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New Scientist

WEEKLY 27 March 2021

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CORONAVIRUS

The global picture on
vaccine hesitancy

*Mistrust among Colombia's
Indigenous peoples*

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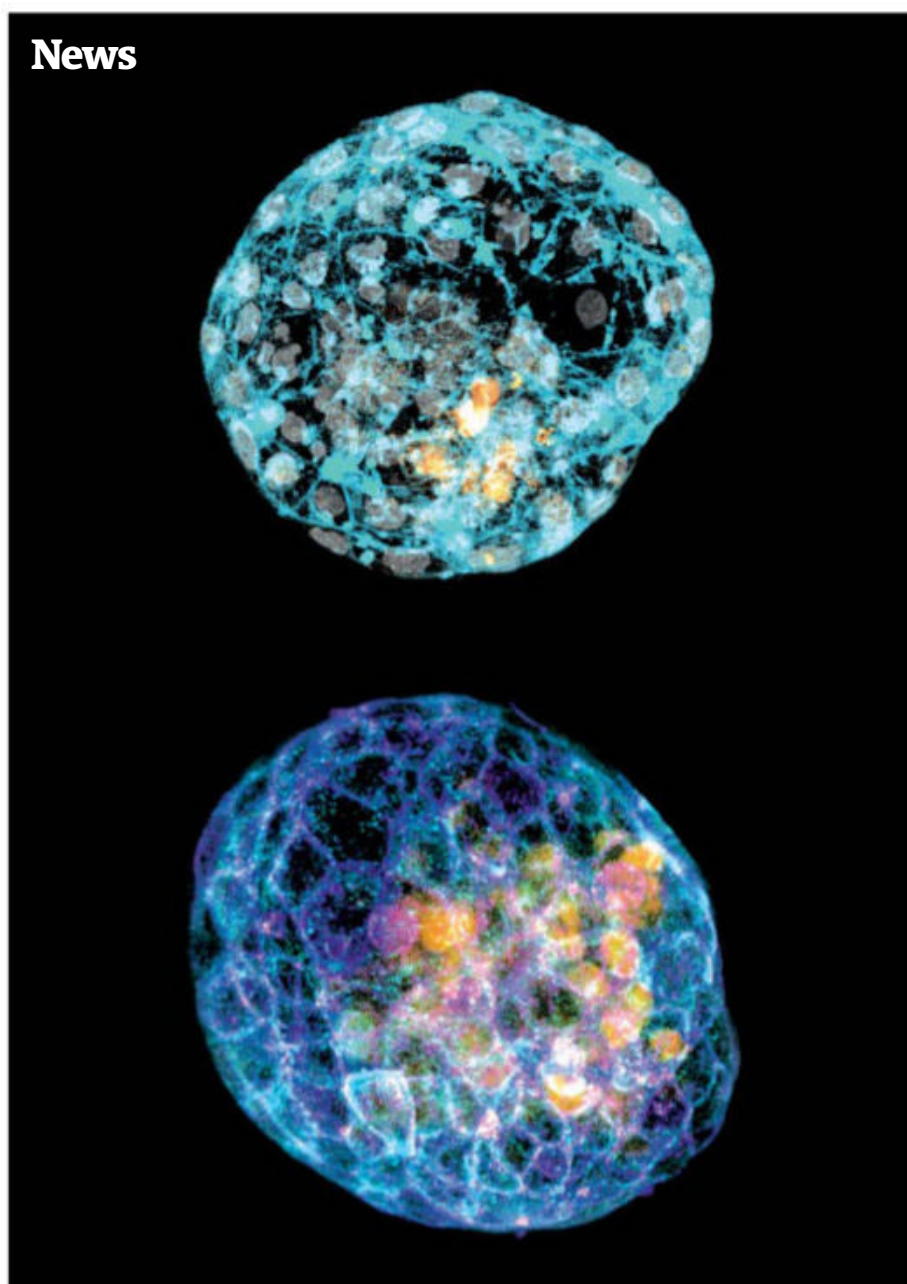
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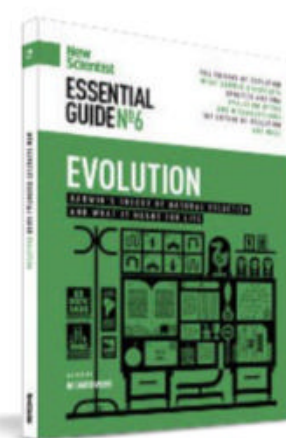
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Cities for all

Our reinvention as an urban species demands the reinvention of urban spaces

IN 2007, give or take, came a watershed moment in the 300,000-odd-year history of *Homo sapiens*. For the first time, more of us were living in urban settings than in small communities embedded in largely natural environments.

Urbanisation has been a driver of human cultural and material development since the first cities arose some 6000 years ago. Yet it is becoming clear that city life brings with it burdens on our evolved psyches. Indeed, green spaces have been shown to be vital not just to our physical health, but also to our mental health, including in alleviating conditions such as depression, anxiety and mood disorders (see page 36). They also help with creativity, positive social interactions, healthy sleep patterns and much more.

The covid-19 pandemic has driven home the reality of those connections for many city dwellers. It has also highlighted the inequalities between socioeconomic groups, both in terms of access to green space and in the degree to which they are exposed to pollution, for example.

Yet all too often urban planning pays

“The pandemic has driven home the connections between access to green space and our health”

only lip service to matters of human health – and still less to creating environments in which the biodiversity we depend on can thrive.

The rapidly expanding cities of Asia and Africa are repeating the mistakes made in the West, subjugating liveability

for all beneath sprawl and the demands of a motorised few. Attempts to reimagine cities for a greener, more sustainable, post-covid future have been piecemeal and disjointed, and often shouted down by vocal minorities with an interest in the status quo.

We are storing up trouble for ourselves. If there is one general lesson the pandemic has taught us, it is that investment up front prevents far greater costs down the line. How we plan our cities affects not just the health of those living in them now, but the health of billions who will live in them in the future.

A liveable environment must be seen as a fundamental human right. That requires consequential decisions to be taken across the world to reinvent cities as spaces in which all inhabitants can thrive. ■

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Tribune Content Agency **Tel** +44 (0)20 7588 7588

Email tca-articlesales@tribpub.com

Subscriptions

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One year print subscription (51 issues) UK £198

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Coronavirus recombination

Hybrid virus is spreading

Recombinant viruses made up of two variants mashed together are circulating widely between people, reports **Graham Lawton**

VIRUSES formed by mash-ups of two variants of the SARS-CoV-2 coronavirus are now spreading from person to person, potentially increasing the risk of dangerous new variants arising.

New Scientist reported on the first detection of this kind of so-called recombination last month, but at that point it was unknown whether the resulting hybrid was circulating in the wild. Two new analyses end any doubt. “Recombinants are circulating,” says Dave VanInsberghe at Emory University in Atlanta, Georgia.

Recombination is a potent source of evolutionary change in coronaviruses. It normally occurs when two variants meet in one host cell. The worry is that it could

bring recent mutations together in new and more dangerous combinations, although there is no evidence yet of that happening. The risk of new variants is particularly concerning given many countries are seeing surges in coronavirus cases, including many European nations.

In an analysis, VanInsberghe and his colleagues estimated that up to 1 in 20 of all SARS-CoV-2 variants circulating in the UK and US are now recombinants. The team analysed over half a million SARS-CoV-2 genome sequences from around the world and

found more than 1000 possible recombinants. Most remain rare, but two are circulating widely, one in the US, UK, Singapore, Japan and Canada, and the other in the US, UK, Canada and Denmark (bioRxiv, doi.org/f3bq).

Neither of these two recombinants carry mutations that have been flagged up as being “of concern”, such as the ones seen in the variants first identified in the UK, Brazil and South Africa. “We have no reason to believe that the recombinants have altered transmissibility or virulence,” says VanInsberghe. Even so,

One recombinant coronavirus is circulating in Japan

he says, “these mark the first instances of widespread transmission of recombinants”.

Some of the other, rarer recombinants do carry those mutations of concern. “The real worry with recombination is that you recombine two lineages that have higher transmissibility or virulence, and that could be really dangerous,” says VanInsberghe.

“The real worry is that you recombine two lineages with higher transmissibility or virulence”

Since the analysis was done, the most common recombinant has become even more numerous and widespread in the US, which could be a sign of greater transmissibility, he says. The research has yet to be peer-reviewed.

A separate analysis by the Walter Reed Army Institute of Research in Maryland looked at 100,000 SARS-CoV-2 genomes collected globally up to the end of October 2020, when fewer variants were circulating. It identified eight probable recombinants (bioRxiv, doi.org/f3br).

The paper says the circulation of SARS-CoV-2 recombinants could have “major implications, especially if circulating recombinant results in escape from both natural and vaccine induced immunity”.

There is precedent for this with a different group of viruses. Recombination between strains of norovirus has been shown to lead to rapid escape from naturally acquired immunity and new pandemics of gastroenteritis.

For now, recombination and regular mutation of coronavirus variants pose similar threats, says Sergei Pond at Temple University in Pennsylvania, although that could change. “[Recombination] is not a major evolutionary driver at this point – recombinant strains are rare – but it will likely increase in prominence,” he says. ■

Daily coronavirus news round-up
Online every weekday at 6pm GMT/BST
[newscientist.com/coronavirus-latest](https://www.newscientist.com/coronavirus-latest)

Public opinion

Global vaccine hesitancy declining...

People in richer nations are becoming more willing to have a covid-19 shot, matching attitudes in poorer countries, reports **Adam Vaughan**

WHEN Margaret Keenan became the first person to receive a covid-19 vaccine outside a trial last December, she was among the 7 in 10 people surveyed globally who said they would be willing to receive a dose. But the significant minority unwilling to have a vaccine led public health experts to worry about how such hesitancy might hamper efforts to achieve herd immunity.

The good news is that with more than 400 million people around the world having received at least one dose of a vaccine, attitudes are changing.

One survey, which included Japan and the UK, found that in 11 of 14 high-income countries, the number of people who “strongly agreed” they would get vaccinated increased by at least 9 percentage points between November 2020 and last month. Seven of these countries saw a rise of at least 20 percentage points.

Meanwhile, the proportion of their population who “strongly disagreed” with getting a vaccine dropped or stayed stable. None of the surveyed countries saw a rise in unwillingness to get vaccinated.

The survey also found that the number of people who were worried about side effects fell or remained constant in all nations over the same period.

“It’s been exciting to see people are seeing this vaccine can get us out of this situation,” says Jeffrey Lazarus at the University of Barcelona in Spain. He says the dial on attitudes may be shifted again by new incentives, such as the US Centers for Disease Control and Prevention recently advising that some vaccinated people in the US can mix in households without face masks or social distancing.

“People are human, they need incentives. Some people say, ‘I’ll save my life, save my family,



OLISCARFF/AFP VIA GETTY IMAGES

help society.’ Others say, ‘This is great, we can go for dinner if we’re all vaccinated.’ We need to reach people on all levels,” says Lazarus.

Recent studies showing the impressive real-world safety and effectiveness of vaccines may also help assuage some people. Before roll-outs began, these were two of the most commonly cited reasons for vaccine hesitancy.

In some places, however, there is a risk that willingness to be vaccinated is set back by the halt in use of the Oxford/AstraZeneca vaccine in several countries over blood clotting fears (see “...but Europeans get cold feet amid vaccine controversy”, right).

The European Medicines Agency concluded last week that the vaccine’s benefits outweigh the risk of side effects, sparking many countries to resume its use.

AstraZeneca has also since published promising safety and efficacy results from human trials in the US, in which no risk of blood clots was reported.

Covid-19 vaccinations at Lichfield Cathedral in Staffordshire, UK

Daniel Freeman at the University of Oxford and his colleagues found that 16.6 per cent of people in the UK were very unsure about getting a vaccine and 11.7 per cent were strongly hesitant. Now, he says, based on unpublished data from 15,000 people surveyed between January and February, things are looking better.

“There has been a noticeable increase in vaccine acceptance in the UK since the vaccination programme began, which is really positive,” says Freeman.

Figures vary depending on the survey, but one data set shows that the share of people in the UK who have received a vaccine already or who would take a vaccine if offered stood at 93 per cent in early March, up from 78 per cent in December, according to the UK’s Office for National Statistics (ONS).

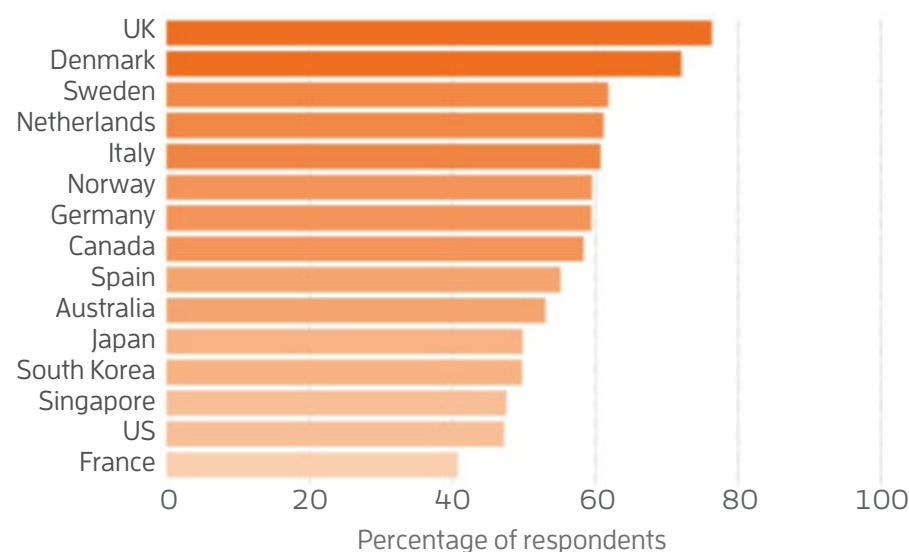
“That is really good,” says Helen Bedford at the UCL Great Ormond Street Institute of Child Health in London. She thinks a combination of factors are shifting views. “When you start seeing

Nevertheless, the suspensions will alter public attitudes, says Lazarus. “We needed to investigate, but we didn’t need to suspend use.”

In the UK, vaccine hesitancy has receded as the country’s rapid vaccine roll-out continues, with nearly 28 million people now having received at least one dose.

Last September and October,

Share of survey respondents who would definitely get a covid-19 vaccine if available



SOURCE: OUR WORLD IN DATA/IMPERIAL COLLEGE LONDON YOUNG GOV COVID-19 BEHAVIOUR TRACKER DATA HUB - 17 MARCH 2021

Roll-out suspensions

... but Europeans get cold feet amid vaccine controversy

Layal Liverpool

your family members being immunised and they're absolutely fine, that's reassurance," she says.

However, Bedford notes that the ONS figures show that young women are more hesitant to receive a vaccine than their male peers. People from ethnic minorities also appear less willing to have one. A study of 19,000 healthcare workers in England found that 36.8 per cent of black staff were vaccinated compared with 70.9 per cent of white workers.

While the hesitancy among young women is a surprise to Bedford, she says the difference by ethnicity was predictable since there has been a similar trend with previous vaccination programmes. She says more preparation should have been done to have trusted local leaders and healthcare workers change minds in some communities.

One bright spot comes in the world's poorer countries. On average, 80.3 per cent of people in 10 low and middle-income countries said they would have a covid-19 vaccine when it became available, according to a study of 46,000 people, surveyed between June 2020 and January this year. That is a much greater proportion than in some high-income countries, such as the 64.6 per cent willing to get one in the US.

The average acceptance across the 10 countries masked differences ranging from 66.5 per cent in Burkina Faso and Pakistan to 96.6 per cent in Nepal. "I think it's good news, conditional on getting people to follow through with their intention," says Mushfiq Mobarak at Yale University, an author on the study. "For the remainder, the data gave us some clues on the sort of messaging we should highlight. [It is] telling us they're concerned about safety and efficacy." ■

THE short-lived suspensions of the Oxford/AstraZeneca covid-19 vaccine by several European countries over fears of blood clotting may have increased vaccine hesitancy, just as a third wave of infections hits Europe.

In mid-March, several countries, including Germany, France, Italy and Spain, suspended the vaccine's use pending investigations into isolated cases of bleeding and blood clots. Many countries have since resumed their roll-outs after the European Medicines Agency concluded that the vaccine was safe and effective.

However, trust in the vaccine has waned in the European Union. More than half of people in France, Germany and Spain surveyed during the latest controversy believe that the Oxford/AstraZeneca vaccine is unsafe – an increase from February – according to a

YouGov poll published this week.

"I am afraid that this will have a disastrous impact," says Caroline Goujon at Montpellier Infectious Disease Research Institute in France, just when full acceptance from the population is needed "more than ever".

Coronavirus cases are rising in much of Europe. "We have now seen three consecutive weeks

"People are desperate to get their normal lives back and vaccinations are seen as the way to achieve this"

of growth in covid-19 cases with over 1.2 million new cases reported last week across Europe," said Hans Kluge at the World Health Organization during a press conference on 18 March.

The rate at which people in the EU are being vaccinated is lagging far behind those in the US, UK and Israel. The EU as a whole had

administered around 13 doses of a covid-19 vaccine per 100 people as of 20 March, compared with 36 in the US, 44 in the UK and 112 in Israel.

Scepticism around vaccines in general is prevalent in Europe. A 2016 survey of 65,819 people across 67 countries found that seven of the 10 countries with the least confidence in vaccine safety were in Europe. France had the highest level of scepticism with regard to vaccine safety of all the countries surveyed.

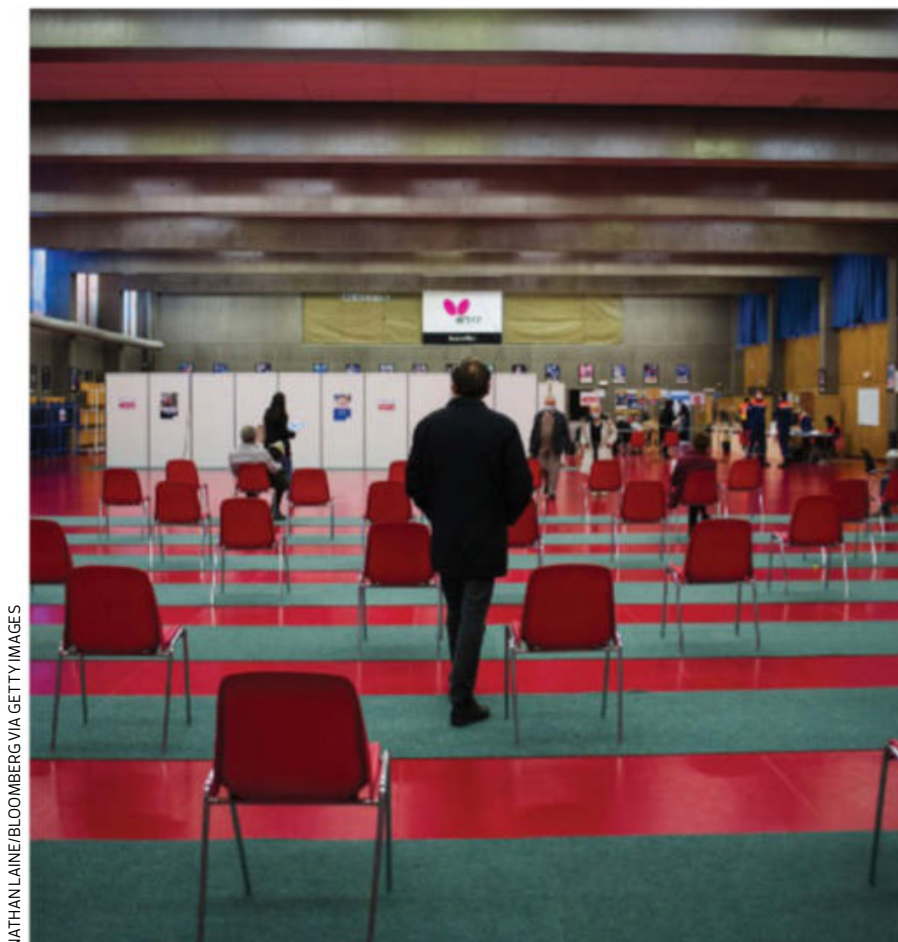
The picture is similar for covid-19 vaccines. A survey in February found that just 40 per cent of people in France said they would take one.

France has a history of negative attitudes around vaccine safety and mistrust in health authorities. In the 1990s, it was revealed that French government officials had knowingly distributed blood products that were infected with HIV. In 1998, France temporarily banned a hepatitis B vaccine due to isolated cases of multiple sclerosis. An investigation found no causal link, but concerns lingered.

Vaccine controversies have led to almost one in four family doctors in France believing that some vaccines recommended by French authorities aren't useful.

Nevertheless, a third wave of lockdowns may change attitudes. Naveed Sattar at the University of Glasgow, UK, suspects that hesitancy about coronavirus vaccines will be outweighed by the desire to see restrictions eased. "People are desperate to get their normal lives back and vaccinations are seen as the best way to achieve this," he says. ■

A covid-19 vaccine recovery area at Jean-Pierre Rives sports centre in Paris, France



NATHAN LAINE/BLOOMBERG VIA GETTY IMAGES

Colombia's Indigenous communities

Mistrust over vaccine roll-out

A lack of government communication is fuelling vaccine hesitancy in Colombia's Indigenous groups

Daniel Henryk Rasolt

AS COVID-19 vaccines begin to arrive in the Andean highlands in Colombia, Maria Pito, a leader of the Nasa people, is reluctant to receive one. "As a nurse, I will be required by the clinic where I work to be vaccinated but if I had the choice, I would not take it and would continue to rely on traditional medicine," she says. "I and many others don't trust this untransparent government."

