequence many of its cells to identify the trunk mutations. Researchers will also extract immune cells from within the tumour and select those that target these mutations. The firm will then multiply the immune cells in the lab, so that many can be injected back into the patient.

Great adaptations

Achilles is by no means the first to try to exploit people's immune response against their cancer. The idea has a long history and has been recently turned into a treatment called CAR-T therapy for leukaemia and lymphoma, cancers that occur when blood cells turn malignant. Using this approach against solid tumours has proved more difficult, though. Several groups have tried and failed at this – although so far none has tried genetically identifying trunk mutations as Achilles is doing, says Swanton.

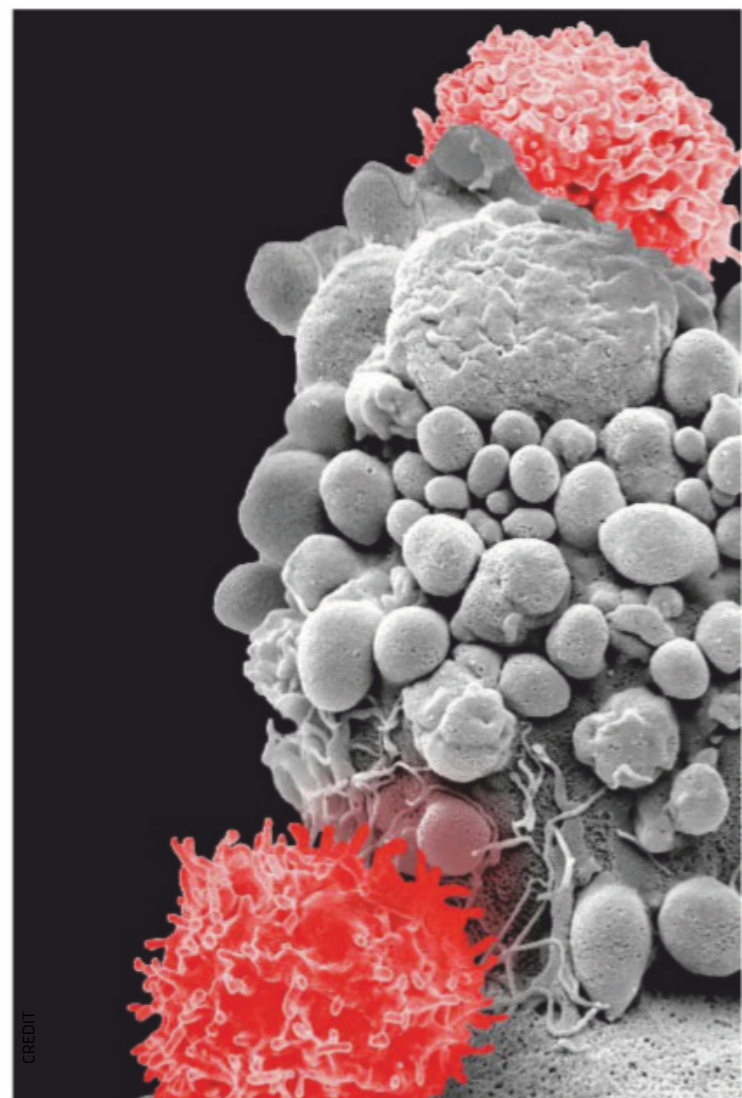
Whether or not this approach works, a focus on evolution may lead to other treatment avenues, such as tweaking the way we use existing anti-cancer drugs. Gatenby sees parallels between the evolution of drug resistance in cancer cells and that of pesticide

