New Scientist

WEEKLY 2 September 2023

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This week's issue

On the cover

32 The smarter way to unwind
Why relaxation could be as vital as sleep – and the six secrets to doing it better

Vol 259 No 3454
Cover image: Antonio Sortino

36 Revealed: the true story behind the 'hobbit' discovery

9 India's moon mission triumph

17 Does every workplace need an AI whisperer?

46 Can all animals get drunk?
29 Avi Loeb on alien first contact
44 How to bake the perfect cookie

36 Features

"This creature was beyond any area where we thought early humans ever got"

News

Views

STUART HOLBOYD/ALAMY

18 Reproduction on ice Emperor penguins lost chicks due to ice breakup

Features

The back pages

Elsewhere on New Scientist

NS Live

Seven wonders of school science

Author and science teacher Alom Shaha will be making an appearance at the New Scientist Live schools' day on 9 October to explain what a good science education should include. His talk will explore the value of exciting demonstrations and the need to discuss the biggest ideas in science, and will convince even the most sceptical students that science is well worth studying.

newscientist.com/nslmag

Tour

The science of the Renaissance: Italy

Immerse yourself in the world of the Italian Renaissance on this tour of Florence, Bologna and Pisa. Led by art and architecture expert Andrew Spira and joined by former *New Scientist* editor Jeremy Webb, you will learn about Leonardo da Vinci and Galileo Galilei, as well as visiting the European Gravitational Observatory. This eight-day tour begins on 13 November and costs £2395.

newscientist.com/tours

Podcast

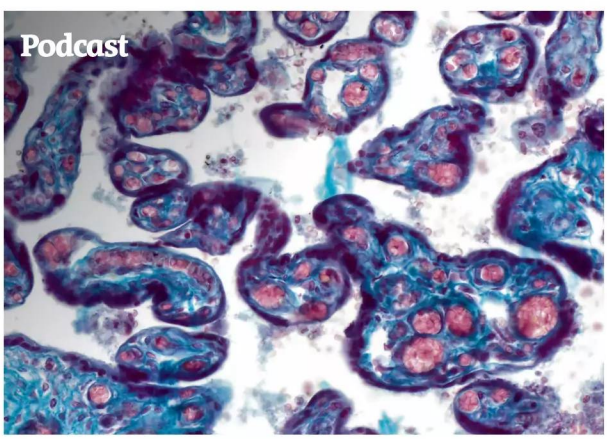
Weekly

Could cells from the placenta help repair the damage caused by heart attacks? Evidence from studies in mice suggests that it may be possible. Christie Taylor and the podcast team also hear about a recent surge in marijuana and psychedelic drug use in the US. Plus, the nuclear records that are locked away in turtle shells.

newscientist.com/nspod

BORCHEE/GETTY IMAGES

Italian style Follow in the footsteps of Leonardo da Vinci in Florence



ALVIN TELSER/SCIENCE PHOTO LIBRARY

Repair system Cells from the pancreas might help heal the heart

Video

Non-stick toilet

On our YouTube channel this week, there is footage of a toilet that is so slippery that virtually nothing sticks to it. Built by researchers in China, it is 3D printed from a mixture of plastic and hydrophobic sand grains and remains slippery even after being attacked with sandpaper. This means it might not need to be flushed as often, potentially saving water.

youtube.com/newscientist

Newsletter

Health Check

The World Health Organization's embrace of complementary medicine is stirring controversy, writes Clare Wilson. We should be free to take any remedy we want, she says, but we deserve access to evidence about its risks and benefits, and this isn't always available for medicines outside mainstream healthcare.

newscientist.com/healthcheck

A note from the magazine editor

Dear reader,

Our flagship event, New Scientist Live, is returning to ExCeL London on 7 to 9 October. For many of you, the world's greatest festival of ideas and discovery needs no introduction. But for those who haven't come along yet, I can wholeheartedly say that this is the highlight of our calendar at *New Scientist*.

Not only will we have three days packed with talks from some of the most brilliant minds in science and technology, there is a huge space full of exciting exhibits and experiences. Subscribers will, as an added benefit, have a dedicated zone to relax in and meet our team.