Her distrust echoes the feeling of many Indigenous people in the region, even though they belong to one of the demographics most vulnerable to covid-19.

Many are choosing to use traditional medicines and well-established isolation tactics to prevent the spread of coronavirus. "The situation with these new vaccines is complicated, and we have very little information about them," says Marcelino Noé, a Tikuna leader from the Caña Brava Indigenous community near Tarapaca, Colombia. "We must protect our elders, but we prefer to trust our traditional medicines."

This approach, which has been supported for decades by intercultural organisations, may not be enough in this situation.

There are several reasons why Indigenous people in the region may be particularly vulnerable to covid-19. Though there is great diversity between groups, many share the characteristics of a community-based way of life. They may also lack access to basic health services, clean water, food security or electricity. In the Amazon, illegal miners, loggers and smugglers have become emboldened since Indigenous communities went into isolation early last year, posing a risk that

they will bring covid-19 with them.

Colombia has almost 2 million Indigenous people. It is a prime example of the obstacles facing vaccine roll-outs in Indigenous communities in South America.

The Colombian Amazon is an area of notable concern, especially along the border with Brazil.

Colombia's Amazonas department has registered one death from covid-19 per every 434 inhabitants, the highest rate in the country. Estimates suggest that Indigenous people living in rural parts of the Colombian Amazon are 2.5 times more likely to die from covid-19 than the general population.

In response to the P.1 variant first seen in Brazil, the Colombian government has prioritised the border regions of the Amazon for the first phase of the national vaccine roll-out, which began at the end of February. But it will focus on urban areas. The region's 64 Indigenous Peoples, who haven't been consulted on the roll-out and may in some cases refuse the vaccines, aren't

designated as high-priority groups.

Communication is also an issue. "The biggest problem is a lack of respectful information sharing, and the government not including Indigenous communities in the decision-making processes," says Pablo Montoya, director of Colombian NGO Sinergias.

"What we are proposing to the Colombian government and Indigenous authorities is a

"Illegal miners, loggers and smugglers have become emboldened, and could bring covid-19 with them"

respectful two-step strategy for Indigenous vaccine roll-out," he says. In an initial consultation, communities would have their questions answered by an intercultural team. Then, if they agree, a second team would vaccinate the community with the one-dose Johnson & Johnson vaccine. It is the government's responsibility to gain informed consent with Indigenous groups,

which is necessary for building trust, says Montoya.

In the Sierra Nevada de Santa Marta in northern Colombia, the 30,000-plus Arhuaco people are taking a pragmatic approach to the vaccines. They have made the collective decision to remain isolated in the mountains during the first phases of vaccine roll-out, after which they will decide whether or not to be vaccinated.

For Brazil's approximately 900,000 Indigenous people, vaccine scepticism is less prevalent than in Colombia, with many scientists and Indigenous leaders demanding that Indigenous communities be prioritised for vaccines.

Elsewhere, where Indigenous groups have been consulted in vaccine roll-out, acceptance has been higher. In Canada, for instance, the government has included Indigenous leaders and doctors in vaccine planning and distribution, leading to a wide acceptance of vaccines by Indigenous communities. ■

REUTERS/BRUNO KELLY



Covid-19 vaccination takes place in an Indigenous community in Manaus, Brazil

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Space exploration

A view from Mars's surface...

The Perseverance rover has sent back pictures and audio, and zapped some rocks

Leah Crane

SINCE NASA's Perseverance rover landed on Mars on 18 February, it has been doing as much research as it can during the testing phase of its scientific instruments. That has involved driving short distances and taking pictures of the rocks near the landing site.

"So far, all of this has been going exceedingly well,"

"If I heard sounds like these while I was driving my car, I'd pull over and call for a tow"

said Ken Farley at NASA's Jet Propulsion Laboratory (JPL) in California, during a presentation at the virtual Lunar and Planetary Science Conference on 16 March. "We've had no major technical issues."

The rover's first drive on 4 March – which lasted 33 minutes and covered about 6.5 metres – demonstrated that it can, in fact, rove, and the other tests are going smoothly as well, he said.

Perseverance has a microphone, which has allowed us to hear the Red Planet for the first time. It recorded more than 16 minutes

of audio as it drove around on Mars on 7 March.

"If I heard these sounds driving my car, I'd pull over and call for a tow," said Dave Gruel at JPL in a statement. "But if you take a minute to consider what you're hearing and where it was recorded, it makes perfect sense."

However, one of the high-pitched scratching noises in the recordings was unexpected and NASA engineers are now trying to figure out what is causing it.

Perseverance has also zapped several of the rocks near its landing site with its laser to determine their chemical compositions. They are similar to basaltic rocks on Earth, and some of them also appear to have water locked up in their molecular structure.

Many of the nearby rocks contain visible holes, some of which were probably bored by wind, whereas others may have been sculpted by flowing water.

All of these findings are exactly what scientists expected. Basalts form from molten rock and we knew that Jezero crater, where Perseverance landed, ought to



Rover tracks in the Martian dirt after Perseverance drove around on 4 March

have volcanic rocks that were once covered by the lake that used to fill the crater.

One of the images taken during testing even showed a Martian dust devil – a rotating column of dust – moving across the surface. These are common on Mars – most of the spacecraft we have sent there, including the Viking landers in the 1970s, have spotted them at some point.

Perseverance's next major task

will be to test Ingenuity, the small helicopter that the rover carried to Mars in its belly. For that, Perseverance will drop Ingenuity off, drive a short distance away and attempt to take a video of the helicopter as it lifts into the Martian air.

After Ingenuity's test flights, which are expected to happen this spring, the rover will be free to drive further afield and begin its science phase in earnest. At that point, it will begin searching for signs of ancient life and take samples to be returned to Earth by a mission planned for 2026. ■

Geology

...and a deeper look to measure the size of its molten core

WE ARE starting to understand Mars's heart. NASA's InSight lander has used seismic waves bouncing around the interior of the planet to measure the size of its molten core.

Since landing on Mars in 2018, InSight has measured more than 500 marsquakes, most of them relatively small. When these quakes occur, the lander measures two types of seismic waves – those

that skim near the surface and travel in a relatively straight line between the quake and the lander, and those that bounce around within the planet before reaching the detectors. It records the intensity of the waves in a graph called a seismogram.

The InSight team found that many of the records of marsquakes included a set of seismic waves with a shape that suggested they bounced off the boundary between the planet's mantle and its core. These arrived about 500 seconds after the first surface tremors.

Using that time difference and the directions from which the various waves arrived, the team calculated that Mars's core has a radius of about 1810 to 1860 kilometres, said Simon Stähler at the Swiss Federal Institute of Technology in Zurich. He presented this work on 18 March at the virtual Lunar and Planetary Science Conference.

That size is at the high end of the range of estimates calculated in previous work, which implies that the core may be less dense than we thought, Stähler said.

This may mean that Mars's interior is richer in relatively light elements, such as oxygen, than researchers had realised.

"So far we did not peer into the core itself, but now we know where in the seismogram to look," said Stähler. "On top of that, we can search for signs of a potential, if unlikely, solid inner core."

However, all of the InSight lander's measurements so far are consistent with previous studies that suggest the core is entirely molten. ■

Leah Crane

Italy | 8 days | 6 September 2021

Hidden science of the Dolomite mountains

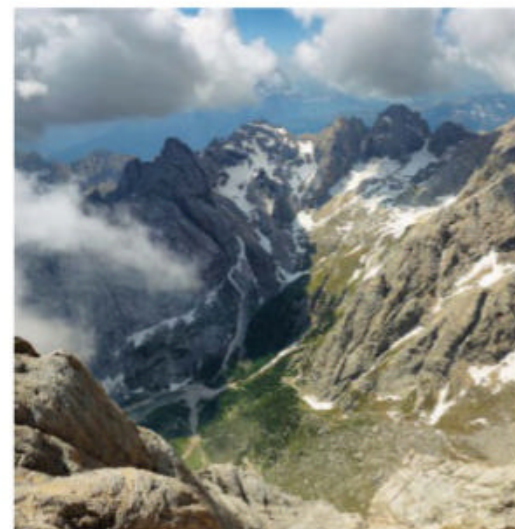
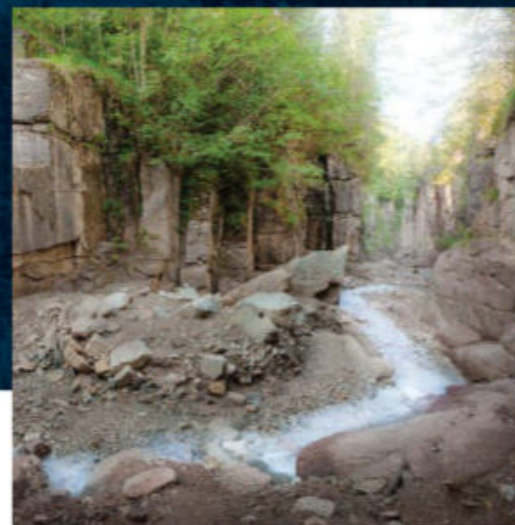
A gentle outdoors tour through the UNESCO World Heritage Site of the Dolomite Mountains that investigates several scientific phenomena including what glacial recession reveals about our history. From Ötzi the Neolithic caveman to the World War 1 high altitude trench remains at Marmolada with writer and journalist Laura Spinney. Plus, the tour reveals the Dolomites fascinating geological and ecological stories including the Geoparc Bletterbach and the Ritten earth pyramids. The tour covers several museums, stays in four-star hotels throughout and starts with an exploration of Venice.

Highlights

- Visit the stunning glacial trenches by cable car at the Museum of the Great War, sat atop Marmolada, the Queen of the Dolomites.
- A guided tour of Venice in Saint Mark's Square. Hear stories about the medieval Doge's Palace and the Bridge of Sighs, and admire the breath taking gilded mosaics and shining treasures of Saint Mark's Basilica.
- Travel to the small town of Ripa where you will visit Juval Castle which can be traced back to 1278, home of part of the Messner Mountain Museum.
- Visit the Helmut Ullrich Astronomical Observatory at 1770 meters above sea-level for a private viewing.
- Visit the South Tyrol Museum of Archaeology with Laura, where Ötzi the caveman and his artefacts are exhibited. Ötzi is Europe's oldest known natural human mummy.
- Explore the South Tyrol Museum of Nature and see detailed exhibits on the geology of the Dolomites and the emergence and developments of its habitats after its early beginnings as a tropical ocean with coral reefs and volcanoes.
- Study the deep-time history of the region at the Geological Museum of the Dolomites, that features geological collections consisting of more than 11,000 specimens, including the richest collection of invertebrate fossils of the middle-Triassic period in Italy.
- Explore the Ice Age in the Dolomites in the impressive gorge at Geoparc Bletterbach.
- Enjoy wine tasting experience and learn about wine production from practicing experts.

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How embryos reverse ageing

The aged cells of parents produce biologically young offspring – now we know how

Claire Ainsworth

WE NOW know how a developing embryo reverses signs of ageing and appears younger than the fertilised egg from which it arose. The finding suggests that embryos are able to rejuvenate, which could lead to ways of reversing age-related diseases.

One of life's great mysteries is how aged parents produce youthful offspring. Our cells show signs of age as a result of the accumulation of damage wrought by the environment and the body's metabolism, and yet the eggs or sperm that our bodies make can combine to produce a baby biologically younger than its parents.

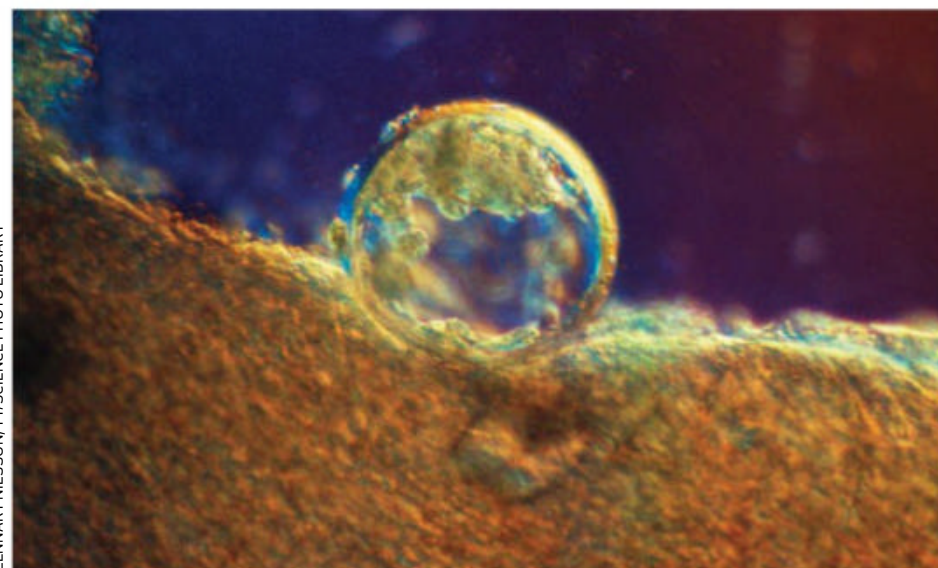
This has led biologists to suggest that the germline, the cells that give rise to eggs and sperm and which carry genes down successive generations, are immune to ageing. But recent research shows that not only does the germline age, but that ageing starts even as embryos develop in the uterus, much sooner than we thought.

"Then the question is, if ageing

begins earlier, when does it actually begin?" says Vadim Gladyshev at Brigham and Women's Hospital in Boston.

Age-related damage manifests as changes to patterns of chemical marks – known as methylation – on the DNA in the genomes of cells. These "epigenetic clocks" correlate reliably with chronological age and can be used

A human blastocyst in the uterus three days after fertilisation



to track ageing in cells and tissues.

Gladyshev and his colleagues looked at these epigenetic changes in cells and tissues from the start of mouse development. The team found that this measure of ageing began to decrease when the early embryo formed into a hollow ball called a blastocyst and reached its lowest point after it had implanted in the uterus. It then increased again as development progressed (bioRxiv, doi.org/f282).

The team also looked at data on human embryos, and found signs

of a similar pattern at work, although ethical restrictions on growing human embryos beyond 14 days in the lab mean the team was unable to study every stage of development (see page 19).

The discovery points to a rejuvenation mechanism that rolls back ageing to a minimal point from which a new individual can begin life, says Gladyshev.

Ageing can also be reversed in adult cells by reprogramming them into more immature cells known as pluripotent stem cells. However, this also makes the cells lose their specialised adult functions, making it less useful as a way to repair age-related damage. Gladyshev hopes that further study will help reveal whether it is possible to separate these two processes.

"This observation is exciting, since it hints at a potential, naturally occurring rejuvenation that resets the biological time of germ cells during the first days of development," says Juan Carlos Izpisua Belmonte at the Salk Institute in La Jolla, California. ■

Marine biology

Male toadfish protect eggs with antibacterial fluid

MALE plainfin midshipman toadfish produce an antibacterial fluid that keeps the eggs in their care healthy.

Plainfin midshipman (*Porichthys notatus*) live in the deep sea of the eastern Pacific, but come to shore to mate. Males build nests in the intertidal zone for females to lay eggs in, although the microbe-rich water means eggs can become infected with bacteria.

Males come in two types: "guarder" males look after the eggs,

while "sneaker" males creep into the egg-filled nests and try to steal fertilising opportunities. Both types have so-called accessory organs, an outgrowth of the testes, that are known to help sperm competition by producing nutrients to make the sperm swim faster. But guarder male accessory organs grow during mating season while the sneakers' shrink, which is the opposite of what we would expect if they were solely to aid sperm competition.

Now it seems the accessory organs also help protect the eggs from bacterial infection.

Sigal Balshine at McMaster University in Canada and her team

collected plainfin midshipman eggs from 18 healthy and 19 infected broods and cultured bacteria from both. The researchers then applied fluids from the accessory organs of 24 guarders and 12 sneakers to the different cultured bacteria.

They found the fluids prevented the growth of bacteria cultured from unhealthy eggs, but not of bacteria cultured from healthy eggs. What's more, guarder male fluids were three times more potent at this than

"The molecules in the male toadfish fluid didn't match known antibacterial agents"

sneaker male fluids (*Proceedings of the Royal Society B*, doi.org/f29k).

The researchers also profiled the molecules within the fluid and found they didn't match known antibacterial agents, meaning the fluids contained a novel bacteria-killing chemical. "It's a mystery how they're producing this," says team member Meghan Pepler, also at McMaster University.

Balshine suggests the accessory organs aid parental care by producing an antibacterial fluid that helps protect the eggs from harmful bacteria while allowing harmless bacteria to survive. ■

Ibrahim Sawal

Technology

Mechanical battery could power US Navy lasers

David Hambling



U.S. NAVY PHOTO BY JOHN F. WILLIAMS

THE US Navy has a mechanical battery based on spinning flywheels, which store energy as they spin and can discharge it in a quick burst when stopped. It could be used to power laser weapons or railguns, or even to store energy for homes.

Generators provide sustained power, but can't be cranked up for short bursts of high power. For that, the US Navy currently uses banks of lithium-ion batteries, which can discharge rapidly but pose risks: they contain hazardous materials and are prone to catching fire. Batteries also don't work well at high and low temperatures.

To address these problems, researchers at Vishwa Robotics in Massachusetts and the Massachusetts Institute of Technology have designed a mechanical battery that uses an array of flywheels set in a box. Flywheels can't usually compete with chemical batteries on energy storage, but this battery has some innovative features.

For a start, it is a collection of smaller units rather than a single large flywheel. "By making the dimensions smaller, each cell can be spun much faster," says Bhargav Gajjar,

president of Vishwa Robotics. Specially created bearings make the unit more efficient and economical. Gajjar says the design stores more energy than a lithium-ion battery of the same weight, and can release it faster with no thermal risk.

The prototype 5-kilowatt mechanical battery is a disc just 25 centimetres across, and many can be stacked to power more energy-intensive weapons, such as lasers to counter drones, says Gajjar.

"Currently available energy conversion and storage devices that can power such long-range, drone-killer weapon systems have two problems. They are made with explosive chemicals and they are very bulky," he says.

Software monitors the mechanical battery, drawing power from different wheels to match demand. Gajjar says it is also suitable for domestic use,



VISHWA ROBOTICS

This mechanical battery, based on a spinning flywheel, can deliver short bursts of high power

Railguns could potentially run on mechanical batteries

and he has a 10 kilowatt-hour prototype charged by rooftop solar panels that powers his whole house at night.

Gajjar says the flywheel is a simple mechanical device and no rare materials are needed to make it, so it could be mass-produced at low cost. Chemical batteries become less efficient after a few hundred charge/discharge cycles, but this battery shows no deterioration after tens of thousands of cycles and should last for decades, he says.

Keith Pullen at City University of London says mechanical batteries seem a good fit for applications requiring sudden bursts of power. He is doubtful

"Flywheels can be safer than chemical batteries if they are properly engineered"

about them producing greater energy than lithium-ion batteries by weight, though.

The Navy's primary goal is better safety than chemical batteries, although there have been notable flywheel accidents in the past where flying debris or flywheels that came loose have injured people. "But they are safer than chemical batteries if they are properly engineered," says Pullen.

The US Navy awarded a two-year contract for the mechanical battery, which will include testing its performance and safety. It will be evaluated for supplying power not just for weapons, but for sensors and propulsion, for example in uncrewed submarines and as backup power. ■

Evolution

Llamas and alpacas carry genes from 'ghost' relatives

Michael Marshall

DOMESTIC alpacas and llamas carry DNA from an extinct "ghost" population of their wild relatives.

The origins of today's domestic llamas (*Lama glama*) and alpacas (*Vicugna pacos*) are mysterious, says Paloma Fernández Díaz-Maroto at the University of Copenhagen in Denmark. Domestication had begun by 7000 years ago, but the details are disputed.

This is partly because the domestic species may have derived from one of two wild South American camelid species: guanacos (*Lama guanicoe*), which live in many habitats, and vicuñas (*Vicugna vicugna*), which only live high up in the mountains.

For a clearer picture of what happened, Díaz-Maroto and her colleagues obtained mitochondrial DNA from the remains of 61 ancient camelids from northern Chile, dated from 3500 to 2400 years ago.

Mitochondrial DNA is only inherited from the mother, so it can reveal the female family line.

They studied the ancient DNA and also DNA from modern llamas, alpacas, guanacos and vicuñas.

Llama and alpaca mitochondrial DNA was most similar to that of guanacos. This suggests that llamas and alpacas were domesticated from ancient female guanacos.

But the results also show llamas and alpacas carry some ancient guanaco DNA that doesn't match that from any present-day guanaco populations. That suggests it comes from a "ghost" guanaco population that has gone extinct in the recent past (*eLife*, doi.org/f287).

However, the male ancestors of today's llamas and alpacas may have included vicuñas. A 2020 study of present-day camelid nuclear DNA – which is inherited both paternally and maternally – found that alpacas have a lot of vicuña DNA. ■

Genetics

A DNA replication mystery

One microbe is missing genes we thought were vital for reproduction

Michael Marshall

AT FIRST sight, it shouldn't be alive: a single-celled organism that lacks most of the molecular equipment needed to copy DNA.