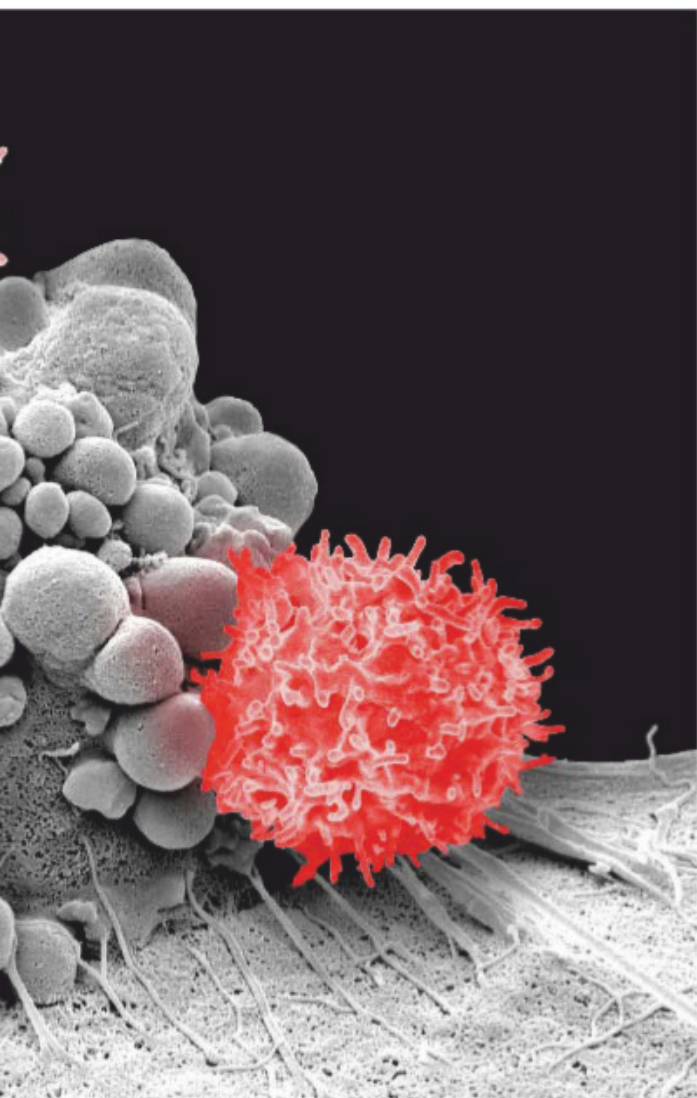
resistance in insects. "They learned 50 years ago you can't eradicate with huge doses of pesticide – all you do is you get resistance." Treating intermittently is a better approach, and might work on cancers too, he says. "If you treat a little bit then take it away, the tumour will regrow over months or years. But when it comes back, there has been no selection for resistance."

Gatenby's institute recently found encouraging signs from an initial small test of this strategy in prostate cancer. Researchers there have now started or are planning five larger trials to put this "adaptive therapy" to a more rigorous test, by comparing it with standard treatment in prostate cancer and three other types of tumours.

In a related tactic, another team at the Moffitt Cancer Center plans to tackle a rare and aggressive form of muscle cancer by switching from one drug to a second one rather than using a single drug intermittently.

The current approach for this is to give a certain drug combination for 10 months and then wait for the cancer to recur with drug-resistant cells, which it nearly always does. At that stage, people are given a second therapy. The new idea is to give the first therapy for just





STEVE GSCHEISSNER/SCIENCE PHOTO LIBRARY

“There may be a better way to tell if people have aggressive or slow-growing cancers”

three months and then immediately switch to the second. The rationale is that a small number of resistant cells must have been there all along, says oncologist Damon Reed, who is planning the trial. Hitting hard and fast with the second therapy could have more chance of killing all the cells.

“The idea is there’s a moment when you can more likely induce an extinction,” says Reed. When the number of cells sensitive to the second therapy are as low as possible, “that’s your chance to do this”.

Better than improving treatments for cancer would be stopping it arising in the first place. This goal is being explored for people who are at higher risk of certain tumours, again using evolutionary principles. One such group is people with Barrett’s oesophagus, a condition in which the tube going from the mouth to the stomach becomes inflamed by leaking stomach acid, making them prone to cancer of the oesophagus. Those affected have a check-up every few years with a camera put down the throat and regular tissue samples taken to try to spot tumours early. But the best time to intervene is unclear. Doctors don’t want to cut out any of the oesophagus unnecessarily and some people end up getting cancer despite the screening. Perhaps we can be more accurate by considering evolution, says Trevor Graham at the Barts Cancer Institute in London.

Evolutionary theory says that, all else being equal, animal or plant species that are more genetically variable are more likely to branch into multiple new species under some new selective pressure, like a change in climate. In the same way, a genetically diverse group of cells in the oesophagus may be more likely to harbour one that can turn cancerous; the new selective pressure in this case could be a change in lifestyle, like starting smoking.

Graham’s team put this idea to the test by sequencing the DNA of cells taken from routine biopsies of 320 people with Barrett’s oesophagus. Twenty ended up developing cancer and those who initially had more genetically diverse cells in their oesophagus were more likely to eventually get a tumour.

That means that offering this sequencing to everyone with the condition might let us decide whether people are at high risk – and could have check-ups every few months instead of years – or low risk. “If someone’s at very high risk we can keep a close eye on them, but the real win is to send people home and tell them not to worry,” says Graham.