I'm intrigued to get inside the mind of a dolphin with Laline Paull, who will be talking about her book *Pod*. I also can't wait to hear Suzanne O'Sullivan speak about the power of mind over body. Then there's the topic du jour, the future of AI, on which Mike Cook and Amy Smith will run a live demonstration.

This year, our schools' day is on the Monday, and it is a time for curious young minds to enjoy talks from the likes of Stefan Gates and Anne-Marie Imafidon, and to get hands-on with the exhibits.

Do check out the full programme at newscientistlive.com, where you can get discounted early bird tickets for most days if you are quick.

I hope to see you there, but if you can't attend in person, the talks will also be available online – details are available on the website.

Catherine de Lange
New Scientist magazine editor

As our farmers know all too well: no pain, no grain.

They say nothing worth having comes easy. Unfortunately for our farmers that's true of the barley we use to brew our beers. We use a classic variety called Golden Promise, grown to our own unique specification. The biscuity, golden malt it produces is the perfect partner to our natural spring water, and is vital to Landlord's depth and delicate balance of flavour. It's also a type of barley that's notoriously hard to grow, and our exacting specification makes it even more difficult. Which makes it a costly ingredient and a real challenge even for experienced farmers. Luckily we can offer some liquid therapy.

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All for that taste of Taylor's

Digging deeper

The way ancient artefacts are discovered tells its own story – if we want to hear it

WITHOUT fossils, we would struggle to understand the ancient roots of humanity. Yet it is easy to overlook the circumstances surrounding their discovery, which may carry additional significance. The way fossils are found can tell its own story, one that can remain hidden from view or skewed in its reporting. But as we reveal on page 36, it is never too late to uncover the truth.

For instance, the 146,000-year-old Harbin skull, which hit the news two years ago, may overturn long-accepted ideas concerning the origin of our species. However, this skull was actually discovered 90 years ago by a construction worker in China. He kept it a secret, as Harbin was under the control of Japanese forces in 1933 and he didn't want the fossil to fall into their hands. He told no one about his discovery until he was on his deathbed in 2018.

No less astonishing is the story behind the discovery of *Homo floresiensis* – known informally as the hobbit – on the Indonesian island of Flores. Unearthed

"The insights that ancient fossil discoveries give us into modern lives is just as valuable"

20 years ago this month, *H. floresiensis* has shaken up the human family tree to an even greater extent than the Harbin skull. But it also led to arguments and outrage across Indonesia and beyond. Now, on the anniversary of its discovery, we explore what really happened when this extraordinary find was unearthed, revealing a different, and more nuanced, version of events.

The story of *H. floresiensis* reminds us that the motivations of scientists vary. We may assume, for instance, that all palaeoanthropologists are driven by the same desire to challenge scientific orthodoxy and emphasise the global significance of ancient remains. We would be wrong to do so.

Discoveries like *H. floresiensis* are the lifeblood of palaeoanthropology and the information they reveal about ancient human species is something to be celebrated. But we would do well to dig a little deeper into the story around these discoveries – the insight this can give us into modern lives is just as valuable. ▮

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News

Natural fertiliser
Sled dogs turn Svalbard greener with their faeces p10

Moving target
Why it is so difficult to make vaccines against dengue p11

Energy storage
Plastic bottles can be recycled into supercapacitors p13

Nature vs nurture
Genes influence education more than we thought p14

Sweet vision
Bees may be able to tell if water contains sugar by looking p16

Space

Cosmic whirlpool captured by JWST

The hypnotic, spiralling arms of the M51 galaxy draw you into this image from the James Webb Space Telescope. M51, also known as the Whirlpool galaxy, is some 27 million light years from us. In this image, created using infrared data, dark regions show warm dust, red ones show complex molecules forming on dust grains, and oranges and yellows reveal areas of ionised gas from young star clusters.

ESA/WEBB, NASA & CSA, A. ADAMO (STOCKHOLM UNIVERSITY)/FEAST JWST TEAM

Physics

‘Demon’ dreamed up by physics actually exists in our cells

Alex Wilkins

A HYPOTHETICAL being described in a 155-year-old thought experiment – believed at the time to break the laws of thermodynamics – actually evolved billions of years ago in the form of proteins used by almost every living organism.