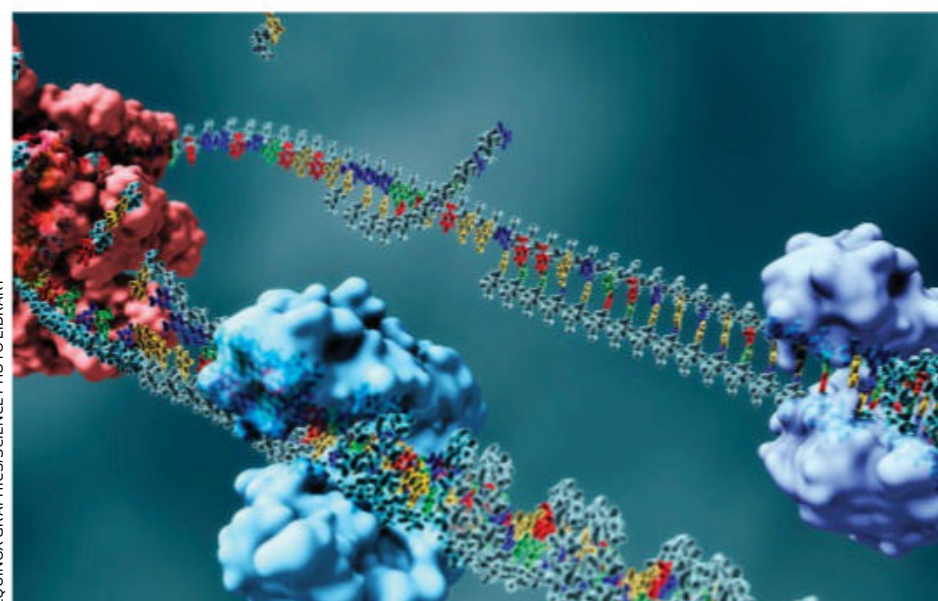
Duplicating DNA is fundamental to reproduction, so DNA replication systems were thought to be present in all non-parasitic species with complex cells. But it seems they aren't.

"I was astonished," says Dayana Salas-Leiva at Dalhousie University in Halifax, Canada. The unusual microbe, *Carpediemonas membranifera*, must have a mechanism for copying its DNA that is unknown to science.

Although *C. membranifera* is a single-celled organism, it is a eukaryote, so its cell is large and complex like those of animals and plants. It lives in low-oxygen sediments.

As part of a general study of the microbe's biology, Salas-Leiva and her colleagues sequenced its genome. They were baffled to find several genes missing, including some that code for the proteins that start DNA replication (bioRxiv, doi.org/f292). Until now, all free-living eukaryotes that have been sequenced have had these.

The researchers wondered if



EQUINOX GRAPHICS/SCIENCE PHOTO LIBRARY

they had failed to sequence the genome thoroughly enough, so they spent a year redoing the work. "To this day, I cannot get those genes," says Salas-Leiva.

"The microbe must have a mechanism for copying its DNA that is unknown to science"

"They sequenced the genome of this organism really well and really deeply," says Vladimír Hampl at Charles University in the Czech Republic. "I believe it."

C. membranifera does have

polymerases, the enzymes that copy one strand of DNA to make a new one. But the cell must also "decide" which sections of DNA need copying. This is done by six proteins that form the origin recognition complex (ORC), plus another protein called Cdc6. All are missing in *C. membranifera*.

"It's such a textbook thing, that eukaryotes have ORC," says Michelle Hawkins at the University of York, UK. "To find something that doesn't have it, that's cool."

The most likely explanation is that *C. membranifera* has another

To copy DNA, the enzymes helicase (red) and polymerase (blue) are usually needed

mechanism for starting DNA replication, says Salas-Leiva.

Organisms have repair mechanisms to copy DNA if a section of the genome gets damaged or lost. Salas-Leiva and her colleagues think that *C. membranifera* may have cobbled them together with other proteins to copy the entire genome – although this might lead to a lot of mistakes during replication.

"It's plausible," says Hawkins. "I think each step has been shown somewhere else in a different species." The next task will be to find out if this is really happening in *C. membranifera* cells.

The lack of the standard DNA replication system isn't the only oddity about the microbe. *C. membranifera* is missing proteins that help move DNA around when cells divide so that both new cells get copies of every gene. It is unclear how the organism copes. "We are very perplexed," says Salas-Leiva. ■

Animal behaviour

Mirror test hints that horses can recognise themselves

HORSES seem to recognise themselves in mirrors, and they may even use the information in their reflection to recognise if their face is dirty and needs wiping clean.

Paolo Baragli at the University of Pisa, Italy, and his colleagues put a large standing mirror in an indoor arena and let 14 horses loose, one at a time, in the open space.

Initially, all the horses treated their reflection as though it were another horse to play or fight with. But most horses later changed their behaviour and began investigating, says Baragli.

Eleven of the horses checked behind the mirror and watched their reflections as they moved their heads around. Some even stuck out their tongues at the reflection.

The researchers then used medical ultrasound gel to mark the 11 horses' cheeks – which horses can't see except in a

reflection – with an "X". At first, they used transparent gel, but they later added colour to the gel to make it stand out against the horse's skin.

When the X marks were coloured, the horses stood in front of the mirror rubbing their faces with their legs for five times longer than when the X marks were transparent. Baragli thinks the horses recognised from their reflection that they had something on their own faces (*Animal Cognition*, doi.org/f2zk).

Self-recognition has already been detected in a few other

species, including elephants and magpies. But Gordon Gallup at the University at Albany in New York, the developer of the mirror self-recognition test, disagrees with the findings of this study.

"None of the horses spontaneously used the mirror to investigate parts of their bodies that could not be seen without a mirror," he says. Without this self-directed behaviour, Gallup says the team's face-marking test "is like putting the cart before the horse". ■

Christa Lesté-Lasserre

Space exploration

The asteroid Ryugu barely reacted when we bombed it

Leah Crane

IN 2019, Japan's Hayabusa 2 spacecraft shot the asteroid Ryugu with a 2.5-kilogram lump of copper to create an artificial crater. Scientists expected this to shake the ground, but its effect was far milder.

Images from Hayabusa 2 have shown that the surface of Ryugu has fewer small craters than expected for an asteroid of its size, which probably indicates that dust is being moved somehow to fill in those craters. Asteroids don't have atmospheres, so the primary suspect to explain this movement has been the ground shaking due to small impacts from other space rocks that produce seismic waves – a sort of asteroid-quake.

Were that the case, rocks around the site where the copper impactor hit Ryugu should have been moved by the impact, but they weren't, said Gaku Nishiyama at the University of Tokyo in a virtual presentation at the Lunar and Planetary Science Conference on 15 March.

Comparing images of the area before and after the impactor hit, Nishiyama's team found that the rocks had moved less than 1 metre. Seismic waves produced by the lump of copper must therefore have been far weaker than expected. What's more, Hayabusa 2's images of Ryugu revealed that, in many places on the asteroid, there are small boulders stacked atop larger ones, which wouldn't be possible if the ground shook regularly. The team calculated that Ryugu must be good at diffusing seismic waves – about 100 times better than our moon.

That is probably because the dust grains on Ryugu are larger than those on the moon, allowing them to scatter energy from seismic waves much more efficiently. Nevertheless, something must be erasing the small craters on Ryugu and if the culprit isn't impact-induced asteroid-quakes, the dearth of small craters remains a mystery. ■

Infectious diseases

Ebola may linger in body and trigger new outbreak

Layal Liverpool

DEADLY Ebola virus has hit Guinea again and the outbreak appears to have been sparked by a person who was first infected during an epidemic there five years ago. This suggests Ebola can persist in survivors and be a source of future outbreaks.

Recent preliminary analyses of viral genome sequences by N'Faly Magassouba at the Gamal Abdel Nasser University of Conakry in Guinea and his colleagues, along with other research teams, revealed that the virus responsible for the new cases hardly differs from the strain that caused the previous epidemic. This indicates the virus may have lain dormant in someone who caught it in 2016.

"This is very surprising and very shocking," says César Muñoz-Fontela at the Bernhard Nocht Institute for Tropical Medicine in Germany, who was in Guinea during the earlier epidemic. "It's like a relapse."

There were 28,646 reported cases from 2013 to 2016 when Ebola hit West Africa and 11,323 reported deaths. These new findings indicate that some of

the people who survived could still harbour the virus years later and pass it on to others.

"What does that mean for [Ebola virus disease] survivors?" says Magassouba. He fears the new findings will worsen the existing stigmatisation of these people.

Researchers already knew that Ebola could persist in the body for a long time, but five years is unprecedented, says

1976

Year of the first known Ebola virus outbreak

Muñoz-Fontela. In 2016, a resurgence of the 2013-2016 epidemic in Guinea was traced back to a survivor who shed the virus in their semen for at least 531 days after first becoming infected, and transmitted it to their partner.

It is possible that the virus behind the current outbreak in Guinea may have persisted in a person's body before being transmitted in a similar way, says Muñoz-Fontela.

In addition to semen, Ebola can also persist in other "immune-privileged" sites in the body – those parts that are difficult for the immune system to reach – such as cerebrospinal fluid in the central nervous system or fluid inside the eye called the vitreous humour.

The first known Ebola virus outbreak was in the Democratic Republic of the Congo in 1976, but the 2013-2016 outbreak in West Africa was much larger, which could explain why more cases of persistent infections in survivors have been detected in recent years. It might be that this is relatively rare, so it is only becoming apparent now that there are more survivors, says Muñoz-Fontela.

Another possibility, he says, is that viral persistence is an inadvertent consequence of an increased availability of treatments. "Now we have [treatments] that can save people [who] in the past were impossible to save – and when you have persons with that amount of virus in the blood, the treatment itself may push the virus to these immune-privileged sites," he says.

Screening for persistent Ebola virus infections and vaccinating the contacts of Ebola virus disease survivors could help to protect people and prevent future outbreaks, says Magassouba, although availability of vaccines could be a limiting factor. As of 16 March, there had been 18 cases and nine deaths in the new outbreak in Guinea, with 366 contacts of cases identified and 3332 people vaccinated. ■

Ebola vaccine is given to people in Guéckédou, Guinea

Briefing

What is causing the global shortage of computer chips?

Matthew Sparkes

COMPUTER chips needed for everything from fridges to cars are in short supply just as demand has skyrocketed, and a perfect storm of problems may keep the shortage going.

Why are there chip shortages?

The covid-19 pandemic led to an initial slump in car sales of up to 50 per cent, because few people were travelling and confidence in the economy was low. Car companies slimmed manufacturing and reduced their usually huge orders of computer chips, which control braking, steering and engine management in modern cars. According to research firm IHS Markit, 672,000 fewer vehicles than usual will be made in the first quarter of 2021 as a result.

At the same time, there was a rush for home office items like laptops and smartphones – vital for many who began working from home. There was a similar rush for game consoles.

Factories supplying chips switched from making car components to smartphone, laptop and tablet chips. In terms of total sales, production is booming: the Semiconductor Industry Association says chip sales in January 2021 hit \$40 billion, up 13.2 per cent on the same month last year. Now, car sales have picked up again, so companies across several industries are fighting to get priority in factory order books.

What about backup stock?

Many companies operate with low stock levels to keep costs down and are now rushing to replenish supplies. Chip factories have limited capacity, and building new factories is expensive and often takes several years. Lower profit



VLADIMIR GERDOITASS VIA GETTY IMAGES

margins on older technology used in cars also gives chip-makers an incentive to focus on smartphone and tablet chips.

Where are the chips made?

Much of the world's supply of computer chips comes from Taiwan, and most are made by the Taiwan Semiconductor

90%

Amount of 2021 chip output by Broadcom that is already sold

Manufacturing Company (TSMC), which has been dealt a double whammy.

A US-China trade war has limited sales to the US. Both countries are building up their own production of chips, with the US getting TSMC to build a \$12 billion chip factory on its own shores.

As if that wasn't enough, the weather is also against many chip-makers. Manufacturing processes require lots of water.

TSMC churns through 156,000 tonnes of water a day normally. But there are droughts in Taiwan at the moment, reservoirs are drying up and the firm is now bringing water to the factory in trucks. Plus, a fire struck a chip factory in Japan in October, while an unseasonable cold snap in Texas temporarily shut down plants there.

How long will the shortage last?

Some analysts say it will take up to a year for manufacturing to get back on track, and then a further six months for stock levels at various companies to reach normal levels. US chip-maker Broadcom says 90 per cent of its 2021 output is already spoken for.

Other figures show that the chip industry has been edging closer to its full manufacturing capacity for some years now, so this could have been expected but there wasn't enough of a buffer in place to handle fluctuations in demand. ■

Space

Satellite set to grab orbiting junk with magnets

Leah Crane

A NEW way of capturing space junk using magnets is set to be demonstrated for the first time. With the number of space launches dramatically increasing in recent years, the potential for a disastrous collision above Earth is continually growing. Now, Japanese orbital clean-up company Astroscale is testing a potential solution.

The End-of-Life Services by Astroscale demonstration mission was launched on 22 March aboard a Russian Soyuz rocket. It consists of two spacecraft: a small "client" satellite and a larger "servicer" satellite, or "chaser". The smaller satellite plays the role of space junk and is equipped with a magnetic plate so the chaser can dock with it.

The two stacked spacecraft will perform three tests while in orbit, each of which will involve the servicer satellite releasing and then recapturing the client satellite. The first test will be the simplest, with the client craft drifting a short distance away and then being recaptured. In the second test, the servicer satellite will set the client satellite tumbling before catching up and grabbing it.

Finally, the chaser will live up to its name by letting the client satellite float a few hundred metres away before finding it and attaching to it. All of these tests will be performed with little to no human input once they are set in motion.

"These kinds of demonstrations have never been done before in space. They are very different to, say, an astronaut controlling a robotic arm on the International Space Station," says Jason Forshaw at Astroscale UK. "This is more of an autonomous mission." At the end of the tests, both spacecraft will burn up in Earth's atmosphere.

If companies wanted to use this capability, they would have to attach a magnetic plate to satellites so they could be captured later. ■

Skin cells to help study infertility

There is now a way to study embryonic development without using embryos

Donna Lu

LIVING structures that model early human embryonic development have been generated entirely from cells in the skin. The models mean it should be possible to study infertility, early miscarriage and early embryonic development without the controversial use of real human embryos – although the models raise ethical issues of their own.

Previously, the only means of studying the early development of human embryos was using blastocysts obtained from IVF procedures. Blastocysts are a ball-like early stage of embryonic development that is formed five days after fertilisation occurs and can go on to form embryos. But their use in science is controversial because of their potential to grow into a living human.

Now, by reprogramming fibroblasts – connective tissue cells taken from skin samples – Jose Polo at Monash University in Melbourne, Australia, and his colleagues have created human blastocyst-like structures.

“This is the first time in humans where we’re making an embryonic structure without any egg,” says Jason Limnios at Bond University

in Gold Coast, Australia, who wasn’t involved in the research. “That’s a big deal.”

The structures, which the team has called iBlastoids, could be used to model the first two weeks of embryonic development.

The iBlastoids are structurally and genetically very similar to real human blastocysts, but aren’t identical. For example, the iBlastoids lack a zona pellucida, a membrane that surrounds a blastocyst before it implants in the uterus.

“That’s something that we will never be able to model,” says Polo.

“Right now, you can’t implant this into a woman and get her pregnant,” says Limnios.

The team used a technique called nuclear reprogramming to create the iBlastoids. This involved taking fibroblasts from adult donors and, by altering the genes expressed in the cells, changing their properties.

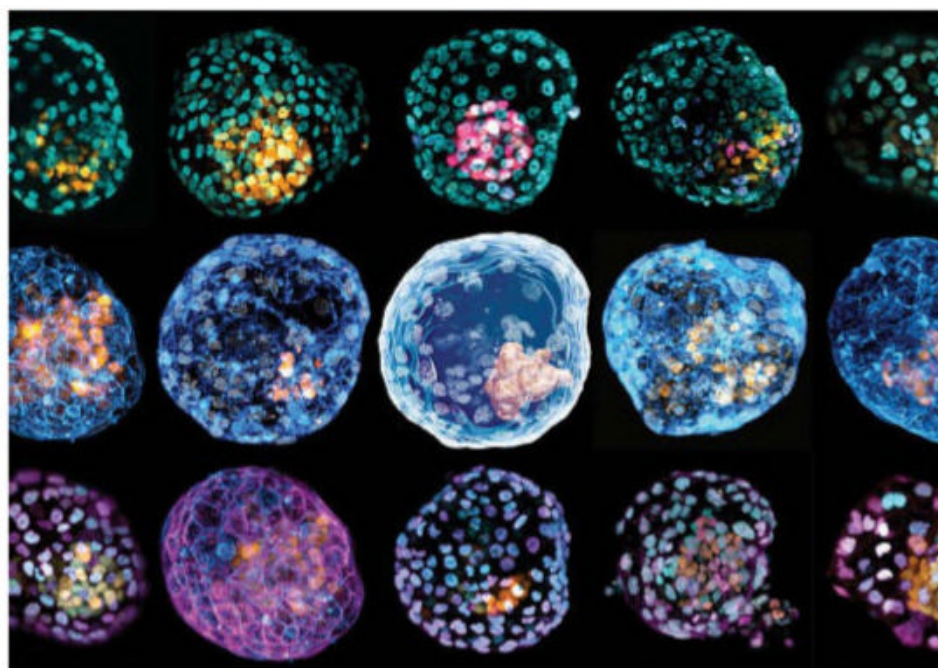
These iBlastoid structures look like real human blastocysts

When placed in a 3D scaffold known as extracellular matrix, the cells spontaneously organised into spherical structures made up of distinct layers of cells that human blastocysts contain (*Nature*, doi.org/f2tw).

The iBlastoids can give rise to pluripotent stem cells – cells that are able to self-renew and differentiate into different cell types of the body. They could help to advance research into infertility, enabling scientists to study what happens when embryos are exposed to toxins or viruses early in development.

The development of the embryo-like models brings up ethical and legal questions. In many countries, human embryos cannot legally be cultured in a laboratory beyond 14 days. There will now need to be a discussion about whether this limit should be extended for iBlastoids, given that they aren’t real human embryos, says Polo.

“The law has to catch up with the science,” says Limnios. “Until that time, everyone’s going to respect the current laws and treat these iBlastoids as if they are embryos.” ■



MONASH UNIVERSITY

Technology

Firefox web browser seems faster when we read that it is

THE key to making your software appear zippier is simply to tell people that it is quicker, according to research from the organisation behind the Firefox web browser.

Mozilla researchers wanted to know why Google’s Chrome internet browser had developed a dominant market share. In 2009, Firefox had a market share of 32 per cent, but

this slipped over the past decade and now stands at just 8 per cent. Chrome is used by 66 per cent of internet users.

Rebecca Weiss and her colleagues asked 1495 participants to read a news article. Some read an article claiming that Firefox was now “faster, smoother, and higher-performing than competitors”; others read about self-driving cars.

Subjects then watched videos of Chrome and Firefox carrying out simple tasks like opening a new tab and decided which was faster.

In the group that read about self-driving cars, 39 per cent of people perceived Chrome to be quicker and 31 per cent believed Firefox was faster.

But in the group shown the article about Firefox, 49 per cent rated it as the quickest, with just 24 per cent opting for Chrome (arxiv.org/abs/2103.06181).

“In the group that read about Firefox’s high-performance, 49 per cent rated it as quicker”

The team says the results show that perceived performance can be boosted without actually making any technical improvements.

“Our big concern was we could sink all of our time into making this browser work better and better and better against all of these conventional engineering performance metrics, but if everyone is only hearing ‘Chrome is faster’, classic psychology theory would predict that it will trump anything we do,” says Weiss. ■

Matthew Sparkes

Environment

Bush fires choked the skies with pollution for months

DEVASTATING wildfires in Australia in 2019/20 injected vast amounts of smoke into the atmosphere – and this led to record aerosol levels over the southern hemisphere.

Ilan Koren at the Weizmann Institute of Science in Israel and Eitan Hirsch at the Israel Institute for Biological Research analysed satellite data from 1981 to 2020 to look at what effect the fires had on amounts of tiny particles known as aerosols high in the atmosphere.

While aerosols in the lower atmosphere have a lifetime measured in minutes to weeks, those that reach the stratosphere can persist for months or years.

The researchers looked at a parameter called aerosol optical depth, which measures how much this type of pollution contributes to the amount of reflected light

that is picked up by satellites.

This showed that over the southern hemisphere in the early months of 2020, aerosols were at record highs: well above the monthly averages prior to the wildfires, and comparable with levels caused by a moderately large volcanic eruption.

Although the fires were out by early May, the researchers noted that stratospheric smoke persisted across the southern hemisphere until at least July 2020.

The overall effect of aerosols in the stratosphere is one of the largest uncertainties in climate science, says Koren. In the case of the Australian wildfires, the smoke blocked some solar radiation, leading to marked cooling over cloud-free ocean areas (*Science*, doi.org/f2zc). **Donna Lu**

Society

Women sleep easier in more equal nations

WOMEN in managerial roles seem to sleep better if they live in a country with greater gender equality. The same isn't true for male managers, who sleep better in countries with higher GDP.

Leah Ruppanner and her colleagues at the University of Melbourne, Australia, used data from the 2012 European Social Survey to study the sleep of 18,116 people, aged 25 to 64, from 29 European countries. Although it is an annual survey, this was the most recent year the participants were asked about sleep patterns.