His team has now done the same study in people with an inflammatory bowel condition

called ulcerative colitis, which puts them at higher risk of bowel cancer and is also monitored with regular biopsies. The results, Graham says, aren’t yet published but are similar. This same thing may also be the case for other types of cancer, such as breast and prostate, says Greaves. In both these tumour types, we often take biopsies from small lumps found through screening tests and don’t know if they are aggressive cancers that must be cut out straight away or slow-growers suitable for watchful waiting, sometimes characterised as “tigers” and “pussycats”.

Give us a steer

For decades, scientists have been trying to develop a test for biopsies to tell us which kind of cancer someone has. Efforts have focused on which mutations are present but that hasn’t led to a useful test so far. We could make more progress by measuring the cells’ “evolvability”, says Greaves. That could be influenced by their genetic diversity, the mutation rate or other factors yet to be discovered.

This is one of many evolution-based research programmes planned by the Institute of Cancer Research. Other avenues will include developing medicines that slow down evolution, by reducing the mutation rate, and a technique known as “evolutionary steering”. This is still a theoretical concept, one that designs drugs in such a way that cells can only develop resistance to them by mutating in ways that make them susceptible to other treatments. “We want to assess candidate drugs by assessing not their ability to kill cells in a dish, but their ability to restrain evolution,” says Greaves.

In the US, the National Cancer Institute began a major new programme focusing on evolution in 2018, setting up the Arizona Cancer Evolution Center. Initiatives such as these will take many years to bear fruit, but for Greaves, it is the only logical way to tackle this most fearsome of diseases.

“For decades, we’ve been getting new drugs by testing them on cells in tissue culture and it’s not good enough. Every new drug sounds great, but you still encourage resistance,” he says. “We need to change track so we see this as an evolutionary problem. Then, we can try to find an evolutionary solution.” ■



Clare Wilson
(@ClareWilsonMed) is a
staff writer at New Scientist

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**Leah
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Almost the last word

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Siena Castellon, neurodiversity advocate **p56**



Science of cooking **Week 10**

Rise to the occasion

Make bread as humans have done throughout history by harnessing wild yeasts and bacteria, says **Sam Wong**



Sam Wong is social media editor at New Scientist. Follow him @samwong1

What you need

White and wholemeal flour
Water
Salt
Glass jar with lid
Casserole pot

For next week

Garlic
Lemon
Oil
Salt

Next week

Garlic: understand the chemistry of its flavour to amplify or tame it

IF YOU buy yeast, you get one species: *Saccharomyces cerevisiae*, a reliable and predictable bread-maker. But for most of history, humans have used a living culture of wild yeasts and bacteria to produce bread.

We call this bread sourdough, and the culture a starter. You could get an established starter from someone else, but it is very easy to make your own. All you have to do is create an environment where wild yeasts want to grow.

Some of the microbes you need will be in the flour already. Others, particularly bacteria, may come from you. In a recent study, researchers sent the same flour and starter recipe to 18 different bakers. They found huge variety in the microbes in the resulting starters, and this was reflected in the flavour of the bread.

To make yours, mix 50 grams of wholemeal flour and 50 millilitres of water in a jar, then cover it with a loose lid and leave it in a warm place. Bubbles should appear after a few days, meaning your starter is active. If nothing is happening, throw away half of the mix and replace it with fresh flour and water. This is called feeding the starter. Once your starter is active, feed it like this every day for at least a week before baking with it.

The sourness in sourdough comes from lactic acid-producing bacteria, the same group that we recruited last week to make kimchi. The acid keeps unwanted microbes away, but *Candida milleri* and other yeast species don't mind it. Don't be alarmed if, at



JAMES WINSPEAR

Science of cooking online

All projects are posted at [newscientist.com/cooking](https://www.newscientist.com/cooking) Email: cooking@newscientist.com

some point, the starter smells of nail polish remover. The bacteria sometimes produce acetone, but this won't end up in your bread.

The night before baking, take 50g of starter and whisk it into 350ml of water. Measure 500g of strong bread flour – I like to use half white and half wholemeal – add 9g of salt, then mix in the diluted starter. Leave this for half an hour until it is less sticky, then shape it roughly into a ball. Cover with plastic and leave it in a cool place overnight, as you want the fermentation to proceed slowly.