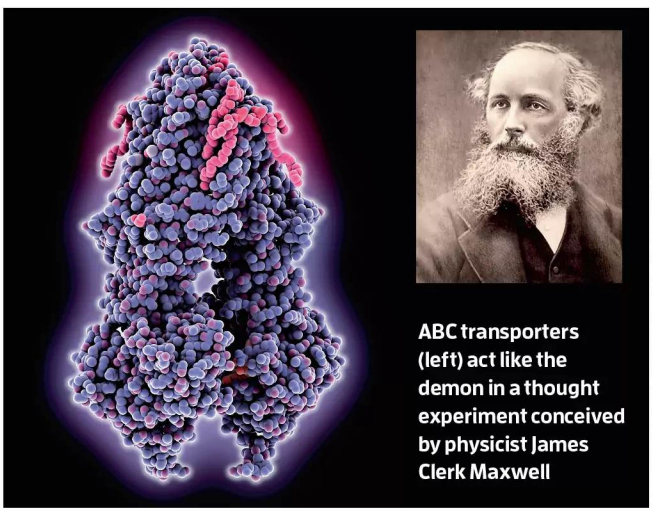
In 1867, physicist James Clerk Maxwell was pondering possible exceptions to the second law of thermodynamics, which says that things must always flow from hot to cold unless there is some energy source to counter this tendency.

He imagined a weightless door between two boxes of gas, operated by a tiny demon. If the demon only lets faster particles move into one chamber and slower ones into the other chamber, one box would heat up and the other would cool down. This would mean you could create energy from nothing by exploiting the temperature difference of the boxes, violating the second law.

This apparent paradox was solved in the 20th century, when information theorists like Rolf Landauer realised the demon would have to measure information about each gas particle, store it in its memory and erase its memory for more measurements. This would require more energy than the demon could create by having boxes at different temperatures.

In nature, there are many “non-equilibrium systems” similar to the hot and cold boxes, such as the different concentrations of molecules inside and outside living cells.

Now, Paolo De Los Rios at the Swiss Federal Institute of Technology in Lausanne and his colleagues have shown that ABC transporters – tiny proteins that can shuttle molecules across a cell membrane – act exactly like the demons proposed in Maxwell’s original paradox.



ABC transporters (left) act like the demon in a thought experiment conceived by physicist James Clerk Maxwell

L: LAGUNA DESIGN/SPL; REALY EASY STAR/TONI SPAGONE/ALAMY

“Nature already understood the rules billions of years ago,” says De Los Rios. “ABC transporters are present in all bacteria. They are really, really ancient. They go back to the last universal common ancestor of all life on Earth.”

“These transporters go back to the last universal common ancestor of all life on Earth”

De Los Rios and his team first wrote down simple equations describing how ABC transporters keep different concentrations of molecules inside and outside a cell. They considered how they work – such as using ATP, a molecular source of energy, to transport molecules across the membrane – and the shapes the transporters take when facing inside or outside the cell.

To play the role of Maxwell’s demon without breaking the laws of thermodynamics, Landauer theorised that an entity needs to consume energy, make recorded measurements and operate the door based on these measurements. De Los Rios and his colleagues found that the solution to their equations had three parts that matched these three conditions (*Communications Physics*, doi.org/krcv).

Their model assumed that each ABC transporter only uses one molecule of ATP at a time, but De Los Rios says more complex models should also work as Maxwell’s demons. Given the similar roles of many molecular machines, Maxwell’s demon is likely to be widespread in nature, he says.

“They make very concrete connections between the rigorous idea of Maxwell’s demon as it is now understood in statistical physics and the way these ABC transporters work,” says Nahuel Freitas at the University of Buenos Aires in Argentina. This connection also means that an ABC transporter can be thought of as a simple computational device, doing the same logical “AND” operation that silicon computer chips perform, says Freitas. ▮

Conservation

Kākāpō genomes sequenced to help save them

Alice Klein

TO SAFEGUARD the critically endangered kākāpō – a unique New Zealand parrot – the genomes of nearly all remaining individuals have been sequenced, providing vital information for conservation.