The survey asked people whether they had experienced restless sleep in the past week, along with which country they live in and their occupation. Ruppanner and her team then combined these answers with data on each country's gender gap, as quantified by the United Nations

gender development index.

The team found that, in general, both men and women in managerial roles report restless sleep more often than people in less senior positions, but that female managers living in countries with a higher gender development index reported better sleep than women with similar jobs living in less equal countries (*PLoS One*, doi.org/f2xf).

"The Nordic countries tended to do really well here, because they have a whole range of policies that work to empower women and close the gender gap," says Ruppanner.

The same wasn't true for men in managerial roles. They slept better in nations with a higher GDP. The study only identifies a correlation between gender equality and sleep, rather than showing a causal link, and there may be complex issues underpinning why female managers reported poorer sleep in countries with a wider gender gap. **Karina Shah**

Zoology

Infected dogs smell good to biting flies

PARASITES that cause the disease visceral leishmaniasis, also known as kala-azar, may make dogs smell more attractive to female sandflies. The insects feed on the dog's blood and can pass on the parasite, which can then transfer to people via a dog bite and cause serious illness.

Leishmania infantum is one of a group of parasites that can cause an infection. Many cases occur in Brazil, possibly because sandflies

there efficiently spread the parasite, says Gordon Hamilton at Lancaster University in the UK.

To study how this happens, Hamilton and his colleagues gathered samples from dogs in Governador Valadares, Brazil.

They extracted odour-causing chemicals from the hair of 15 infected and 15 uninfected dogs, and then presented them to male and female sandflies. They monitored which odour samples the flies chose. Female sandflies feed on blood, while the males don't. Both sexes were generally attracted to the dog hairs, but 65.7 per cent of the female sandflies were drawn to the infected samples while the males were equally attracted to samples from infected and uninfected dogs (*PLoS Pathogens*, doi.org/f2w8).

Shaden Kamhawi at the US National Institute of Allergy and Infectious Diseases says that understanding these biological interactions could help efforts to control the disease. **Krista Charles**



CAPUSKI/GETTY IMAGES

Really brief



S. SIDEBOTHAM

City deserted after ancient eruption

Egyptians abandoned the city of Berenike in about 200 BC. Excavations there have uncovered a well filled with detritus from the time, such as coins (pictured). If the well stopped working, abandonment may have been due to a drought with possible links to a volcanic eruption (*Antiquity*, doi.org/f2xd).

Abel prize honours algorithm research

One of the biggest prizes in maths has gone to László Lovász at the Alfréd Rényi Institute of Mathematics in Budapest, Hungary, and Avi Wigderson at the Institute for Advanced Study in Princeton, New Jersey. The pair explore computational complexity – the study of the speed and efficiency of algorithms.

Sea creatures swim in mysterious circles

Tracking data shows that several marine animals swim in circles, but the reason for the behaviour isn't known. For example, tiger sharks (*Galeocerdo cuvier*) off the Hawaiian coast circled up to 30 times with each circle an average of 9.4 metres in diameter (*iScience*, doi.org/f3bc).

Fossils

Large dinosaur was made for digging

THE remains of an ankylosaurid, an armoured herbivore that lived sometime between 72 and 84 million years ago during the Cretaceous period, suggest that it was adapted to digging.

Yuong-Nam Lee at Seoul National University in South Korea and his team collected the ankylosaurid fossils – belonging to an individual that was more than 6 metres long – from the Gobi desert in Mongolia.

Ankylosaurids were bulky quadrupeds with short and powerful limbs. They had a club tail and an armoured body with wedge-shaped bony protrusions in the skin known as osteoderms.

“Articulated body skeletons of armoured dinosaurs are quite rare,” says Lee. To date, only four individuals with fairly complete skeletons have been discovered.

The bones of the ankylosaurid show it had heavily built forelimbs and forefeet suited to digging. The fusion of several vertebrae and ribs may have helped keep the dinosaur's trunk rigid, stabilising

the body while it dug using its forelimbs (*Scientific Reports*, doi.org/f2xj). “They may have been able to dig out roots for food, and dig wells to reach subsurface water as modern African elephants do today,” says Lee.

Digging dinosaurs are relatively rare, although some small species are known to have burrowed. The ankylosaurid specimen was excavated in 2008, as part of 700 vertebrate fossils the team collected over a five-year field trip. “It takes a lot of time and effort to identify, classify and study these specimens,” says Lee. **DL**

Palaeontology



VULLO ET AL., SCIENCE (2021)

Prehistoric winged shark cruised the ancient oceans

THE discovery of a fossil in a Mexican quarry has revealed that a bizarre shark with manta ray-like wings slowly patrolled the seas more than 90 million years ago.

Named *Aquilolamna milarcae*, it was unique in being wider than it was long, with a wingspan of 1.9 metres and a length of about 1.6 metres. Romain Vullo at the University of Rennes in France, who helped describe the species, says the body shape and wide mouth suggest it hoovered up plankton.

It was probably a steady swimmer. “Like modern manta rays, relatively slow swimming was enough to eat plankton,” says Vullo.

But unlike manta rays, which use pectoral fins for propulsion, the shark probably relied on the fin at its rear to propel it.

As the only known specimen, it is unclear whether the fossil (pictured) belonged to a juvenile or a mature shark. Vullo suspects it was an adult and that the species was probably a medium-sized shark, 3 metres long at most, with very small teeth.

Vullo and his team compared the fossil with 26 modern shark species and, based on vertebrae shape and the skeleton of its tail fin, assigned it to the order Lamniformes, which includes great whites (*Science*, doi.org/f2w6). **Adam Vaughan**

Locomotion

Secrets of how your body reacts to a trip

MISS a step when walking down stairs and your legs will attempt to recover your balance – but how? The key seems to be in the way our calf and foot muscles are activated.

Taylor Dick at the University of Queensland in Australia and her team conducted an experiment that involved attempting to make people fall over. They got 10 people to jump up and down on platforms with devices measuring the forces exerted by each foot individually.

The platforms were dropped without warning. As participants tried to retain balance, sensors on their legs tracked muscle activity and changes in muscle length.

The team found the timing between when the muscles in participants' legs and feet first activated and when they reached their shortest length increased. This enabled foot muscles to absorb and dissipate energy more effectively, aiding recovery. While opposing muscles normally contract in turn when walking, both groups of muscles contracted at the same time during the unexpected drop (*Proceedings of the Royal Society B*, doi.org/f2xg).

The researchers hope that this work can inform the design of lower limb assistive devices, such as prostheses. **KC**

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The columnist

Can local honey help with hay fever, asks James Wong **p24**

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Fukushima's real impact was in the evacuation **p28**

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Catching bats to study viruses that could harm us **p30**

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A gripping account of Earth's extinct humans **p32**

Culture columnist

Simon Ings on a film about an analogue champion **p34**

Comment

A too familiar threat

Understanding how covid-19 has been perceived in West African nations like Ghana is crucial to tackling it, says **Ama de-Graft Aikins**

IN A comedy sketch that recently went viral on Ghanaian social media, Coronavirus arrives late to a meeting. "What's up, fellow deadly diseases," Coronavirus says, as Malaria, Cholera and AIDS jump up from their seats and rush for their face masks.

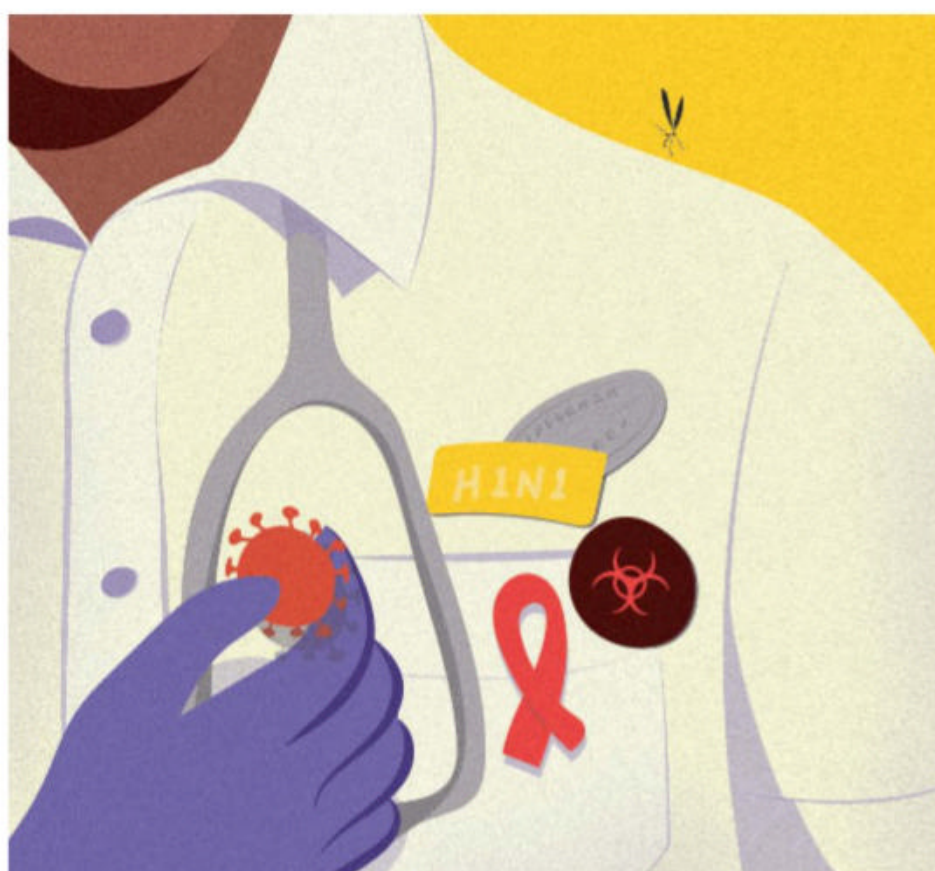
The sketch illustrates how some people in Ghana are making sense of the pandemic. While covid-19 is new and unique, for some it feels like just another on a list of long-standing and omnipresent threats to public health.

Social psychologists often use the term "familiar alien threats" to describe situations that people actively distance themselves from in their minds because they represent disruption or danger. But these threats still change the way we think, feel and behave.

In 1918, the Spanish flu came to colonial Ghana through European travellers. It quickly spread across the country, killing an estimated 100,000 people in six months. This was preceded by a plague pandemic, and was followed by epidemics of smallpox, yellow fever and sleeping sickness.

Ghana and other West African countries have since had serial public health crises, including HIV and AIDS, Ebola virus disease and swine flu, and the silent epidemic of chronic diseases, such as diabetes. Social responses to covid-19 are being shaped by this deep collective knowledge of sickness, debility and death.

In March 2020, covid-19 arrived



in Ghana's capital Accra via Asian and European countries where it was endemic. Because early hospital admissions and deaths were linked to international air travel, many Ghanaians distanced themselves from the domestic threat by describing covid-19 as a disease of a privileged urban class.

As infections spread and preventive measures were imposed, public understanding and practices developed in ways that mimicked responses to previous public health threats.

Popular artists evoked collective memories of past health crises and reminded people about inequitable official responses. On social media, conspiracy theories about anti-

African vaccines used the same emotive language that fuelled protests against Ebola vaccine trials in 2014. Stigma and secrecy around coronavirus infection emerged. People started to experiment with faith healing, herbal cures and home remedies. As a professional woman in Accra told me: "Nobody goes to the hospital... When you have symptoms, you boil cloves, lemon, ginger and garlic and drink it like tea."

At a deeper level, the idea of Africa as a conduit for infection is an enduring familiar alien threat in the global imagination. Social responses to covid-19 are also shaped by awareness of this idea.

From the 1880s to 1970s,

colonial medical treatments of infectious diseases in West Africa led to advances in tropical medicine and laboratory sciences. But this history was marred by unethical and racist practices, such as toxic treatments for sleeping sickness forced on hundreds of thousands of people. During the Ebola crisis that began in 2014, West Africa was stigmatised and exoticised by global media, causing a negative financial impact on tourism, higher education and industries with international ties.

During covid-19's first wave, global health experts predicted huge numbers of African deaths, even as local scientists developed effective methods for testing, prevention and treatment. These forms of defamiliarisation devalue complex African realities and compound mistrust of Western interventions, like vaccination drives. But they also force critical self-reflection and new ways of engaging with the world, from independence movements in the 1940s to the current "decolonise global health" movement.

Equitable healthcare, social protection and global cooperation will play a large part in fighting the covid-19 pandemic. Understanding social responses to it is equally important. ■



Ama de-Graft Aikins is British Academy Global Professor at University College London

#FactsMatter

A sweet idea Eating local honey is often recommended as a treatment for hay fever. Does it have any effect?

James Wong investigates



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

James's week

What I'm reading

Clinical and consumer trial data for a brand's new botanical skincare formulations.

What I'm watching

US crime drama Bosch, having pretty much exhausted the back catalogue of every streaming service.

What I'm working on

I am about to start a new series of a BBC food and farming documentary I made last year.

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

IT IS that time of year again. The days are brighter, daffodils start popping up around my neighbourhood, the dawn chorus of birdsong finally returns each morning and my social media starts filling up with anxious questions about whether local honey can treat hay fever. Now, I realise this is a little self-interested, but here is my attempt to get to the bottom of the best evidence we have to date, once and for all. Or at least until more studies come in.

With approximately 20 per cent of people in the UK affected by an allergic response to airborne pollen, it is perhaps unsurprising that many are turning to an everyday food that contains small amounts of pollen, but doesn't trigger the allergy, as a plausible-sounding remedy. Being great-tasting, widely available and relatively inexpensive, honey would indeed be an excellent vehicle to administer non-triggering doses of pollen. This is supposed to work as a form of immunotherapy to prime our bodies to deal with the summer onslaught. When you consider the potential side effects of the antihistamines used in conventional medication, you can definitely see the allure. But what does the evidence actually say?

Despite the frequency with which local honey's therapeutic effect is claimed, there seem to only be three scientific studies that have systematically investigated it. Sadly none of them, arguably, in a particularly robust way.

The most recent one is a 2013 study carried out in West Malaysia. This found that after consuming a multifloral honey produced by a tropical bee species deep in the rainforest for four weeks, people showed an improvement in symptoms for allergic rhinitis,

which continued to the end of the eight-week study and beyond. PDFs of the report are often sent to me by people from the UK and US as "proof" that local honey is indeed a cure for hay fever.

The first thing that piqued my interest as a Malaysian botanist coming across this study is that hay fever is essentially unknown in the humid tropics. In the equatorial climate, plants don't release pollen en masse in the same short windows that they do in highly seasonal, temperate regions. Indeed, when you look at the methodology of the study,

"They didn't track the weight of the participants after the addition of more than 10,000 calories during the study"

it didn't even look at hay fever at all, but at other allergies to dust and pets.

Even if it did, is a rare honey from a rainforest bee comparable with that of European honeybees foraging on totally different plants for people in the UK and US? Can this Malaysian honey even be described as local to the participants in the study, who didn't live in the heart of rainforest reserves, let alone to people on the other side of the planet?

Finally, let's look at the dose of 1 gram per kilogram of body weight used in the study. For me, that's 90 grams of honey per day, which is three times the maximum daily amount of sugar the National Health Service in England recommends I consume. I note the researchers didn't track the weight or blood sugar levels of the participants after the addition of more than 10,000 calories from sugar during the study.

What about the other studies? A few years before the Malaysian trial, a team in Finland reported that people consuming birch pollen honey had "significantly better control of their symptoms than those on conventional medication only". But birch trees are pollinated by wind, not by bees, so what is birch pollen honey? The answer is honey with added pollen. So, again, is this a like-for-like comparison?

The only other study is from 2002 from the University of Connecticut, which appears to be the best-designed of the three to test the claim of whether ordinary honey consumption can improve hay fever symptoms, by people consuming one tablespoon of honey per day, and found no significant difference.

It is important to point out that in the latter two trials all the participants were given honey on top of the existing antihistamines they were taking. So whatever the result, the idea that honey is a more (or less) effective alternative to these medications can't be established as there was no side-by-side comparison. Furthermore, all the trials were very short term and tested really small groups of people, so much more evidence is needed to authoritatively confirm or negate this claim.

What we can say, however, is that the bold statements we often see simply aren't supported by solid evidence at this time. Indeed, when we look at the alleged mechanism of action behind this claim, it seems increasingly shaky, because the vast majority of people with hay fever are allergic to tree and grass pollen, not those from insect-pollinated flowers, which are what are used to make honey. So, for now, I am afraid this online fact should probably be confined to the fiction pile. ■

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Editor's pick

Reaching out on the issue of friendship

6 March, p 36

From Charlotte Stansfield,
Backwell, Somerset, UK

Robin Dunbar talks about the differences between people who are "larks", using their phones mostly during the day, and "owls", using them mainly at night, in a study of 30 students. The owls phoned more people frequently than larks did, but spent less time on the phone to each person.

Some years ago, a friend suggested that larks may be more introverted than owls – they find the activity of the day, which often requires them to be extroverted, tiring and will be ready for sleep earlier than owls, who gain energy through the day and are ready to stay awake and continue activity into the night. This is borne out by observation of friends and family.

If the larks noticed by Dunbar tended to talk for longer, but to a smaller number of friends than owls did, I wonder whether this fits with introverts having fewer friends.

From Howard L. Ritter Jr,
Sun City Center, Florida, US
Your article on friendship brought a flashback to a science-oriented cruise of the Norwegian fjords that my wife and I took. One of the talks was by Dunbar, on the hierarchies of friendship groups.

He mentioned "Dunbar's number", the 150 or so people you know well enough not to be embarrassed to join uninvited for a drink if you run into them at a bar. I gained 15 pounds in my quest to verify Dunbar's number.

Fukushima's real impact was in the evacuation

13 March, p 18

From Geoff Russell,
Adelaide, South Australia
Regarding your look at the Fukushima nuclear power plant accident 10 years on, I wasn't surprised by the small impact

of radiation on life expectancy.

A 2011 study of survivors of the atomic bombings of Hiroshima and Nagasaki found that those who got an amount of radiation of less than 1 gray, a massive dose and many times that received by anyone living in the Fukushima area, had a median loss of life of just two months. So why did those at Fukushima see life expectancy cut by three months?

The atom bomb survivors have been followed for decades and results from this informed the international guidelines existing at the time of the Fukushima meltdown. Those guidelines were ignored when Japan ordered a mass evacuation, including of sick and older people. Unsurprisingly, many people died because of those evacuations.

For me, time marches in one direction only

6 March, p 46

From Robert Masta,
Ann Arbor, Michigan, US
Julian Barbour suggests that time may flow in two directions, highlighting that the physics of a billiard ball collision appears the same with time flowing forwards or backwards. That doesn't work if the event is seen as a whole: balls would jump out of pockets and self-assemble in the centre of the table, violating Newton's laws.

Surely causality is the indicator of time's direction, and an argument against universes with reversed time.

From Alex Bowman, Glasgow, UK
Perhaps at the big bang, time did move backwards and forwards. Our universe moved forwards and the antiverse, with antimatter, moved backwards.

This would explain a flaw in the big bang theory over what

happened to the antimatter, which should have appeared in equal amounts to matter.

Antimatter may experience antitime and antigravity, so in our universe it would fall up. However, if we study antimatter in our universe, it may seem to fall, but is actually rising, only in reverse time.

Have we found the solution to space junk?

13 March, p 12

From David Turvey, York, UK
The article on the laser thruster to power satellites was fascinating, and got me thinking about another application. Would it be possible to use the same principle to deorbit defunct satellites or push space junk into lower orbits so it burns up in the atmosphere?

Big spending may lead to even bigger corruption

27 February, p 38

From David Wilkinson,
Los Angeles, California, US
Rowan Hooper's plan to eradicate world poverty by spending \$1 trillion doesn't mention corruption, which is said to waste far more than \$1 trillion per year.

Well-overseen pilot projects, like those he cites, may not scale up to well-overseen megaprojects. Do we simply assume that corruption will be obliterated by the flood of money? Rather, I would expect corruption to scale up: the sweeter the pot, the more grasping hands.

Childhood mental health has long been in decline

6 March, p 8

From Russell Wells,
Bunbury, Western Australia
Your report on the impact of the pandemic on children's health is

all well and good, but we need an investigation into why we have seen a big spike in mental illness in the past few decades.

The recent mental health decline seems attributable to the lockdown conditions affecting everyone, yet your figures make it clear the pandemic wasn't the cause of the decline, but the latest factor contributing to it.

I have a plethora of ideas as to why young people might be experiencing pathological levels of distress given the rapid deterioration of the planet and relentless evolution of social dynamics perpetuated by the online world. However, I am curious whether my assumptions are correct or if this decline is related to factors that I haven't considered.

There is a good side to slugs and flies

27 February, p 49

From Jeff Doodson, London, UK
In recent weeks on your pages, we have learned how to deal with or even kill both slugs and flies.

Perhaps it is time to give their side of the story. Most of the 40 or so species of slug are active recyclers/composters in the garden, with similar positive roles for the thousands of flies. Most of these animals do no harm, yet we kill many of them because of the few species that are generally no worse than minor irritants.