By morning, the dough should have expanded. If you poke it, it should spring back partially, but an imprint will remain. Now shape the loaf – this can be tricky so you

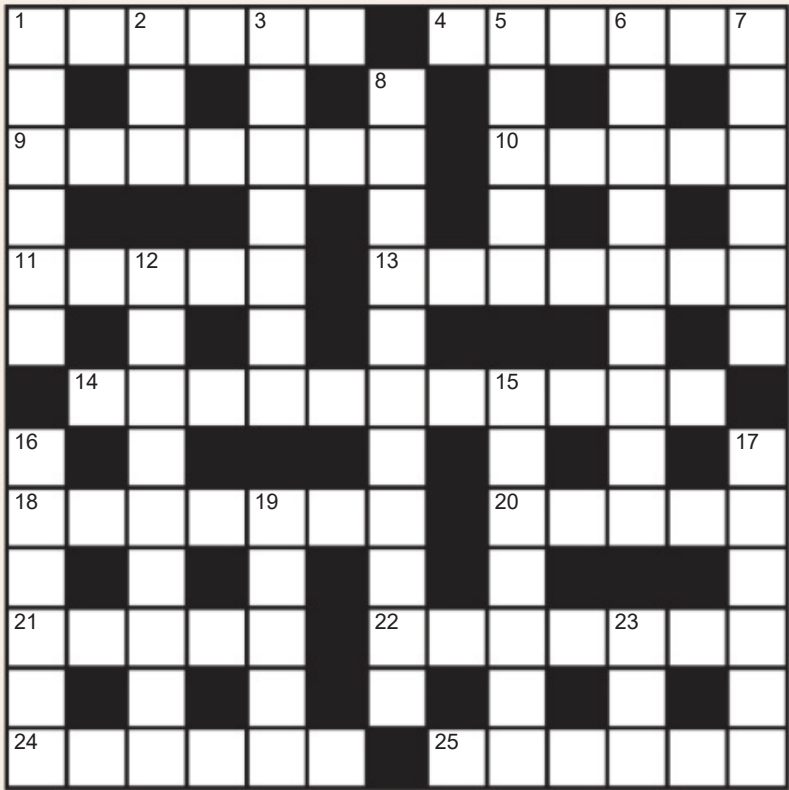
might want to look for tips online – or put it in a tin, then leave it to prove for another hour or two.

Preheat the oven to 230°C with a lidded casserole pot inside. Baking inside a pot traps steam, which delays crust formation and lets the bread expand more. Alternatively, bake it on a flat tray with a bowl of hot water on the shelf below.

When the loaf is proved, lower it carefully into the pot and slash the top with a knife to help the dough expand. Bake for 20 minutes with the lid on, then 30 more with it off.

Keep your starter in the fridge and feed it once a week when you aren't baking. Take it out a day before you want to bake and give it a feed. You can keep doing this indefinitely. ■

Cryptic crossword #26 Set by Wingding



- ACROSS**
- 1** I made a mistake putting health agency before surgical procedures (6)
4 Me, the best looking? That's what's reported in questionnaire (2,4)
9 Ungulate expert having a look (7)
10 Jelly-like image (5)
11 Plants putting gallium in drink (5)
13 Take ore liberally, a source of building material (3,4)
14 Cutting ends, vaguely injure circulatory vessel (7,4)
18 Turning over, I sleep with German drums (7)
20 Energy getting into French city is relative (5)
21 It helps to hear security number not applicable (5)
22 Awake a lot, puts on a cloud? (7)
24 Fake tigers at zoo's centre (6)
25 Holiday without Virginia - that's positive (6)
- DOWN**
- 1** Trap next to river that feeds a stream? (6)
2/17 Less busy time for fans of SEO, strangely (3,6)
3 Plain sheet of gold (7)
5 Cheese particle (5)
6 Knowledge of old sprite, addled by drug (9)
7 News provider you can't live without? (6)
8 Horrible carnivorous disease (1,1)
12 Starters of green onion, udon and rice from upmarket food store - who shops there? (9)
15 Pod and half of bean inside house (7)
16 Small movement reported on grassland (6)
17 See 2
19 Perhaps Lovelace starts physical training to get fitter (5)
23 African country removing leader, a fighter (3)

Answers and the next quick crossword next week.

Quick quiz #41

- 1** What is the heaviest living reptile?
2 Physicists give what name to hypothetical theories that explain all the fundamental forces except gravity - that is, the strong and weak nuclear forces and electromagnetism?
3 Which data storage medium is read using laser light with a wavelength of 405 nanometres emitted by gallium nitride diodes?
4 The maxilla - where do you find it?
5 What name is given to latitudes between about 30 and 35 degrees north and south of the equator, known for their equable, if not equine, temperament?