More than one way to crack interstellar travel

6 March, p 16

From Robert Peck, York, UK
The idea of a slower-than-light warp drive is interesting. But I wonder if any civilisation with the resources necessary to fabricate a spaceship's shell compressed from something that was Earth's mass, and then accelerate it, would find it easier to achieve time dilation by the still complex, but slightly more practical, method of a low-mass vessel propelled as close as possible to the speed of light? ■



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Conservationist, UNEP Youth Advocate and adviser to the presidency of Angola

Partha Dasgupta

Economist, University of Cambridge, and author of the UK government review “The Economics of Biodiversity”

Susan Gardner

Ocean conservationist and director of the Ecosystems Division, UNEP

Cristián Samper

Tropical biologist, president and CEO of the Wildlife Conservation Society





The bat mystery



Photographer Adam Dean
Agency Panos Pictures

THIS striking image by photojournalist Adam Dean shows bats streaming out of Khao Chong Pran cave in Thailand at dusk as researchers collect individuals to study.

The cave, the largest of several in a cluster west of Bangkok, is a popular tourist spot because millions of bats flock there to roost. Now scientists from Thailand's Department of National Parks, Wildlife and Plant Conservation are becoming frequent visitors, too.

More than a year after covid-19 was labelled a pandemic, we are still trying to discover definitively whether the SARS-CoV-2 virus originated in bats. Researchers are collecting tissue samples from bats and checking local people – some of whom use bat droppings as fertiliser – for covid-19 antibodies. The viruses that cause severe acute respiratory syndrome (SARS) and Middle East respiratory syndrome (MERS) came from bats, and a virus similar to SARS-CoV-2 was found in horseshoe bats in Cambodia and China in late 2020.

There are concerns that urbanisation and agriculture are destroying or infringing on bat habitats, making the animals more susceptible to viruses and increasing the chances of them passing diseases to us.

This image is part of Dean's *Bats and the Pandemic* series, and won him an award in the 78th Pictures of the Year International competition earlier this month. ■

Gege Li

When we were not alone

What happened to the Neanderthals, Denisovans and other types of human we shared Earth with? Enjoy a great insider account, says **Michael Marshall**



Book

The World Before Us

Tom Higham

Viking

ASK any well-informed human living up to 40,000 years or so ago if they were the only intelligent being around, and they would have answered, “No”. That is because at that (geologically) recent time, our ancestors would still have been sharing Earth with several other human groups. In a very real sense, we were not alone.

Today we are. The Neanderthals who roamed Europe and western Asia are long gone. So are the Denisovans of east Asia, the “hobbits” of Flores Island in Indonesia and many more. Who were they? What were they like? What happened to them?

Archaeologist Tom Higham at the University of Oxford tackles these questions in his first book for a popular audience, *The World*

Before Us: How science is revealing a new story of our human origins. It is a slightly misleading main title because Higham barely discusses the world before *Homo sapiens* emerged about 300,000 years ago: you won’t find Lucy or any other ape-like australopithecines. But he does deliver on the subtitle, with a fascinating insight into groups belonging to the same *Homo* genus as us that lived alongside us for much of their existence.

Higham has been involved in many of the biggest discoveries in human evolution in recent decades. A specialist in dating methods, he helped trace the Neanderthal extinction, studied the mysterious Denisovans, who are mostly known from DNA extracted from bone fragments, and helped push back the date *H. sapiens* arrived in the Americas.

The book gets off to a shaky start, as the opening chapters are overstuffed with unnecessary detail that isn’t immediately explained. For example, Higham

repeatedly mentions nuclear and mitochondrial DNA, but doesn’t explain them until chapter 5 – although at one point there is an apologetic footnote directing readers to that part.

However, once past these bumps the book settles into a lively groove. Higham devotes whole chapters, sometimes multiple chapters, to each extinct

“When it comes to what happened to groups like the Neanderthals, Higham wisely embraces nuance”

hominin group. He packs in startling discoveries, impressive insights and the occasional debunking of a foolish idea.

Higham’s personal involvement means he has lots of good stories. He vividly describes Denisova cave in Siberia, Russia – where the first traces of Denisovans were found – along with its adjacent field camp.

There are also thumbnail portraits of the scientists involved. A highlight is Higham’s account of the discovery of Denny, a girl who lived in or around Denisova cave, with a Neanderthal mother and a Denisovan father. One of Higham’s students, Samantha Brown (now at the Max Planck Institute for the Science of Human History, Germany), spent weeks testing bone fragments before identifying one that belonged to a hominin.

Higham reproduces the flurry of excited, expletive-ridden texts he sent after being told the news. The reader gets a real sense of what it is like to “do” science as Higham emphasises Brown’s boring, reward-free slog before she finally struck pay dirt.

When it comes to the perennial question of what happened to groups like the Neanderthals, Higham wisely embraces nuance and complexity. It is unlikely there is a single explanation for the extinction of such a group as widespread and adaptable as the Neanderthals – and conservation biologists tend to find that species experience a multitude of threats.

For groups like the Denisovans, of whom we have barely any remains, he refuses to commit himself at all. He knows it is too early to make a big claim about what happened when we don’t even know the extent of their range or what they looked like.

In any case, many of them haven’t entirely gone. Thanks to interbreeding, the DNA of Neanderthals and Denisovans lives on. In our genes, at least, we still share the world with them. ■

Mike Marshall is a science writer based in Devon, UK

Archaeologist Tom Higham, with a skull from a modern human



MARK HARDY

Looking for other Earths

With NASA's next space telescope in sight, top scientists talk about what it may find in a new documentary, says **Katie Smith-Wong**



Film

The Hunt for Planet B

Nathaniel Kahn

Distribution to be announced

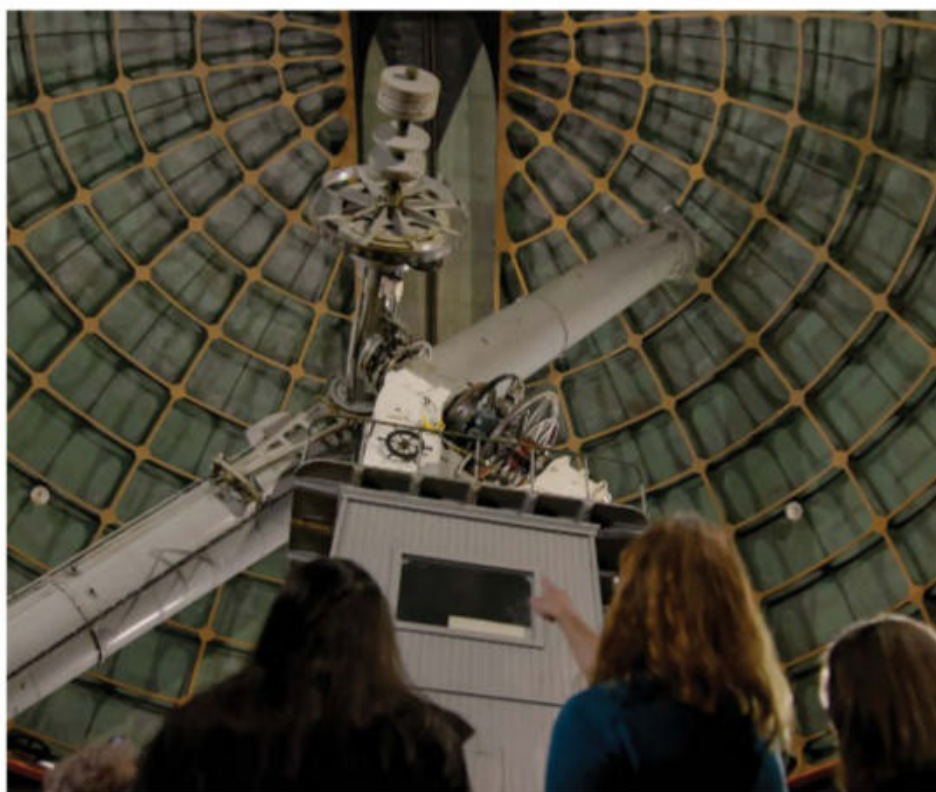
THE question of whether we on planet Earth are alone in the universe has been a constant over millennia. *The Hunt for Planet B*, a new film by award-winning documentary film-maker Nathaniel Kahn that premiered at the recent South by Southwest festival, documents efforts to explore not only exoplanets but also other potentially hospitable worlds.

At the centre of this effort is the James Webb Space Telescope (JWST), successor to the Hubble Space Telescope. NASA, the European Space Agency and the Canadian Space Agency have spent more than \$10 billion (so far) on the project, which has faced many delays and budgetary issues during its 25-year development and has needed scientists to fight its corner. The telescope is finally due to launch in October 2021.

In 2016, Kahn made two short films about JWST: *Into the Unknown* and *Telescope*. These show his artistic investment in the project, sharing footage and interviewees, such as JWST scientists John Mather and Matt Mountain.

The Hunt for Planet B updates these films in important ways. While it doesn't shy away from science, with so many scientists contributing, the sheer volume of details, diagrams and formulae may confound viewers new to the field. And the documentary can lose track of its narrative, as the story of one scientist's personal history with astronomy quickly shifts to habitable planets and alien life.

On the upside, Kahn uses the film as a platform to explore research into exoplanets, which can signify



CRAZY BOAT PICTURES

The Lick Observatory in *The Hunt for Planet B*

the existence of habitable worlds outside our solar system. This allows him to highlight the leading female scientists in the field, who each bring a fascinating perspective.

Take astrophysicist Sara Seager, who we first meet during a 2013 NASA congressional hearing. Amid laughter from sceptics on the House Committee on Science, Space, and Technology, she brushes off doubts about alien life by firmly arguing for the probability of an Earth-like planet amid the billions of galaxies in the universe. The idea of a "Planet B" empowers her to fight for the continuation of the JWST project and displays a no-nonsense attitude that sets the tone for the film.

Then we are introduced to astrophysicist Natalie Batalha, JWST engineer Amy Lo, astrobiologist Maggie Turnbull and former Center for SETI Research director Jill Tarter – all of whom deliver insights about space exploration that subtly underscore their achievements.

They also highlight growing

diversity in the field. This may only be a passing moment in the film, reinforced by JWST programme manager Gregory Robinson, but the documentary is a welcome companion to films such as *Hidden Figures*, which celebrated a group of African-American women working as NASA mathematicians and engineers and was set in the 1960s.

Kahn intersperses the interviews with snippets showing JWST's ongoing development – as well as news and sci-fi movies – to support the possibility of finding another habitable planet besides Earth. In January 2020, the first potentially habitable world, TOI 700 d, was discovered more than 100 light years away by NASA's Transiting Exoplanet Survey Satellite, so the possibilities are endless.

Aided by Robert Richman's stirring cinematography, *The Hunt for Planet B* does a terrific job of placing Earth in a new context – as perhaps one of a number of planets capable of hosting life. ■

Katie Smith-Wong is a film critic based in London

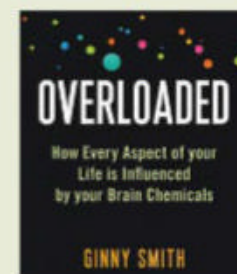
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Read

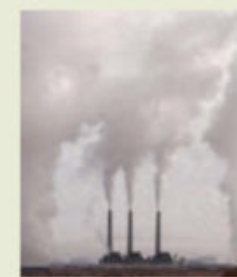
The Best of World SF:

Volume 1 contains 26 sci-fi stories, some celebrated and others new, representing 21 countries and five continents. Edited by writer Lavie Tidhar, the collection is a celebration of a truly global genre.



Read

Overloaded is science writer Ginny Smith's exploration of how our lives are influenced by neurotransmitters, the brain chemicals behind everything, from what we remember and who we love to basic drives such as hunger, fear and sleep.



Watch

Our Future Planet:

Global greenhouse gas removal, the latest in the climate talk series from the UK-based Science Museum Group sees scientists and engineers discuss carbon capture. Watch online at 7.30 pm BST on 31 March.

The film column

From the heart *An Impossible Project* is an extraordinary film following the strange life of entrepreneur Florian “Doc” Kaps, who rescued Polaroid film and champions the analogue. It even recreates the look of instant film, says **Simon Ings**



Simon Ings is a novelist and science writer. Follow him on Instagram at @simon_ings



Entrepreneur Florian Kaps finds analogue technology irresistible

long since kicked him off it.

It is hard to feel too sorry for him. His subsequent ventures in analogue – including a museum-cum-bar-cum-store in Vienna called Supersense – address his delight in goods you can touch and smell, in machines you can take apart and understand.

Kaps curates analogue printing and recording equipment, cameras and telephones. All the machines work, and those for sale sell quickly. After hours, he uses his shop floor to stage concerts cut straight to vinyl, creating unique records of live events.

David Bohnett, who founded web service GeoCities and was one of Silicon Valley’s first millionaires, thinks Kaps is inventing a new class of luxury item – unique records of unique experiences. Is he right?

People under 25 seem to think so. This cohort, who grew up in a digital world, are Kaps’s keenest customers. Kaps believes a monotonously digital diet has starved them of sensory pleasure, and that “after a long period of analogue companies trying hard to become digital, it’s now time for the digital companies to start thinking how to connect with people in analogue ways”.

An Impossible Project is an ingenious movie. Meurer has gone to extraordinary lengths to portray the man who saved Polaroid in a film that captures the casual, magical, slightly unreliable Polaroid feel. Practically every take looks like an out-take. People grin as if they have never seen a camera before. The shots don’t seem that well framed, yet add up to an extremely beautiful film. And the colours are gorgeous. ■



Film

An Impossible Project

Directed by Jens Meurer
iTunes, Amazon, Chili

Simon also recommends...

Films

Takumi

Clay Jeter

Car-maker Lexus bankrolled this feature on the survival of human craft in the age of artificial intelligence. Former British Museum director Neil MacGregor presents the work of four fantastic Japanese artisans.

Blow-Up

Michelangelo Antonioni

In this frustrating and fascinating art-house thriller, David Hemmings plays a fashion photographer who believes he has accidentally captured evidence of a murder in the background of one of his images.

JENS MEURER is a hard figure to pin down. The European Film Academy named him documentary filmmaker of the year in 1995, but the following decades saw him (as producer) bring movies like wartime drama *Black Book* and biopic *Rush* to the big screen.

He is also prepared to spend months following an eccentric Viennese entrepreneur, Florian “Doc” Kaps, who is convinced the future of technology is analogue, or at least post-digital – a strange mash-up of the two, perhaps.

The result is a film close to Meurer’s heart: *An Impossible Project*, featuring Kaps (who everyone calls “Doc” on account of his PhD work studying spiders). Although Kaps can never be too sure how to pay next month’s bills, he moves in interesting circles. We follow him around Berlin, New York and California and say goodbye as he is hosting a dinner party for “analogue champions”, including people from Moleskine, Polaroid and Facebook’s analogue research lab in a mothballed grand hotel just outside Vienna.

Kaps is a one-man cultural

revolution. In 2008, he bought the last Polaroid factory, just before demolition. He got it running again, only to discover that several chemicals needed to make Polaroid’s signature instant-developing film were no longer in production.

Early attempts to replicate the original formula were, in Kaps’s

“Kaps believes a monotonously digital diet has starved the under-25s of sensory pleasure”

memorable phrase, “perfect in a special way”: the colours were wildly unreliable; half the time the image would melt off the backing.

Still, Kaps persevered. For him, analogue technology has an irresistible mystique: if he rebuilt it, new customers would appear. He was right. Impossible, the company he founded, has now taken the Polaroid name and sells a million of the instant films a year. Kaps, though, is a dreamer not a manager: the board of Impossible

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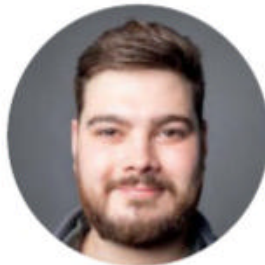


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Speaker Spotlight



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The nature fix

Natural spaces are essential for our physical and mental health – and designed in the right way they can help biodiversity to thrive too, says **Kate Douglas**



Crowds fill a park in Essen, Germany, at a summer music festival in 2013

JOCHEN TACK/ALAMY

FROM the Hanging Gardens of Babylon to the orange gardens of Seville, urban planners down the ages have taken inspiration from nature. And those of us living in the concrete and brick jungle have perhaps never appreciated scraps of green space more than during the covid-19 pandemic. During lockdowns, city dwellers across the world have found parks and gardens – where they exist – an unexpected source of calm and joy.

That comes as no surprise to the growing number of psychologists and ecologists studying the effects of nature on people's mental health and well-being. The links they are uncovering are complex, and not yet fully understood. But even as the pandemic has highlighted them, it has also exposed that, in an increasingly urbanised world, our access to nature is dwindling – and often the most socio-economically deprived people face the biggest barriers. Amid talk about building back better, there is an obvious win-win-win here. Understand how to green the world's urban spaces the right way and it can boost human well-being, help redress social inequality and be a boon for the biodiversity we all depend on.

On evolutionary timescales, urban living is a new invention. Our species has existed for at least 300,000 years, but the oldest cities are only some 6000 years old. Only recently – little more than a decade ago, according to figures from the UN Population Division – have we become a majority-urban species. Now the number of us living in cities is booming like never before. By 2050, projections suggest almost 70 per cent of us will be urban dwellers (see "Urban latecomers", page 39).

Our late arrival into cities might help explain our affinity with nature and green spaces. In 1984, biologist Edward O. Wilson made this connection explicit with his "biophilia" hypothesis. His idea was that the environment in which humans evolved has shaped our brain, priming it to respond positively to cues that would have enhanced survival for our ancestors, such as trees, savannah, lakes and

waterways. This, Wilson argued, is why being in nature makes us feel good.

Whether that is the reason or not, the past few years have seen an explosion of research finding concrete links between increased exposure to nature and not just improved physical health, but better mental health, too. Mental health issues are estimated to account for as much as a third of all years lived with disability, and account for around 13 per cent of disability-adjusted life-years (DALYs) lost, similar to the toll of cardiovascular disease and circulatory disorders.

The evidence of positive effects from nature includes studies on specific psychological conditions such as depression, anxiety and mood disorder. Access to nature has also been found to improve sleep and reduce stress, increase happiness and reduce negative emotions, promote positive social interactions and even help generate a sense of meaning to life. Being in green environments boosts various aspects of thinking, including attention, memory and creativity, in people both with and without depression. "The evidence is very solid," says psychologist Marc Berman at the University of Chicago.

Complications in comparing studies and saying exactly what's good for whom makes it hard to distil the effects into an individual prescription (see "How much nature do I need?", page 38). In the UK's remote Shetland Islands, however, they are doing just that: since 2018, doctors there have been able to prescribe nature-based activities such as birdwatching and beach walks to treat mental health conditions and stress, as well as physical conditions such as heart disease and diabetes. They aren't alone, either: a review in 2019 identified 28 nature-based interventions used in various countries to improve health and well-being, from organised gardening programmes to forest bathing.

If we are to maximise the benefits of nature for the world's legion of nature-deprived city dwellers, we need to know exactly how they ➤

About this feature

This feature is the fourth in our "Rescue Plan for Nature" series produced in association with the United Nations Environment Programme and UNEP partner agency GRID-Arendal. *New Scientist* retains full editorial control over, and responsibility for, the content. The fifth and final part of the series, on 10 April, will look at the links between climate change and biodiversity loss.



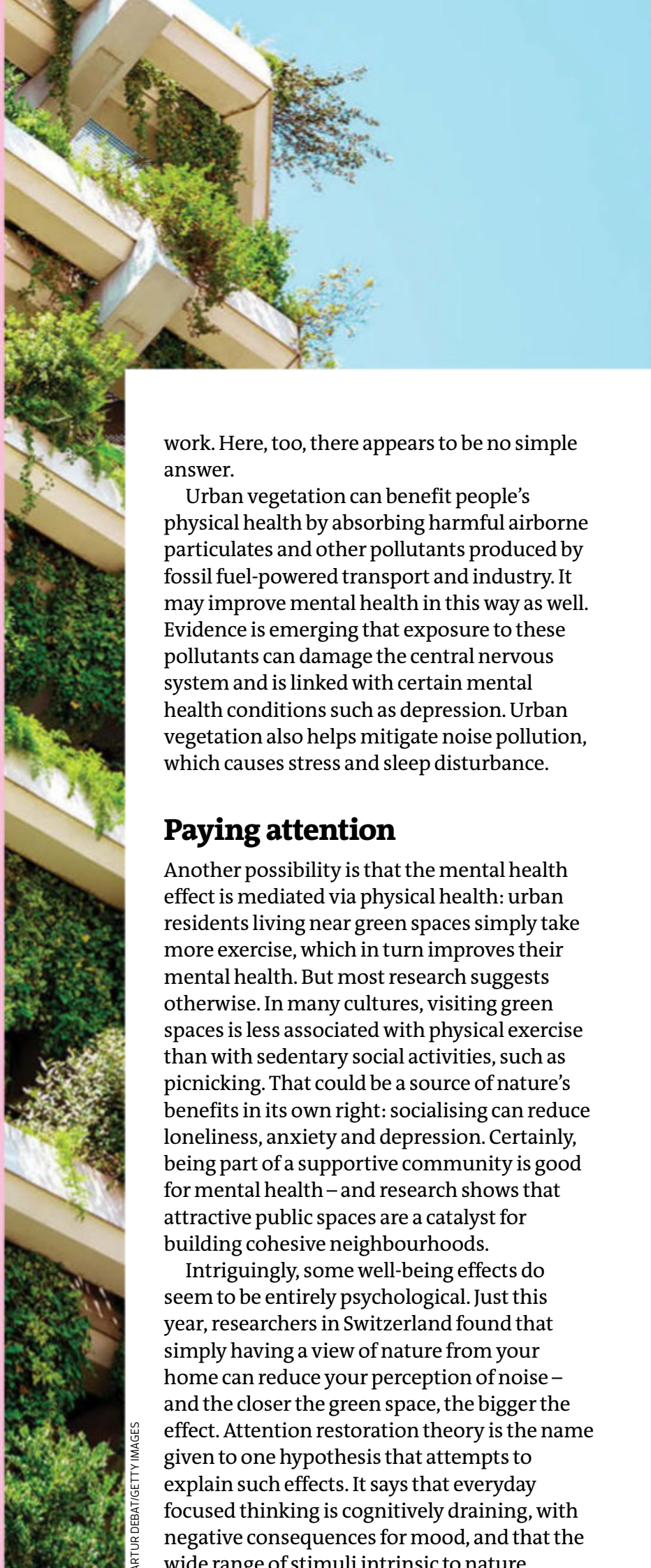
HOW MUCH NATURE DO I NEED?

When it comes to pinning down the link between well-being and access to nature, there are big confounding factors. To begin with, what is psychological well-being? The World Health Organization defines mental health as “a state of well-being in which an individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and is able to make a contribution to his or her community”. That is hard to quantify.

Then there is the question of what “access to nature” means. Some studies measure passive access, or how much green space is available in someone’s local area. Others look at active access, which is the actual exposure a person gets to green space. That makes it difficult to compare results and build a coherent picture.

A few researchers have tried to assess what the appropriate dose of nature might be. A 2019 study involving almost 20,000 participants in England concluded that at least 120 minutes a week of recreational nature contact was associated with good health or well-being. The team, led by Mathew White at the University of Exeter, UK, found that the effect peaks at between 200 and 300 minutes a week, with people reporting no further gain after that.

What exactly this means for you – or any individual – is unclear. As other studies indicate, the mental health benefits a person gets from access to nature are likely to be influenced by myriad factors, including age, gender, personality traits, personal preferences and socio-economic status. Your culture matters too – and, so far, most research into the well-being effects of nature has been done in Western societies.



work. Here, too, there appears to be no simple answer.

Urban vegetation can benefit people’s physical health by absorbing harmful airborne particulates and other pollutants produced by fossil fuel-powered transport and industry. It may improve mental health in this way as well. Evidence is emerging that exposure to these pollutants can damage the central nervous system and is linked with certain mental health conditions such as depression. Urban vegetation also helps mitigate noise pollution, which causes stress and sleep disturbance.

Paying attention

Another possibility is that the mental health effect is mediated via physical health: urban residents living near green spaces simply take more exercise, which in turn improves their mental health. But most research suggests otherwise. In many cultures, visiting green spaces is less associated with physical exercise than with sedentary social activities, such as picnicking. That could be a source of nature’s benefits in its own right: socialising can reduce loneliness, anxiety and depression. Certainly, being part of a supportive community is good for mental health – and research shows that attractive public spaces are a catalyst for building cohesive neighbourhoods.

Intriguingly, some well-being effects do seem to be entirely psychological. Just this year, researchers in Switzerland found that simply having a view of nature from your home can reduce your perception of noise – and the closer the green space, the bigger the effect. Attention restoration theory is the name given to one hypothesis that attempts to explain such effects. It says that everyday focused thinking is cognitively draining, with negative consequences for mood, and that the wide range of stimuli intrinsic to nature provide a restorative sensory environment that alleviates this attention fatigue.

But that is as yet educated guesswork. “There’s a lot going on. We have to be creative with our studies to try to isolate the different mechanisms,” says Berman.

And it is only half the story. Besides mental health benefits, we know that healthy natural spaces provide us with a whole range of

“Some of the well-being effects of nature seem to be entirely psychological”

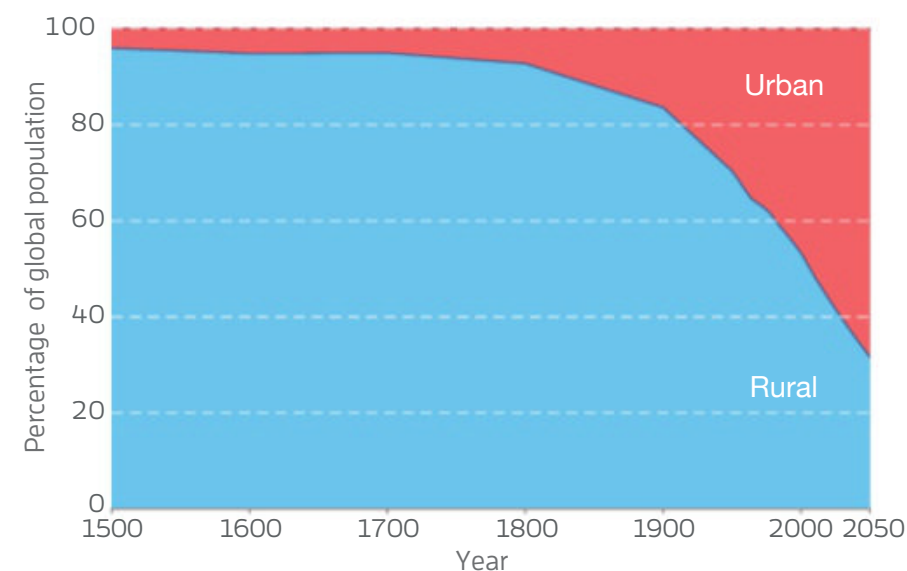
essential “ecosystem services” for free, from clean air and water to nutrient recycling, flood defence and pollination. Ideally, in designing or reconfiguring urban environments, we should aim to maximise the benefits for biodiversity too. How do we do that?

That is always going to be a trade-off because cities occupy land that could be wild, says ecologist Karl Evans at the University of Sheffield, UK. “Urbanisation is a major and increasing cause of global extinction risk,” he says. What’s more, we have a limited understanding of urban ecology upon which conservation-minded planners can draw. In 2017, Evans and his colleagues highlighted some fundamental questions yet to be resolved. These include how large, connected and diverse urban green spaces must be to promote biodiversity. Many animal species need access to different types of habitat to thrive. “It’s not just about the amount, it’s about the quality of those spaces,” says Evans.

He points out that about half the green space in urban environments in the UK is just closely mown grass, a pattern repeated in many Western cities. “You could convert this to meadows or plant more trees,” he says. In a study of urban meadows in the south of England, his team found that people responded more positively to the more-biodiverse meadows than to mown grassland.

Urban latecomers

Although the first cities arose some 6000 years ago, it is only in the 20th century that urban living really took off – and only in the past decade or so that humanity became a majority-urban species



SOURCE: OVID BASED ON UN WORLD URBANIZATION PROSPECTS 2018 AND HISTORICAL SOURCES

Even minimal green spaces, such as under this overpass in Osakoko, Japan, boost our mental well-being



NICK HANNES/PANOS PICTURES

Similarly, a recent study led by landscape architect Anna Jorgensen, also at the University of Sheffield, concludes that what urbanites, at least in the UK, most value in their encounters with nature is variety.

We still don’t know whether increased biodiversity equates to increased mental health benefits for urban dwellers. But incomplete as these findings are, they nevertheless make a strong case for greening cities. “People think of nature as being an amenity, not a necessity,” says Berman. “But we all need it and we need to take it very seriously.” Environmental engineer Anu Ramaswami at Princeton University agrees. She says green public spaces are one of seven key provisioning systems in cities, along with shelter, water,

food, energy, connectivity and sanitation. “I think they are exactly on par,” she says. “People need green spaces.”

This is something that enlightened urban planning has long taken to heart, from the UK’s Garden City movement at the turn of the 20th century to the recently announced plan to turn Paris’s Champs-Élysées, currently a busy thoroughfare, into a green oasis. Our evolving understanding of nature’s broad health benefits, plus our ongoing pandemic experience, is a wake-up call to apply that lesson more widely.

“The pandemic has shown that we don’t have enough [access to nature],” says Berman. That is especially true for people in more deprived socio-economic groups. “Access to green infrastructure is very income-based,” says Ramaswami. A recent survey by Natural England, for example, found that children from low-income families spent less time outside in green spaces during the pandemic than children from higher-income families.

Meanwhile, a study by Berman and his colleagues in Toronto, Canada, found that adding just 10 trees to a city block has a huge impact on people’s perceptions of their health and well-being, equivalent to the effect of earning \$10,000 more per household. If urban greening were an investment priority, it needn’t take much to have a big impact, with the most disadvantaged benefiting the most.

So, what does an ideal green city of tomorrow look like? “I would think of compact, walkable cities,” says Ramaswami. “You want four or five-storey buildings in a liveable fabric. That’s the base. Then you include green spaces that are accessible and equitable.” Berman ➤



L-R: GEOGIFGETTY IMAGES; MIXETTO/GETTY IMAGES

says it is important to make green spaces multipurpose so they meet a variety of needs. He also favours incorporating more natural elements into the built environment, such as green roofs, and even designing buildings that mimic patterns found in nature such as curves and fractals. Research using eye-trackers indicates that people are drawn to such shapes, and Berman thinks there is something about the way our brains process the aesthetic of nature that is comforting.

Advocating for nature itself, Evans's utopia is quite similar, emphasising building compactly to minimise the amount of land taken by cities. "A model green city for me would be one that was relatively densely packed," he says. "But the green space within it would be highly connected and extremely high quality and, crucially, highly accessible to all sectors of society."

Realising such visions won't be easy. Evans says it is incredibly hard to retrofit existing cities to match his ideal, and he doubts that new urban areas will be built with such a brief in mind. "I don't think biodiversity conservation needs are given high enough priority to make that a realistic prospect," he says.

But Ramaswami is more optimistic. She notes that the trend for urban greening has already begun, pointing to some inspiring examples in the US, including the Million Trees Los Angeles initiative and an ambitious greening programme in New York.

This isn't just a richer-world phenomenon, either. Most urban growth in the next decades will occur in lower-income nations. The Milan Urban Food Policy Pact, which aims to increase urban gardening around the world, has 211 cities signed up, many in Africa, South America and South-East Asia. China's Ministry of Ecology and Environment, established in 2018, has made fighting pollution one of its three

People use green spaces for physical and social activity, here tai chi in Taiwan

critical battles, spurring the building of parks, green spaces and wildlife corridors in many cities. Admittedly, lower-income countries face many challenges in building greener cities, but they can learn from the mistakes already made in older-growth cities in the West, says Ramaswami. "There's a lot of opportunity for sustainability in developing cities," she says.

Urban greening

Some researchers are thinking of new ways to get policy-makers across the world to value nature more. Biologist Gretchen Daily at Stanford University in California pioneered the concept of ecosystem services as a way of evaluating the benefits nature provides and factoring these values into economic decision-making. In conjunction with Berman and others, she published a paper in 2019 outlining how this approach could be used to put a price on the mental health benefits of nature in cities. "The intense pressure on urban land means we need to invest strategically," she says. Daily has founded the Natural Capital Project, which offers free science-based computer programs to guide such investments. "Software modules on health are being tested now for release in the first half of 2021," she says.

But it will take more than policy-makers

to push urban greening up the agenda. "We need a grassroots movement," says Berman. Community involvement ensures that different cultural and local needs are met, says Ramaswami. "You want the imagination of those people in those communities to think of their own vision."

In some parts of the world, that is already happening: the economically disadvantaged favelas of Rio de Janeiro in Brazil, for example, are home to a burgeoning forestation movement. A common problem, however, is that people don't know about the benefits of nature, says Berman. "Scientists need to work a bit harder to get out of the ivory tower, to get their message across," he says. "It's important to talk to communities. It's not going to work to be paternalistic."

And it isn't just about knowledge: people need to also experience the effect that urban green spaces have on their sense of well-being. "If we can do interventions where we can encourage people to try it, then I think they will buy in," says Berman.

That is why the pandemic could be such a powerful force for change. "Our planning – today and into the future – will affect the well-being of billions of people," says Daily. And if we can build back greener, that will create a virtuous circle. Recent studies from both China and England find that feeling more connected with nature makes people more likely to adopt positive environmental behaviours. If so, then greener cities won't just improve the mental health of their residents, but also focus our minds on the needs of nature beyond our urban jungles. ■

Kate Douglas is a feature editor at *New Scientist*. Additional reporting by Joe Douglas

"How we plan cities now will affect the well-being of billions in the future"



GUY EDUARDES/NATUREPL.COM

Monsters of the seas

Giant waves that rise up out of nowhere and wreak havoc on shipping are more common than we feared. **Petro Kotze** investigates

“**F**or God’s sake, hold on! It’s got us!” When explorer Ernest Shackleton uttered these words in Antarctica in 1916, his ship *Endurance* had already been crushed by ice and sunk. Desperately rowing to the island of South Georgia with a small crew, Shackleton spotted another disaster heading their way: an enormous wave.

“During twenty-six years’ experience of the ocean in all its moods I had not encountered a wave so gigantic. It was a mighty upheaval of the ocean, a thing quite apart from the big white-capped seas that had been our tireless enemies for many days,” he later wrote, “but somehow the boat lived through it.”

Although freak waves like Shackleton’s “mighty upheaval” are peppered through mariners’ tales, on dry land, accounts were met with raised eyebrows. However, when a gargantuan wall of water slammed into the Draupner oil platform in the North Sea on 1 January 1995, science finally caught up with folklore. Dubbed the New Year’s wave, it was ➤

the first official recording of a rogue wave. The 25-metre giant rose from a surrounding sea churned by waves averaging 12 metres.

Since then, our understanding of the complex forces that drive water to abruptly rise to create rogue waves far taller than those around them has become clearer, propelled by more reliable measurements, advances in wave modelling and ramped-up computational power.

Destructive power

But to protect ships and lives at sea, we need to predict when these rogues will occur. Given the complex patterns of waves across the vast reaches of the seas, making accurate forecasts is no simple task. Still, the need for such predictions may be getting more urgent; as climate change intensifies weather systems, we may see even more of these ocean monsters.

Waves are swells of energy, created mainly by wind. They grow bigger over distance when egged on by strong winds, and very occasionally the conditions cause one to rise far higher and much more steeply than its neighbours. While there is no set definition of a rogue wave, it is generally accepted that they have a crest-to-trough height that is more than twice the average height of the tallest third of the surrounding waves.

In essence, a rogue wave is a very high concentration of energy, says Alessandro Toffoli at the University of Melbourne, Australia. These monsters can appear as walls of water reaching close to 30 metres in height, with great destructive power (see “Four freaks”, p 45). They pose a serious threat to even the largest vessels, and are estimated to have sunk at least 22 supertankers between 1969 and 1994 with the loss of more than 500 lives. Even when less extreme, they can still be deadly. In South Africa, many anglers have died after being washed from the rocks by freak waves on calm days in False Bay, a location that has consequently been dubbed “death coast”.

These giants can come in groups, too. On 30 November 2018, a series of three abnormally high waves were spotted by radar in the North Sea. Dubbed the Justine Three Sisters, this was



JOHN LUND/GETTY IMAGES

the first formal detection of a rogue triplet.

Rogues appear unexpectedly, so are very challenging to study at sea. Ironically, wave researchers are unlikely to ever see one. Instead, they rely on data from remote monitoring and laboratory simulations to understand and visualise their behaviour.

So what causes them? Originally, they were thought to arise through a straightforward mechanism, where waves with different speeds and directions interact with each other and, under the right conditions, merge. But this so-called linear approach doesn't account for all rogues, and it also predicts that they should be extremely rare – yet we now know that freak waves aren't so freakishly uncommon.

When the MaxWave project carried out the first census of rogue waves using European Space Agency satellites, for instance, it identified at least 10 rogues in a region of the South Atlantic within a three-week period in 2001. And a 2011 study of buoy data estimated that there is a 1 per cent chance per day of

encountering rogue waves higher than 11 metres along the main shipping routes of the North Atlantic.

According to an alternative approach to modelling the ocean surface, instead of being created by simple merging, these giants can be understood in terms of the physics of the movement of wave energy. This uses equations such as the Schrödinger equation, which can help predict future behaviour of chaotic systems such as stock markets or weather patterns. This “non-linear” method predicts that rogue waves aren't so rare after all, as confirmed by observations in the real world.

“We believe there are many more of these waves than we expect,” says Elzbieta Bitner-Gregersen, who studies rogue waves at DNV, a consultancy in Oslo, Norway. Toffoli came to a similar conclusion while “playing around” with the conditions under which wind-generated waves would turn rogue in a 2017 study. He and colleagues used a ring-shaped tank at the University of Turin, Italy, to run their tests. The customary laboratory



Knowing what causes rogue waves could help us forecast them (composite image)

“These monster waves can appear as walls of water up to 30 metres in height”

practice is to generate waves with paddles in a straight tank, but their novel circular tank allowed fan-generated waves to flow freely and, in principle, indefinitely.

Rogues in the wild

The researchers measured the surface elevation as the wind blew over the water, increasing the wind speed until the waves were saturated with energy. At that point, just before the wave broke, the probability of extreme waves “went sky high”, says Toffoli.

But it is all very well understanding waves in the controlled environment of a lab. It is a completely different matter out at sea. “The big question is: can I find the results that I’ve seen in the model, and in the lab, in the real ocean?” says Toffoli. In 2017, after 15 years of studying centimetre-high freak waves in labs, Toffoli set out to do just that. He was on board South Africa’s Antarctic research vessel, the SA Agulhas II, as part of a University of Cape Town-led expedition. They were on a mission to ➤

Was The great wave a rogue?

The Great Wave off Kanagawa is one of the most famous images in Japanese art. Katsushika Hokusai’s image, printed in 1831–33, captures the moment three cargo boats battle a huge wave, with Mount Fuji in the background. “For a long time, this painting was used as an illustration of a tsunami, but a tsunami doesn’t look like this at all,” says Frédéric Dias at University College Dublin, Ireland.

In 2013, Dias co-authored a paper which concluded that a process called linear focusing can predict characteristics similar to those of the Great Wave. The authors also pointed out the remarkable similarities of the wood print to a rogue wave photographed in the sub-Antarctic by Véronique Sarano, founder of the French organisation Longitude.

Sarano happened to witness the wave while on

board the French icebreaker L’Astrolabe on the way to Antarctica in 1991. It was a sunny day and sea conditions were “not very rough”, she says. Suddenly, a much bigger wave, around 7 metres from peak-to-trough, emerged, and Sarano, alone on deck, quickly took a shot of it.

It isn’t the first time the Great Wave has been called a rogue. A 2009 paper pointed out that the wave, estimated at 10 metres, is so much larger than the average waves in Tokyo Bay that it must be a freak. A tsunami at sea, in comparison, is just “an unnoticeable small amplitude swell with a very long wavelength”, the authors wrote.

To ram this point home, in 2019 researchers created a wave strikingly similar to the Great Wave in their laboratory, using two smaller wave groups travelling at a crossing angle.

The great wave off Kanagawa might be a depiction of a rogue wave



KATSUSHIKA HOKUSAI PUBLIC DOMAIN

characterise the waves in the Atlantic and Indian ocean sectors of the Southern Ocean, especially at the margin with the sea ice. One of Toffoli's aims was to establish the probability of extreme waves in this area.

Unexpectedly, the conditions turned. "We were so lucky to find ourselves at the edge of the sea ice in the middle of a polar hurricane," says Toffoli. "It was a once-in-a-lifetime experience." With the data still to be confirmed, Toffoli is careful not to claim that he saw an actual rogue, although he describes the findings as "very exciting". When that research is published later this year, it should provide insight into how closely his experimental wave patterns map onto waves seen in the wild.

Meanwhile, also of great interest to researchers are the shipping lanes off the east coast of South Africa, where dozens of ships have been damaged or sunk as a consequence of rogue waves. Here, the Agulhas current thunders southwards at speeds up to 8 kilometres an hour, eventually meeting up with massive ocean swells from the Southern Ocean running in the opposite direction. In 1991, a large oil tanker called the ULCC Mimosa was hit by a wave that its captain described as the biggest he had ever seen. The ship limped to port with a hole of more than 20 square metres in its side.

Researchers are hopeful their models can make these channels safer, but something in the data wasn't adding up. "We were very much aware that the Agulhas current influences the wave climate along the east coast," says Christo Rautenbach, former marine scientist at the South African Weather Service (SAWS), now at the National Institute for Water and Atmospheric Research in Hamilton, New Zealand. Yet the actual wave recordings from the region didn't correlate with the researchers' models of the movement of energy in the waves, he says.

Then in 2020, new computer simulations revealed how other factors – the strength of the current and its direction relative to the direction of the waves – affect wave height. "When the waves oppose the direction of the current, the current will slow the wave down," says Michael Barnes at SAWS. "This results in



JOHN LUND/GETTY IMAGES

Rogue waves are thought to have sunk at least 22 supertankers between 1969 and 1994 (composite image)

“We were lucky to find ourselves in the middle of a polar hurricane”

wave steepening." It also focuses the energy into a rhythmic succession of waves known as a wave train. Based on these results, the SAWS has launched the first wave forecasting system which includes the effect that the Agulhas current has on wave steepening. Although it is still a far cry from predicting individual rogues, Rautenbach says it can statistically paint a better picture of where and when to be on the lookout for extreme waves, and these forecasts are now broadcast through maritime alerts.

Death coast

New research has also clarified the mechanics of South Africa's "death coast". This shows that a shallow bank acts like a lens, refracting the incoming open ocean swell and focusing the wave energy towards the shore, creating unexpectedly large waves under certain conditions. Researchers are hopeful that this information could ultimately prove useful for creating coastal warning systems.