Answers below

Quick Crossword #52 Answers

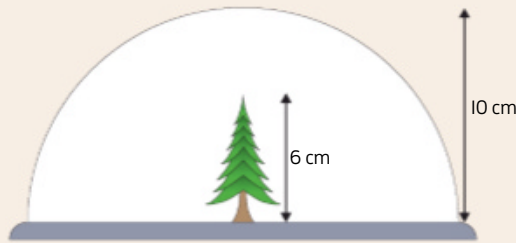
- ACROSS 1** Coccus, **5** Pnictide, **9** Nagasaki, **10** Fibula, **11** Shooting star, **13** Talc, **14** Bat bombs, **17** Scalable, **18** Okra, **20** Capricorn One, **23** Diodes, **24** Acidosis, **25** Decimals, **26** Eyelid
DOWN 2 Oval, **3** Classical, **4** Shadow, **5** Printable organs, **6** Infinity, **7** Tubes, **8** Dollarbird, **12** Saccharide, **15** Ozone hole, **16** Abscissa, **19** Cosine, **21** Radii, **22** Kiwi

Quick quiz #41 Answers

- 1** The saltwater crocodile
2 Grand Unified Theories, or GUTs
3 Blu-ray Discs, the "blu" referring to the (really) rather violet) colour of the laser light
4 In your face. It is the static upper jaw bone - the mandible is the movable lower one
5 Horse latitudes. They are subtropical regions of generally low wind and precipitation

Puzzle set by Catriona Shearer

#49 The tree in the snow globe



I have a snow globe that is a hollow hemisphere. At its highest point, it is 10 centimetres tall, and in the centre stands a tree that is 6 cm tall. How far away from the centre can the tree be moved and still stand upright?

Answer next week

#48 Seeing red Solution

If I see a green traffic light, I should ease off as I will miss the light. If I see a red light, I should accelerate. The actual speed/distance doesn't affect the answer, but suppose I am riding at 4 metres per second. The lights are then 60 metres away when I first see them.

If they are green, then I can speed up by at most 25 per cent to 5 m/s, but there is really no point - I will certainly miss the green light by at least 10 metres. That's life, so there is no point in getting upset.

If they are red, then the best strategy is to go at 5 m/s for just 4 seconds. That way I will be 40 metres away, close enough for when the lights change to green. If the lights change during those 4 seconds when I have bothered to speed up, then I will be "really upset" because I am still too far away. The total lights sequence takes 100 seconds, so on average, that is going to happen on 4 per cent of my journeys.

Our crosswords are now solvable online
Available at
newscientist.com/crosswords

It takes all sorts

There are three types of people in this world: those who believe that the full spectrum of human variety can be reduced to a few discrete personality types, those who don't, and Capricorns.

OK, maybe not, but we are all, to one extent or another, suckers for the idea of personality types. Maybe your preference is for the Western zodiac, which unerringly distinguishes between Leos, who are outwardly bashful but have a strong personality yearning to break free, and Geminis, who have a strong outer personality but an inner bashfulness yearning to go back inside.

Or perhaps you favour the Myers-Briggs test, which divides respondents into one of 16 subcategories based on their extroversion, intuition, feeling and perception. Some employers prefer a streamlined version of this test, which simply divides people into two camps: those willing to subject themselves to it, and those happy to seek employment elsewhere.

However, the most popular classification mechanism of recent years has surely got to be the four Hogwarts houses in J.K. Rowling's Harry Potter universe: Slytherin (interesting but evil), Gryffindor (dull but brave), Ravenclaw (intelligent but dull) and Hufflepuff (dull and not terribly intelligent nor brave but at least not evil).

Interested in getting a sense of the personality types drawn to different medical specialities, two US doctors sent a questionnaire to 251 of their colleagues asking them which Hogwarts house they felt best reflects their identity.

To a large extent, the results were unsurprising. Surgical specialities had more self-regarding, contrarian Slytherins, while general surgery was bursting with heroic Gryffindors. Paediatrics was stuffed with patient and unobtrusive Hufflepuffs, and obstetrics and gynaecology was full of brainy, self-proclaimed Ravenclaws.

Charming research of which

even Professor Filius Flitwick would be proud.