Rogue-wave forecasting has moved forward in the North Atlantic too, through Extreme Wave Warning Criteria for Marine Structures or ExWaMar, a Norwegian project that aimed to develop warning criteria based on weather forecasts. ExWaMar further highlights the challenge of predicting these rare events.

First, the ExWaMar researchers used wave

Four freaks

Most rogue waves pass unnoticed in the oceans, but occasionally they get spotted or cause damage to a ship. Here are four notable recent ones

Significant wave height (average crest-to-trough height of the tallest third of surrounding waves)



Dec 2010

Significant wave height: 3.5m
Rogue wave height: 9m

Cruise ship Clelia II is hit by a 9-metre wave while returning from Antarctica. The wall of water smashes the pilot's window on the fifth deck, knocking out all communications, with passengers "rattled like dice in a casino".

Oct 2015

Significant wave height: 9m
Rogue wave height: 23.4m

Cargo ship SS El Faro travelling from Florida to Puerto Rico sinks during Hurricane Joaquin, with all 33 crew lost. According to analysis of the sea state, it was hit by a massive rogue wave.

Nov 2006

Significant wave height: 3.9m
Rogue wave height: 21m

A huge wave smashes the windows of the bridge of container ship Westwood Pomona in the Pacific Ocean, damaging the electronics and forcing the vessel to seek shelter at port in Oregon for repairs.

Nov 2007

Significant wave height: 10m
Rogue wave height: 23m

The Andrea wave, one of the steepest rogue waves ever recorded, was detected at a North Sea oil platform during a storm.

and weather data to see if they could simulate irregular waves, using a method based on the Schrödinger equation. This approach was able to successfully recreate that famous Justine Three Sisters triplet, proving that accurate forecasting is in fact possible.

There was, however, a snag. This process is so computationally "intense", says Bitner-Gregersen, who led the project, that it is impractical for meteorological offices to use. Instead, the ExWaMar researchers turned to less computationally demanding alternatives, including using machine learning, to predict indicators of rogue waves. They had some promising results, but it is still not enough to accurately forecast individual rogues.

Bitner-Gregersen thinks the solution may be to zoom out a bit. "The sea surface is random. It oscillates," she says, and so it doesn't make sense to develop warning criteria for a single point. Instead, the ExWaMar criteria for the risk of rogue waves should be applicable to an area of 2.5 square kilometres. This strategy is currently being tested, with the aim of including these predictions in the Norwegian Meteorological Institute's open access weather maps, which look ahead to the next six days.

If this proves accurate, the strategy could be rolled out internationally, she says. This would add a new level of detail to the predictions of organisations such as the European Centre for

"In the future, extreme waves may be more likely due to climate change"

Medium-Range Weather forecasts, which now provide estimates of the tallest waves to expect in an area.

Making better predictions of rogue waves could already help to make the seas safer for ships in potentially dangerous waters, but many believe this need will become even more pronounced in future. Extreme waves may become more likely as a result of climate change, both due to an increase in storm activity and the fact that melting polar ice will give the wind a larger sea surface to blow over.

It is also possible that the changing climate won't cause more rogue waves, but instead fewer, bigger ones, as has been observed in a study of rogue waves off the western US coast.

Predicting these trends is even more tricky than forecasting rogues. Another Norwegian project, called ExWaCli (Extreme Waves &

Climate Change), ran from 2013 to 2016 to investigate changes to the North Atlantic wave climate with an eye on safe ship design. Large variations in climate change projections, future ice coverage and winds made it tough to draw many robust conclusions.

However, it did highlight some places in the North Atlantic that could face more rogue waves. In one area off the coast of northern Norway, for example, they could result from melting sea ice combined with potential increases in wind duration and speed. The results show that conditions ripe for rogues will be more common, says Bitner-Gregersen. Changes to the extent of sea ice and more swell due to climate change in the Arctic may also increase the occurrence of rogue waves there.

There is a long way to go to be able to accurately predict rogues in the wild. In the meantime, watch out. The maths shows that "super rogue waves" up to five times higher than those around them are theoretically possible. Not only that, but they have been generated in a tank. What would Shackleton have said if he had encountered one of those? ■



Petro Kotze is a freelance writer based in Cape Town, South Africa

The hidden costs of AI

Beyond the headline breakthroughs, artificial intelligence is a planet-wide industrial complex that is already reshaping our world,

Kate Crawford tells
Timothy Revell



ARTIFICIAL intelligence is everywhere these days, from the Alexa virtual assistant in your kitchen to the algorithms that decide on your suitability for a job or a mortgage. But what exactly is it? The definition matters because to a great extent it dictates how we think about AI's impact.

If AI is something that outperforms humans by definition, it seems logical to trust it to identify people who should be stopped and searched via facial recognition, say, or to make judgements on which offenders should get probation. If it is solely about algorithms, it becomes a lot easier to sweep aside issues of bias and injustice as mere technical issues.

Kate Crawford takes a broader view. Co-founder of the AI Now Institute at New York University and now a researcher at Microsoft Research and the École Normale Supérieure in Paris, she has spent the best part of two decades investigating the political and social implications of AI. In her new book, *Atlas of AI*, she also looks at the global infrastructure that underpins the rise of this technology.

She argues that AI, far from being something abstract and objective, is both material and

intrinsically linked to power structures. The way it is made involves extracting resources from people and the planet, and the way it is used reflects the beliefs and biases of those who wield it. Only when we come to terms with this, says Crawford, will we be able to chart a just and sustainable future with AI.

Timothy Revell: What is AI?

Kate Crawford: I think of it in three ways. Technically speaking, it is an ecosystem of techniques that we can put under the banner of machine learning. Secondly, it's about social practices: who is designing the systems and who is deciding which problems to solve. And finally there is infrastructure, the process of massive data harvesting and where it is going.

Why do we tend to focus on the technology itself rather than its effects?

There's a tendency to be blinded by innovation. In the 1970s, Joseph Weizenbaum, who created the first ever chatbot, called Eliza, noticed that people were completely prepared to be taken in by the powerful delusion that AI systems were entirely autonomous technical boxes that could

engage with us as autonomous entities. He said there was a trap we would fall into, in that we would focus too much on technical innovation and not on the deeper social impacts these systems would have. Weizenbaum wrote about these issues in the mid-1970s and we still haven't learned that lesson.

You say in your new book that AI is neither artificial nor intelligent. What do you mean?

Often when people think about artificial intelligence, they'll think about binary code and math, or something that's ethereal and in the cloud, or they might think about a series of corporate products like Alexa, Siri or Google's search algorithm. But none of these things are artificial – in fact they are profoundly material. They only function because of large amounts of data scraped from the internet and an enormous extraction of resources, including minerals, energy and the human labour that is necessary to label the data used by AI systems. In this sense, AI is a material system that is very much coming from humans, created by humans, and more widely from the earth.

Then we think about intelligence. There's ➤

a trap, in which ever since the very early days of AI we have assumed that computers were like the human mind. The writer and engineer Ellen Ullman once wrote that the belief that the mind is like a computer, and vice versa, has infected thinking in the computer sciences for so long that it has become like an original sin. We don't look at how these systems are different to human intelligence. They're doing statistical analysis at scale and that's very useful for some things. But let's be really clear: it's not like human intelligence.

How does thinking of AI like human intelligence cause problems?

One phenomenon I discuss in my book is the idea of enchanted determinism, the belief that these systems are both magical and at the same time can provide insights about all of us in ways that are superhuman. This means we're not expecting these systems to produce forms of bias and discrimination. Nor do we focus on the ways in which they're constructed and their limitations.

What have you learned about how products that use AI are made, and the impact that has on people and the environment?

One of the most eye-opening projects I've worked on was "Anatomy of an AI System" with Vladan Joler at the University of Novi Sad in Serbia. We traced the life cycle of a single Amazon Echo, the voice-enabled AI system. It was remarkable how difficult it was to track where all of the components came from, to study the ways in which user data is harvested and processed, all the way through to the devices being disposed of in e-waste tips in countries like Ghana and Pakistan.

That project inspired me to look deeper into the full logistical pathways and supply chains of the AI industry. AI requires a lot of industrial infrastructure. When I started researching the book, I began by focusing on hardware. But the past few years we've all learned a lot about the large energy consumption of AI. If you look at cutting-edge systems like OpenAI's GPT-3, a language model that produces human-like text, they are extremely energy intensive. There is a

sizable carbon footprint and we need to contend with it. Combine that with the labour exploitation that happens on digital piecework services like Amazon Mechanical Turk and you can start to see the ways in which AI can be understood as an extractive industry.

You say that it is inherently political too. How?

Artificial intelligence is politics all the way down. From the way in which data is collected, to the automated classification of personal characteristics like gender, race, emotion or sexual identity, to the way in which those tools are built and who experiences the downsides.

Time and time again we've seen that people who are already marginalised are the ones who experience the worst harms from large-scale artificial intelligence systems. We've seen communities of colour targeted by predictive policing systems, immigrants surveilled and tracked by deportation tools, and people with disabilities cut off from support services due to poorly designed healthcare algorithms.

I'm optimistic when I see people starting to demand greater justice, transparency and accountability. We've seen widespread student protests in the UK over algorithmic mismanagement in the education system and we've seen substantial public pushback around facial recognition in the US.



HOWARD LIPIN/TNS/ALAMY

AI-powered virtual assistants are harvesting your data

Are we also seeing government pushback? Like when the Australian government drafted legislation for big tech firms to pay for content from news organisations and Facebook responded by briefly turning off all news for Australians on its platform?

It was horrifying to see that. This was a signal being sent by Facebook to the world that says: "If you pass laws that we don't like, we will simply take our toys and go home." And given how many countries right now are looking to produce much stricter forms of regulation on the tech sector, it seems like a troublesome type of strongman tactics.

Are tech companies any different to powerful companies that have gone before them?

Tech companies have taken on the roles of states in terms of things like providing civic infrastructure. Facebook, for example, has spent huge amounts of money to convince populations that they are the place where you can communicate with family, where student groups can put up their information. This is where you connect with your communities. What was so extraordinary to see was that this civic infrastructure can be switched off any minute. The power of technology companies has in some ways leapfrogged the power of states and this is very unusual.

What can we do about that?

We have a long way to go, but I'm actually optimistic. Think about the car. Cars didn't have safety belts for decades, but now laws mandating them have been passed around the world. You can also think about the way that some countries have extremely strong food safety regulations that have a real impact on people's lives. We have to come up with similar policies to control the harmful impacts of artificial intelligence.

In terms of the bias built into AI and the unjust outcomes it produces, are we just seeing the tip of the iceberg?

If you think about the biggest stories about bias in AI over the past decade, they've come because an investigative journalist, a whistle-blower or a researcher has discovered



AI companies are marketing emotion-detection technology to spot potential criminals

"Artificial intelligence is politics all the way down"

a particular issue. But there is a myriad of issues that have never been made public, which is why we need to shift our focus from the idea that bias is a thing that requires a tech fix to looking at ways in which discrimination is built into the DNA of these systems, such as in the data sets used to train them.

What are the most problematic uses of AI you can see coming down the track?

One I find particularly concerning is so-called emotion detection. There are companies that use this in hiring tools so that when you're doing a job interview, the micromovements in your face are being mapped to all sorts of interpretations of what you might be thinking and feeling – often in the context of previous successful applicants. One of the problems with that is that you end up hiring people who look and sound like your existing workforce.

There was also a tool that has been marketed for shopping malls that looks at people's faces to see emotions that will indicate that you might be about to steal from shops. What was the training data for that, and what are the assumptions about what somebody looks like when they are shoplifting?

Does the underlying technology of emotion detection work?

It has been almost entirely demolished. Psychologist Lisa Feldman Barrett looked

at every single paper that's ever been written on this question and found no correlation between the expression on your face and your internal emotional state. Which, frankly, is known to anyone who has had their picture taken by a photographer who said "smile".

What is really interesting is how the assumption becomes ingrained in a field like machine learning. It is a case of the theory fitting the tools. Machine learning can look at movements of the face, so if the theory says there are universal emotions that can be detected from microexpressions, then AI can be used. Or misused. And it can end up being applied in something as important as education or criminal justice.

When it comes to the future of AI, are you an optimist or a pessimist?

I'm a sceptical optimist. I am optimistic about the ways in which we think about the next generation of civic infrastructure. How do we make sure infrastructures are going to really serve us, and in ways that can't just be switched off in the middle of a political negotiation, as we saw with Facebook and Australia?

The conversation about climate change has reached a point that means we are going to think about the impact technical systems have on the planet from an energy and natural resources perspective. I'm also optimistic that, in some ways, AI allows us

to have conversations about how we want to live. These conversations have often been quite segmented. If you think about conversations about labour rights, climate justice and data protection, they've primarily been in very separate silos, but right now artificial intelligence touches each one. This is the moment to bring those issues together.

So the detrimental effects of AI, which is still in its infancy, can be reversed?

The important thing to remember is that no technology is inevitable. Just because something is designed, doesn't mean it has to be widely deployed. And just because something has always been done a certain way, doesn't mean we can't change it.

That is the most important thing when we think about labour exploitation, environmental degradation and the mass harvesting of data, all of which can be profoundly detrimental. These are all practices that can change, and the great legacy of industry over the past 300 years or so is that industries have changed once regulated. We can remake these systems and there's profound political hope in that. ■



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For an informal discussion about your application, please contact the Centre Director. We also welcome conversations with any organisations who want to become part of our growing stakeholder community. Professor Matt Jones (Director-Enhance-CDT@swansea.ac.uk).

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Science of gardening

Wonderful nectar

Some pollinating insects are in decline. Gardeners can help by growing flowers rich in nectar in their gardens, says **Clare Wilson**



Clare Wilson is a reporter at New Scientist and writes about everything life-science related. Her favourite place is her allotment @ClareWilsonMed

What you need

Plants, mainly with flowers that are single varieties. Avoid too many double flowers, which lack nectar

MOST people are aware that bees are in trouble. Due to factors including habitat loss, use of pesticides and a mysterious phenomenon called colony collapse disorder – when most of a hive's workers just buzz off – many bee species are seeing downturns in their numbers worldwide.

There have also been declines in other pollinating insects, such as hoverflies, which, like bees, rely on sugar-rich nectar from flowering plants. The amount of nectar in England and Wales fell by about a third in the past century, mainly due to changes in farming practices, such as the growing use of weedkillers and the loss of hedgerows.

But it isn't all bad news. In the UK, big changes in farming had mostly petered out by the 1970s; nectar availability stopped falling and has even risen slightly since. On average, the UK's towns and cities have as much nectar available for pollinating insects per square hectare as farmland and even nature reserves and parks, according to a recent study.

The nectar bounty of such areas is down to home gardeners. "The decisions you make as a gardener really do make a difference," says ecologist Nicholas Tew at the University of Bristol, UK, who led the research.

Tew's team analysed the nectar supply from urban areas, farmland and nature reserves by gathering existing data and also by measuring nectar production from more than 3000 flowers by sucking it out in fine glass tubes.



SHUTTERSTOCK/RUDAK HANNA

They found that the nectar supply from urban areas was actually better than that from farms and nature reserves because it was from a more diverse range of plants: gardeners tend to stuff their flower beds with a broad range of non-native species.

This is good for insects as it helps ensure nectar is available throughout the year, and there are options that suit different species. "If you have a lot of different plants, all pollinators will be able to find something they like," says Tew.

People who want to maximise nectar in their garden should mow the lawn less often, use fewer pesticides and avoid too many frilly "double" flower varieties. These showy blooms, such as some varieties of roses and

dahlias, look gorgeous but lack nectar because the reproductive parts of the flower have mostly been converted into extra petals.

In "semi-doubles", only some of the reproductive parts have been made into petals. Usually, if you can see the yellow-topped anthers in the middle of the flower, insects can reach the nectar.

Some large, exotic flowers normally pollinated by birds are too deep for insects to be able to reach the nectar. However, smart bees and wasps have been spotted stealing the nectar by cutting holes at the base of the flowers. "Pollinators are very ingenious," says Tew. ■

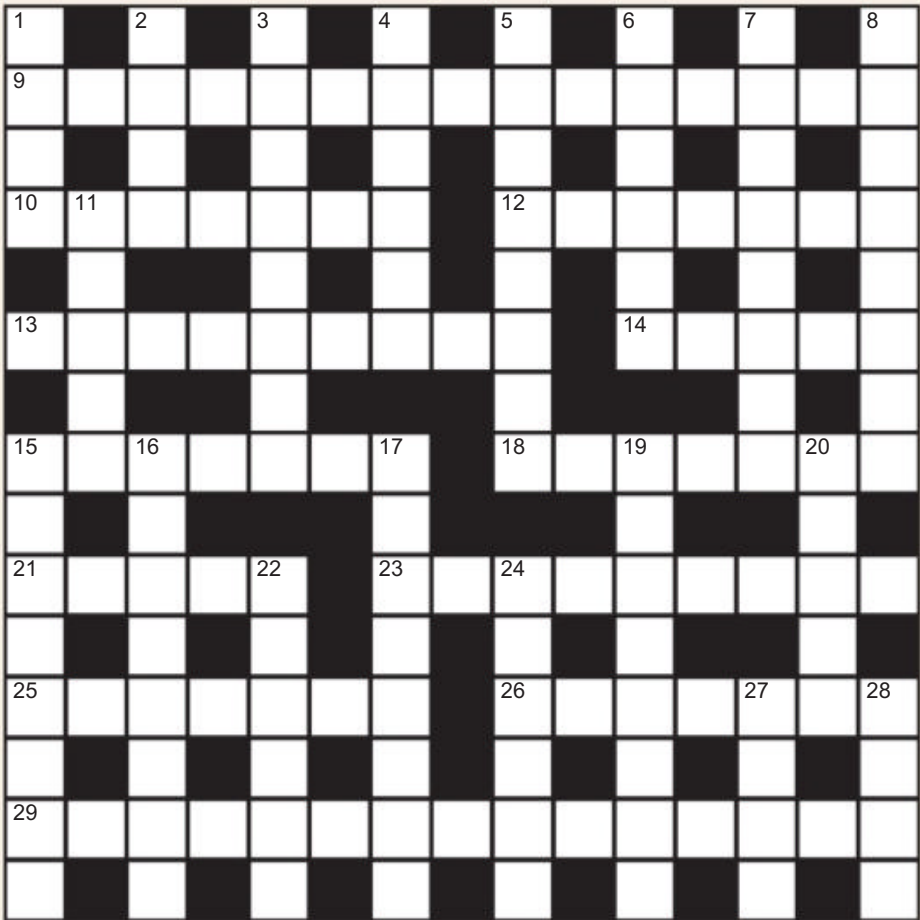
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Citizen science

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Quick crossword #79 Set byRichard Smyth



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

- 9 Component in the irresistible force paradox (9,6)
10 Unit of energy (7)
12 Medical study of the ear (7)
13 Microsoft co-founder (4,5)
14 Fly without thrust (5)
15 Negatively or positively charged (7)
18 Power (7)
21 Forged; staged (5)
23 Concerning colour (9)
25 Brought about deliberately – of coma or childbirth, perhaps (7)
26 Glass apparatus used in titration (7)
29 Doctors' pledge (11,4)

DOWN

- 1 Zn (4)
2 ___ nitrite, C₅H₁₁ONO (4)
3 Means, perhaps (8)
4 Entity (6)
5 Mid-sized joinery tool (5,3)
6 Rectangle (6)
7 Plant genus that includes speedwell (8)
8 Alkene, C₂H₄ (8)
11 ___ acid, compound important in animal biology (5)
15 Airborne (2,6)
16 The ___, 1967 anthropology work by Desmond Morris (5,3)
17 People or machines that convert or decrypt (8)
19 Tree also known as red larch (8)
20 Grain for milling (5)
22 MD or PhD (6)
24 Droids or Transformers, perhaps (6)
27 Streetcar (4)
28 E, in the NATO phonetic alphabet (4)

Quick quiz #94

- 1 When did the largest geomagnetic storm recorded on Earth occur?
2 What plants do galanthophiles collect?
3 Seahenge, an ancient timber circle in Norfolk, UK, is believed to have been built when?
4 What trait of elephants, manatees and kangaroos is unusual among mammals?
5 Who holds the record for the longest time spent continuously in space?

Answers on page 55

Puzzle

set by Tom Rainbow
#106 Having a dart

Where should I aim to maximise my score when I play darts? If I were a pro, I should aim at 20. However, I tend to miss, so maybe I'd be better off aiming at 19, with its higher scoring neighbours. Or close my eyes and aim randomly? I tried an experiment. Throwing three darts in a turn, I had six turns with each of those strategies. My scores:



Set A: 76, 13, 18, 83, 38, 40
Set B: 49, 19, 57, 14, 78, 20
Set C: 41, 85, 45, 20, 19, 59

All darts scored, and when not blindfolded, my darts always landed on the number I aimed for or one either side, sometimes hitting a double or treble. Can you work out which strategy I was using with each set of darts? Do you have any advice for me?

Answer next week



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SAVE SCHRÖDINGER'S CAT

ONLY TWO THINGS ARE INFINITE:
 THE UNIVERSE
 AND HUMAN STUPIDITY.
 AND I'M NOT SURE ABOUT
 THE FORMER.
 ALBERT EINSTEIN

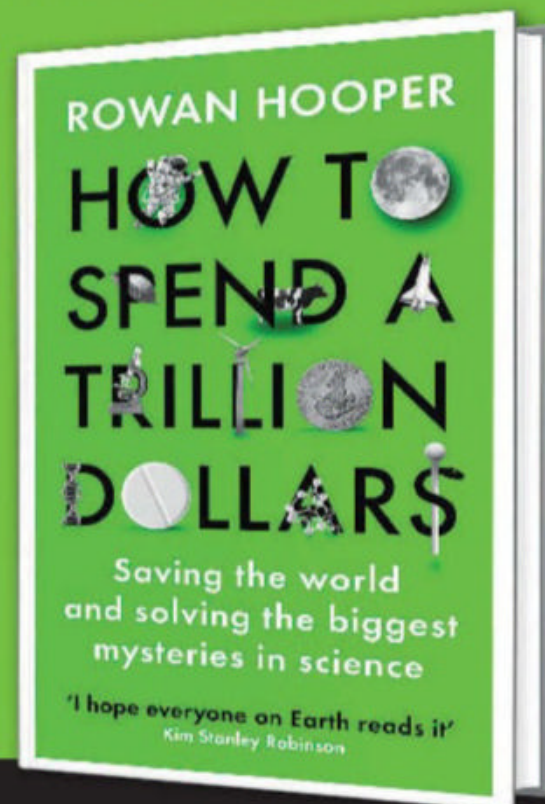
EARTH IS ROUND
VACCINES WORK
WE'VE BEEN TO THE MOON
CHEMTRAILS DON'T EXIST
CLIMATE CHANGE IS REAL
DINOSAURS HAD FEATHERS
EVOLUTION IS A FACT

We Do Mugs Too!

Rowan Hooper doesn't have a trillion dollars – but if he did...

**'Original and ingenious...
I hope it sells a trillion.'**

PHILIP PULLMAN



P
PROFILE BOOKS

THE ULTIMATE THOUGHT EXPERIMENT – OUT NOW

Feline fix

Is it possible, or desirable, to produce a genetically engineered cat that doesn't have an urge to kill wildlife?

Tilly the cat,
transcribed by Pat Sheil
Camperdown,
New South Wales, Australia

I am more than happy to be part of any experiment that involves the genetic modification of domestic cats to reduce their desire to attack endangered wildlife, but on one condition: that I, Tilly, highly evolved carnivore that I am, be part of the unmodified control group, given free and equal access, 24/7, to the same wildlife as my CRISPRed fellow research subjects.

Any results obtained without such controls would clearly be meaningless. Agreed? Well, count me in.

Anne Barnfield

London, Ontario, Canada

A simpler solution to this problem may be environmental rather than genetic. Recent research shows giving household cats engaging play opportunities and a diet high in meat protein significantly decreased predation by the cats studied (20 February, p 21).

Saif Ahmad

Basingstoke, Hampshire, UK

Humans first domesticated animals thousands of years ago.

"I, Tilly the cat, am happy to be part of a genetic experiment to reduce the urge to attack wildlife... on one condition"

Back then, the main reason why was to aid human survival. Cats were probably domesticated to help get rid of pests. It is only in very recent times that cats have been kept as pets rather than for their killing abilities.

It may be possible to genetically engineer them to make them less



HYDROMET/GETTY IMAGES

This week's new questions

Popular support What is the minimum population needed to sustain me in a comfortable life in the US, in terms of the people who create and maintain infrastructure, goods and services? The combinatorial explosion of dependencies boggles my mind: for instance, I enjoy *New Scientist*, so its journalists and all their dependencies would have to be added in too. And so on... **Bill Hay**, Lacey, Washington, US

On time Since I was a child, most measurements have been decimalised. Why not time? **Ruth Garrod**, London, UK

inclined to kill wildlife. However, this might come at the risk of losing desirable features like playfulness and independence.

Maurice Pitesky

University of California, Davis, US

Without predatory cats, I suspect that poultry farms throughout the world would have a much bigger rodent problem. Historically, barn cats have played a role in hunting rodents that eat chicken feed.

One upside if cats didn't hunt wildlife would be a reduction in the disease toxoplasmosis, caused by the parasite *Toxoplasma gondii*. The only place that this pathogen can reproduce is the gut of a cat,

and the only way it can spread to cats is via the ingestion of an infected animal, typically a rodent.

Without the predatory behaviour of cats, *T. gondii* couldn't reproduce and the infection rate of toxoplasmosis in humans (which can be up to 50 per cent in some populations) would decrease.

Brian Stewart

Elgin, Moray, UK

I have long believed that we should intervene to suppress the hunting instincts of predators. Nature is unthinking, and indifferent to the suffering of sentient creatures.

Clearly this would have wide-reaching consequences for the

What is the minimum population needed to sustain a good lifestyle?

tangle of life on the planet, but I am confident our superbeing descendants will be capable of reprogramming the world.

This isn't a new idea. For thousands of years, many religions have questioned how a benign God could create and oversee so much violence and suffering. The Bible refers to a future time when ravenous beasts become peaceable, in which "the lion will eat straw like the ox" and "the wolf and the lamb will feed together".

Pull the other one

If there are other universes, would our universe feel their gravity?

Mike Follows

Sutton Coldfield,

West Midlands, UK

We can't be certain. Recent astronomical evidence supports the view that the universe is infinite in extent.

At the same time, Einstein's general theory of relativity suggests that our universe is finite but lacking a boundary or outer edge. As an analogy, imagine that our universe is the surface of a sphere; this would give it a limited size without a boundary.

This ushers in the possibility that parallel universes exist "beyond" our own. If this were the case, we might expect to see peculiar motion of galaxies in our universe as they are pulled towards a massive neighbouring universe.

Using the European Space Agency's Planck spacecraft, scientists have looked for evidence of this in the cosmic microwave background radiation, but have found no sign of it.

Quantum mechanics, however, hints at a multiverse. The famous double-slit experiment shows that an electron behaves both as a wave and a particle, and can pass through a pair of adjacent slits at the same time.



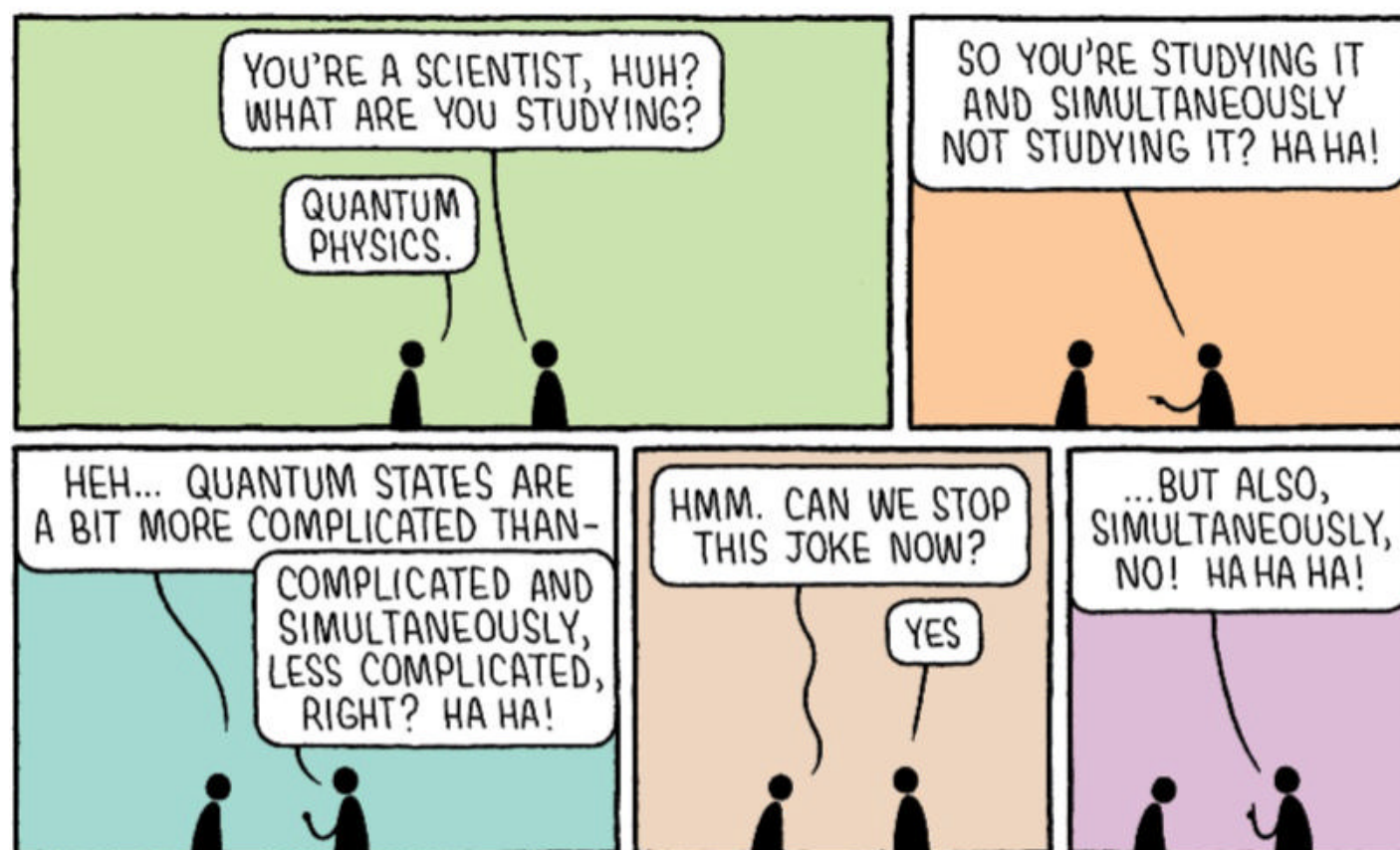
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Tom Gauld
for *New Scientist*



In 1925, Erwin Schrödinger came up with his eponymous equation to describe this wave-like behaviour. The equation implied that many different states are possible, even if only one is seen. This was “solved” by the Copenhagen interpretation, which holds that the act of observing the particle banishes all the other states.

Later, Hugh Everett III devised his many-worlds interpretation of quantum mechanics, suggesting that all the states not seen in our universe are seen in parallel universes. A phenomenon called quantum entanglement would allow all the parallel universes to act in unison, each exhibiting a different state.

But the jury is still out on whether we live in a multiverse.

Roger Savidge

Shoreham-by-Sea, West Sussex, UK
The term “universe” is widely accepted to mean everything that exists, which would clearly exclude the possibility of other universes existing, except in our

“Our universe could be an insignificant dot in a multiverse of billions of galaxies of universes, and could feel their gravity”

imagination. Therefore, any meaningful discussion of “other universes” requires a more restricted definition.

One such definition is that “our universe” includes everything whose existence we can verify – in other words, everything that is capable of interacting with us, even if, like dark matter, it only does so gravitationally. Anything that affected us gravitationally would therefore be a part of our universe.

It is possible to conceive of the existence of a form of dark matter that doesn’t even interact gravitationally. Such matter and anything composed of it would truly occupy another universe, even if contiguous with our own in space and time.

However, the existence of

such other universes could never form the basis of a scientific theory since it is unfalsifiable. It can never be more than speculation.

Shake it off

Why do dogs like to shake themselves dry besides a person rather than doing this as soon as they get out of the water? (continued)

Eric Kvaalen

Les Essarts-le-Roi, France

Previous correspondence on this topic, describing the physics of the motion that dogs use to shake water off their wet fur, referred to the “centripetal” force caused by the movement.

“Centripetal” means seeking the centre, whereas “centrifugal” means fleeing the centre.

When a dog, for example, shakes off water, it is the centrifugal force that causes the water to go away from the dog. Centripetal force is what holds the water on the dog. ■

Answers

Quick quiz #94

Answers

- 1 In 1859
- 2 Snowdrops
- 3 In the Bronze Age
- 4 They are polyphyodonts – their teeth are continuously replaced
- 5 Valeri Polyakov

Cryptic crossword

#53 *Answers*

ACROSS 7 Beluga, 8 Purine, 9 Silt, 10 Obsidian*, 11 Kilauea*, 13 Bends, 15 Terms, 17 Furtive, 20 Cinnamon, 21 Sole, 22 Portal, 23 Parrot
DOWN 1 Gemini, 2 Suet, 3 Baloney, 4 Spasm, 5 Gradient, 6 Inward, 12 Ammonite, 14 Turnips, 16 Epizoa, 18 Volvox, 19 Smelt, 21 Surd

*Apologies, two Across clues were wrong. They should have read:

10 Igneous rock formed of silicon detective found in Scottish town;
11 Krill manure occasionally dropping next to a volcano

#105 Mastermind

Solution



The first two rows confirm the colours are four of red/orange/yellow/white/pink/blue, but not green. Row 4 confirms two are red/orange. Row 3 eliminates pink and yellow. The four colours are red/orange/white/blue (grey is the “white” peg, brown is “black”). Blue must be position C or D. If red is in the wrong spot in row 1, its right position is C, but that means orange must be right in row 1, leaving nowhere for blue. So red is right in row 1 and orange must be position B, white D and blue C.

Units of experience

"Imagine an adult African male elephant suspended from a rope that's the same diameter as a table tennis ball." Yes, we're trying very hard to imagine this scenario as we read this passage from an article in *The Wall Street Journal* sent in by Peabody Bradford. Sadly, the effort is failing to help us grasp much meaning from what follows, that the "tension in that imaginary rope is about equal to the tension at the center of a typical piece of tempered glass". Our mental imaging software is busy elsewhere. How exactly is the elephant suspended? Is he entirely happy? Should we be worried?

Feedback has had much cause in recent weeks to muse on the enduring popularity of measurement units such as the Burj Khalifa (20 March) or the massed ranks of the northern hemisphere blue whale (30 January). Now, what we might term "experiential" units seem to be emerging as a distinct journalistic sub-genre.

The key to a good experiential unit is that it should be rooted in an experience that no one could ever be reasonably assumed to have had. Ideally, an excess of detail should make it a very exact unrelatable experience: not for nothing are the sex and life stage of the elephant clearly stated.

As highlighted by many of you, various UK media had clearly got the memo when they reported that a fatberg "with the same weight as a small bungalow" had been cleared from a sewer in the east of London. Clearly, this is a hefty weight – although for those of us who have felt the crushing load of a medium-sized semi-detached bearing down on us, it's not quite as much as that.

Or there is the "Beware of the Rhino" campaign run by Newcastle Transport in New South Wales, Australia, sent in by Ian Dawes. A brief rootle in our piling system reveals that this is an iteration of similar campaigns run in recent years in Australian cities blessed with light rail transit systems, but not necessarily rhinocerotids.

Twisteddoodles for New Scientist



Got a story for Feedback?

Send it to feedback@newscientist.com or

New Scientist, 25 Bedford Street, London WC2E 9ES

Consideration of items sent in the post will be delayed

"Did you know a Newcastle tram is as hard to stop as a herd of thirty rhino?", it asks. Never – 20 at the most! Further examples of units from outside your own experience to the usual address.

Rhinos on rails

Slightly puzzlingly, Newcastle Transport's website also states that "[S]imilar to a herd of charging rhinos, trams can't divert from the tracks to avoid an obstacle".

We recall this esteemed magazine asking "Why don't wildebeest have wheels?" not too long ago (19/26 December 2020). The better, perhaps, to dart out of the path of the fearsome steel-wheeled rhino-tram hybrids our mind's eye now sees careering across the savannah of New South Wales – a majestic and awe-inspiring sight indeed.

Deer oh deer

Never mind the rhinos, "How Can Suburbs Control Deer Populations?", *Smithsonian Magazine* asks on behalf of its readers ("You've got questions. We've got experts"). We agree with our reader Jane Monroe from Arcata, California – which looks beautifully non-suburban on Route 101 – that the answer "Scientists have developed contraceptive darts for areas densely populated with humans" doesn't make it as clear as we might like who the darts are being aimed at. Beware people lurking behind hedges with clipboards and tranquiliser guns when next out in the 'burbs.

Conference clumping

"'Blastoids' – Scientists form human cell clumps that act like early-stage embryos", read a

headline on *The Guardian* website, in a further entry to the suboptimal phrasing of the week competition. (You will find our write up of this study on page 19 of this very issue.) Reader David Marsh asks whether this is referring to "the half-forgotten days when we could gather at conferences".

It might not be quite what you had in mind, David, but Feedback was privileged once in the *Before Times* to have attended a conference of the American Physical Society when, thanks to a triumphant miscalculation, it was held in New Orleans during Spring Break. Some sort of clumping mechanism was very much in evidence as laptop-clutching physicists braved the mass of hula-hooping humanity in the streets of the French Quarter.

Rather than blastoids, it reminded us of the sardine run, when massed migrating fish leaving their spawning waters off the coasts of South Africa form tight defensive bait balls as they run the gamut of their predators. Nature very much in the raw.

Crab bytes

Of which, Twitter has recently been crawling with the rediscovery of a paper from unconventional computing researchers Yukio-Pegio Gunji, Yuta Nishiyama and Andrew Adamatzky. In "Robust Soldier Crab Ball Gate" from 2012, the team showed that, in a constrained environment, swarms of soldier crabs formed compact propagating groups that, guided by "intimidation plates" mimicking the shadows of aerial predators, can be made to operate mechanical logic circuits.

From the starting point of 80 soldier crabs to operate a logic gate, eight logic gate operations per byte and an average data consumption of about a kilobyte, Twitter user Ethan Mollick now calculates it would take an army of about 640,000 crabs to curate one tweet.

Impressive, if slightly unnerving, stuff. We'd like to know how many clumping physicists it takes to operate a logic gate. ■

The Land of the Pharaohs

From the Pyramids to the Valley of the Kings – in the April issue of AQUILA children can investigate Egypt's amazing history and follow the River Nile as it winds south through wilderness and steamy rainforests.

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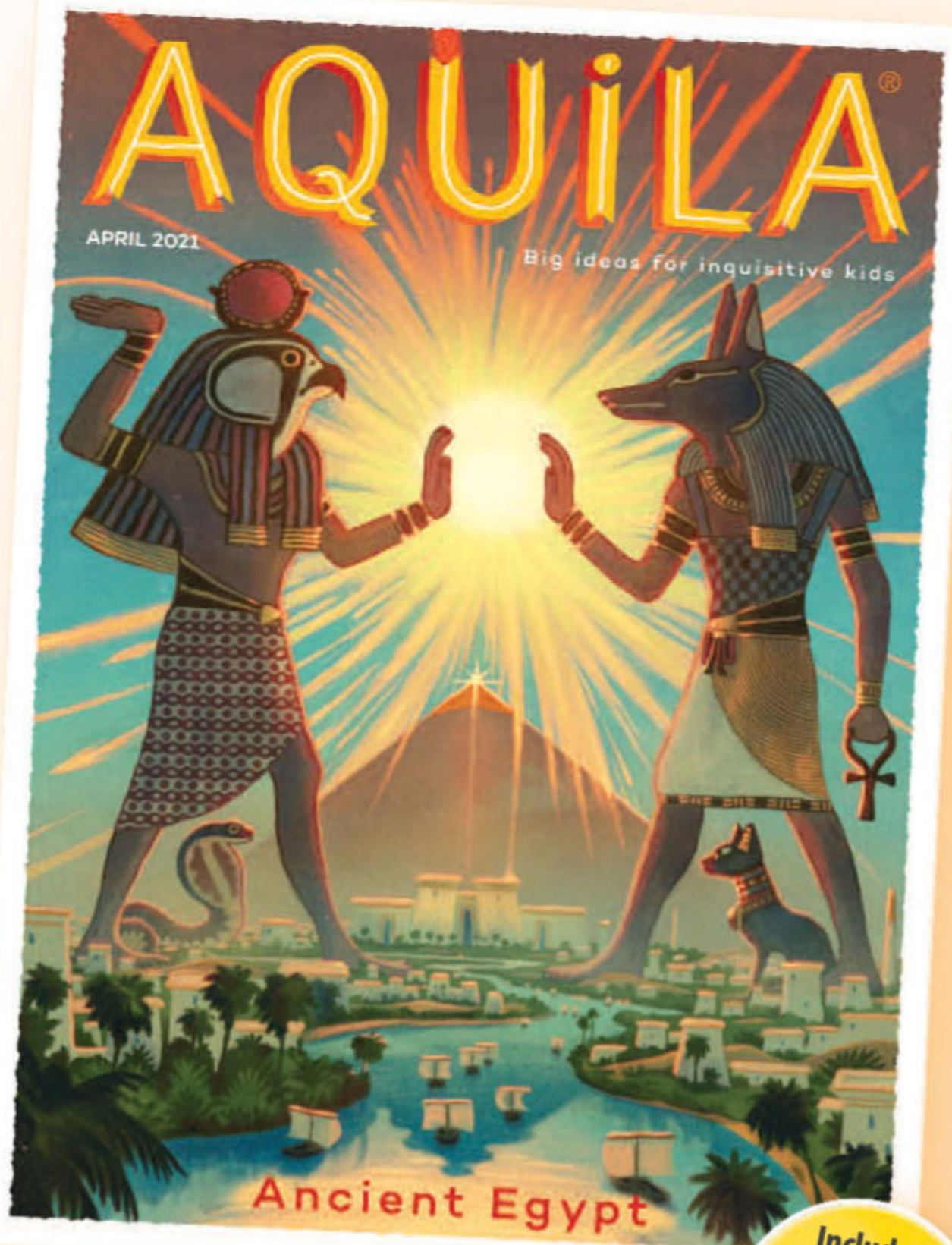
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