Now, the next time you have a medical appointment, you know what to ask your doctor: are you one of those who wasted time filling in the Harry Potter survey, or can I actually trust you to take out my spleen?

Plane speaking

Big news, weight-watchers: Feedback has decided to go on a diet. From this day forward, we pledge to keep an eagle eye on the calories we consume, and to work rigorously towards reducing them to net zero. Outside of meal times, and perhaps barring the occasional palate-cleansing snack, we will aim to be completely calorie neutral.

We know this represents a dramatic undertaking, but it is one we feel is long overdue. It will, of course, involve much sacrifice, but the time for action is now.

We were inspired in this pledge by London's Heathrow airport, which has announced it is carbon neutral in its emissions. There was, however, one small caveat. According to *Sky News*, it has achieved carbon neutrality "only from the parts of the airport it runs and not including flights".

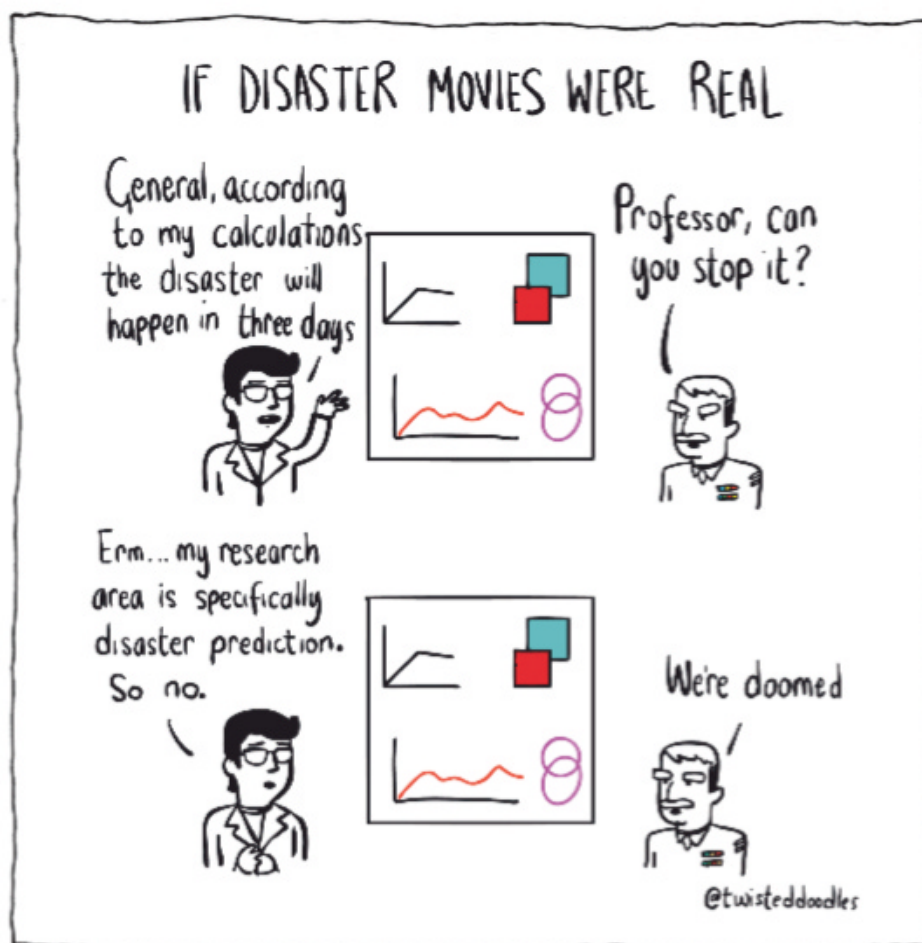
Some might say that for an airport to claim to be carbon neutral without including the impact of flights would be akin to someone going on a diet and not including the calorie count of their food intake.

That sounds exactly right to us. So much simpler and more reasonable. So much less fuss! If you would like to join us as we undertake the Heathrow diet, then do please keep us apprised of your progress.

Unhumble pie

Top of the list of diet dishes for Feedback to try is one on the menu at Champneys, a UK spa and wellness chain favoured by the stars. The health resorts have welcomed everyone from Posh

Twisteddoodles for New Scientist



to Becks through their lavish doors, but what keeps them coming back?

Could it be that the menu includes an apple crumble so delicious it has health-boosting effects to rival even the most indulgent pampering? According to *The Times*, the spa chain allegedly told guests that the crumble "may help reduce the risk of cancer, cardiovascular disease and diabetes". Not since Steve Jobs revealed the iPod has an apple product shown so much promise.

Feedback suspects the word "may" is doing a lot of heavy lifting. For fans of logical reasoning, the proposition is of course true. The crumble may have extraordinary health benefits. Just as Feedback's true identity may be that of an intelligent and overachieving octopus kept in an ornate tank at New Scientist HQ with access to a typewriter, an encyclopaedia, the day's papers and a constant

supply of artisanal coffee to help it churn out witticisms with just the right level of snark to be acceptable to its overbearing editor. Then again it may not.

Call a spade

Feedback knows to give the people what they want. Nominative determinism has made up the majority of the emails in our inbox in recent times, and as an astute reader of public sentiment, we are, once again, ready to provide you with highlights of the genre.

Just one this week, though, and that is because if one more person emails us to point out that the CEO of a human composting service is called Katrina Spade, we will arrange for an immediate introduction between the two of you. ■



Got a story for Feedback?

Send it to New Scientist, 25 Bedford Street, London WC2E 9ES or you can email us at feedback@newscientist.com

Atomic space

A hydrogen atom consists of a proton with an electron whizzing around it. What is in the space between them, and what happens to the space when the atom loses its electron?

Richard Swift

Darmstadt, Germany

Thinking of an atom as a nucleus with electrons circling it and empty space in between, like a mini solar system, is a useful analogy, but it isn't a true picture. Humans sense material objects in terms of solid particles or waves, so we apply this same imagery to the microworld of atoms. This solar system viewpoint has been replaced by quantum descriptions that produce predictions verified by experiments. These depict a hydrogen atom's electron as occupying one of several discrete energy levels, but with a position that is never well defined.

Quantum physics sees the space within the atom not as empty, but as a vacuum fluctuating in energy, represented by the continuous creation and destruction of virtual particle-antiparticle pairs. In a hydrogen atom, the binding of the proton and electron by an electromagnetic field can be viewed as consisting of additional quantum particles – photons – occupying the space in between.

In truth, the reality of the atomic world is something we will probably never comprehend fully. Richard Feynman supposedly said: "If you think you understand quantum mechanics, you don't." To adapt another quote, ascribed to both Arthur Eddington and J. B. S. Haldane, the atomic world isn't only stranger than we imagine, it is stranger than we can imagine.

David Muir

Edinburgh, UK

It is more accurate to imagine the electron as a fog where an electron is more likely to be found, rather than a particle. The fog is less dense in some



CAVAN IMAGES/GETTY IMAGES

This week's new questions

Running while cycling Why is it that whenever I go out on my bike in cold weather, my nose starts to run? Is there an evolutionary advantage? **James Fradgley**, Wimborne Minster, Dorset, UK

Broadly speaking How do we know the universe is expanding? Why can't there be an alternative explanation, say that all atoms are shrinking? **Alexander Cowie**, Oxford, UK

places, like next to the nucleus, and more dense in areas with higher probability of finding an electron.

When an atom loses an electron, the quantum "wave function" describing the electron changes so that it has a lower probability of being where it was, but there is a chance that it still could be there.

Blowing hot and cold

In summer, I feel comfortably warm when the thermometer in my living room reads 20°C. Yet in winter, I feel cold at the same temperature. What causes this?

Richard Horton

Whixley, North Yorkshire, UK

One explanation may be convection currents, or the lack of them. The room's thermostat is likely to be positioned roughly midway between floor and ceiling. On a 20°C day in the summer, the temperature in the room will be within a few degrees of the temperature outside, so you will feel comfortable.

Why does cold air make your nose run, and is this advantageous?

you feel less comfortable in strong winds than on a calm day.

The radiant temperature of your surroundings is a function of the temperatures of all the surfaces around you. These are likely to be lower in winter than in summer. We feel pleasantly warm in bright sunshine and out of draughts, even when the air temperature is low. Conversely, you have probably experienced "cold" radiating from cool surfaces, even in a warm environment. This is akin to the process that may be going on in your living room in winter.

This also shows why it pays to draughtproof and insulate. Combined, they give more comfort at the same air temperature and, when done properly, allow for cosy living at lower air temperatures.

Christine Warman

Hinderwell, North Yorkshire, UK

There is a psychological element to this feeling. It has been suggested that the most energy efficient way to keep people comfortable indoors is not to turn up the heating, but to provide stronger lighting. Lack of sunlight is a strong predictor for seasonal affective disorder. Its symptoms are similar to those of clinical depression, and feeling cold can be part of this condition.

Winter often offers less sensory stimulation and social contact. Conversely, stimulating activity, even if only mental, goes some way to distracting from the cold. The most striking example of mood affecting perception can be seen on the streets of any city at night, when hordes of young people intent on having a good time appear to be completely impervious to cold. ■

In winter with the heating on, the radiators produce convection currents. Colder, denser air falls, displacing warmer air.

If the thermostat records 20°C, the temperature at floor level will be significantly lower. The air in the layer just below the ceiling will be above 20°C, but you won't feel this warmth unless you climb a stepladder.

Jan Meulendijk

Haverfordwest, Pembrokeshire, UK

Air temperature is only one of three parameters that influence thermal comfort. The others are air movement and the radiant temperature of the surroundings.

In winter, you may experience more discomfort from draughts, as air entering the room is likely to be colder. This gives you an increased feeling of cold at the same air temperature, just as



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After Siena Castellon was diagnosed with autism, she started to campaign for a society that both embraces and benefits from neurodiversity

So, what do you do?

I am a neurodiversity advocate. I believe that neurological differences, such as autism, dyslexia and dyspraxia, are natural variations in the human brain. Our society pathologises these conditions and focuses on trying to cure them. I am trying to flip the narrative so that society stops viewing us as defective and starts to embrace and harness our many strengths and talents.

Your new book is called *The Spectrum Girl's Survival Guide*. Why did you write it?

When I was growing up, there were no books specifically aimed at autistic teen girls. They were all written for autistic boys by neurotypical adults.

I decided to write the book that I wish had been available. I also wanted to write an uplifting book that encouraged autistic girls to embrace who they are and that reminds them that they aren't alone.

What is in the book?

There are two main themes. The first is that we deserve to be accepted and embraced for who we are. Society pressures autistic girls to mask their true selves so that they can fit in and appear "normal". This can be devastating to our sense of self-worth and our mental health. The second theme is advice on how to navigate school as an autistic teenager. I discuss socialising and making friends, crushes and dating, gender identity, social media, bullying and much more.

You talk about being bullied. Does this happen a lot to children with autism?

Unfortunately, society isn't very tolerant of people who are different. I can't remember a time at school when I wasn't bullied, which explains why I have been to 11 schools. When I was diagnosed as being autistic, I learned that 75 per cent of autistic students report being bullied.

What are you working on right now?

Neurodiversity Celebration Week is coming up soon. I launched this campaign in 2018 to encourage schools to recognise the strengths and talents of neurodiverse students, instead of just focusing on their weaknesses and difficulties. There are currently more than 600 schools and 458,000 students taking part from across the UK, Australia, Canada and the US, and many organisations, including The Alan Turing Institute.

Is autism awareness and understanding improving?

I don't think so, especially not in relation to girls and women. I am constantly told I look "normal" and that I don't look autistic. The people saying this genuinely believe that they are complimenting me, when it is actually an insult. Most people's benchmark seems to be Raymond from [the film] *Rain Man* and so people often tell me I can't be autistic. Also, awareness isn't enough. We should be striving for acceptance and equality.

What areas of science are you most interested in?

Physics and maths. I have been passionate about both since primary school.

If you could have a conversation with any scientist, living or dead, who would it be?

Alan Turing. He was a brilliant mathematician, computer scientist, cryptanalyst, theoretical biologist and philosopher. I can also relate to him because I know what it is like to not be accepted for who you are.

Do you have an unexpected hobby, and if so, please will you tell us about it?

I collect packs of cards. I have been able to count cards from a young age, which means I almost always win. That may explain why I love cards so much.

"I am told I look 'normal' and not autistic. People think this is a compliment, when it is actually an insult"



How useful will your skills be after the apocalypse?

Physics and maths are the language of nature. So my skills would be useful in rebuilding civilisation.

OK, one last thing: tell us something that will blow our minds...

Did you know that there is a hidden bear and fish in the Toblerone logo? One of the many advantages of being autistic is that I see details others may miss. ■

Siena Castellon's book *The Spectrum Girl's Survival Guide: How to grow up awesome and autistic* is out this month (Jessica Kingsley Publishers). Neurodiversity Celebration Week begins on 16 March @NCWeek

GIUSEPPE RAMOS/ALAMY



Is autism a gift?

Join Siena and cognitive scientist Anna Remington for our evening event on 12 May in London [newscientist.com/events](https://www.newscientist.com/events)

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