The kākāpō (*Strigops habroptila*) is the world’s heaviest parrot, with some males exceeding 3 kilograms. It is also the only parrot species that can’t fly, instead climbing trees or foraging on the ground for food.

The once-widespread greenish birds were almost completely wiped out by introduced predators like cats and rats. The 250 or so left are managed by New Zealand’s Department of Conservation in partnership with Māori groups on five predator-free islands.

The small population size makes it challenging to prevent inbreeding. So, Joseph Guhlin and Peter Dearden at the University of Otago in New Zealand and their colleagues have sequenced the genomes of about 90 per cent of the remaining birds. The Department of Conservation is now using this information to decide which kākāpōs to move between islands, aiming to increase the chances of mating between less closely related birds and raise the genetic diversity of the overall population, says Guhlin.

The department also picked four kākāpōs to reintroduce to New Zealand’s North Island last month, after an absence of more than 50 years. The chosen ones had fairly standard genomes, meaning “they could afford to go because they weren’t carrying rare genetic variations”, says Dearden.

The research identified genetic variants associated with traits like the number of eggs laid, the growth rates of chicks and disease susceptibility (*Nature Ecology & Evolution*, doi.org/krcj). Guhlin hopes that the work can serve as a blueprint for the conservation of other animals. ▮

Space exploration

India's historic moon mission

The success of Chandrayaan-3 has made India the first nation to land a craft near the moon's ice-rich south pole, reports **Matthew Sparkes**

INDIA'S Chandrayaan-3 moon mission is now exploring the lunar surface near the south pole. Buoyed by its success, the country is looking to push ahead with putting a human in space and sending a craft to Mars.

Four hours after the Indian Space Research Organisation (ISRO) mission landed on 23 August, and the sun had risen on the landing site, Chandrayaan-3 lowered a ramp and the six-wheeled Pragyan rover, which weighs 26 kilograms, rolled onto the lunar surface.

Over two weeks, the rover will carry out experiments to research the composition of the surface with its Alpha Particle X-Ray Spectrometer and look for water ice, which has the potential to provide a future crewed base with drinking water, oxygen and fuel for spacecraft.

Both the lander and the rover are expected to operate for one lunar day (equivalent to 14 Earth days) before sunset cuts their ability to harvest energy from solar panels. ISRO hasn't ruled out the possibility that both will revive once the sun rises after two weeks of darkness and temperatures that will dip to -238°C, but this would be a bonus.

India achieved a historic first with the landing near the moon's south pole. Only China, the US and the Soviet Union had previously softly landed craft anywhere on the moon and no country had explored the south pole.

The mission has been remarkable not only for its firsts, but also for its budget of just Rs 615 crore (£59 million). This is less than half of the inflation-adjusted $149 million budget for the 1995 film *Apollo 13*, which needed only to depict a mission to the moon.

Chandrayaan-3, which takes its name from the Sanskrit word for "mooncraft", took off onboard a Launch Vehicle Mark-III rocket from the southern state of Andhra Pradesh on 14 July and spent six weeks covering about 380,000 kilometres en route to the moon.

After a soft landing – which ISRO said had taken place 40 days, 3 hours and 29 minutes after launch – Shri M. Sankaran, director of ISRO's U R Rao Satellite Centre, referenced the preceding Chandrayaan-2 mission, which ended in failure in 2019 when a software glitch caused its Vikram lander to crash into the moon's surface. It was destroyed, along with the six-wheeled rover it contained, also named Pragyan, that would have explored the moon's south pole.

"These missions are highly visible and they serve as an indicator of a state's great power"

"Today, we have achieved what we set out to achieve in 2019," said Sankaran. "It was delayed by about four years, but we have done it."

Sankaran went on to say that India would now look to push ahead with its space programme and put a human into space and send a craft to Mars. A planned mission to monitor the solar atmosphere from an orbit at a point between Earth and the sun, called Aditya-L1, is already due for launch on 2 September.

The success of Chandrayaan-3 follows a string of failures in moon missions from around the globe. A private attempt by a Japanese start-up in April ended unsuccessfully when it crashed into the surface. Russia's latest attempt at lunar exploration – its first moon mission in nearly half a century – also ended in disaster last week.

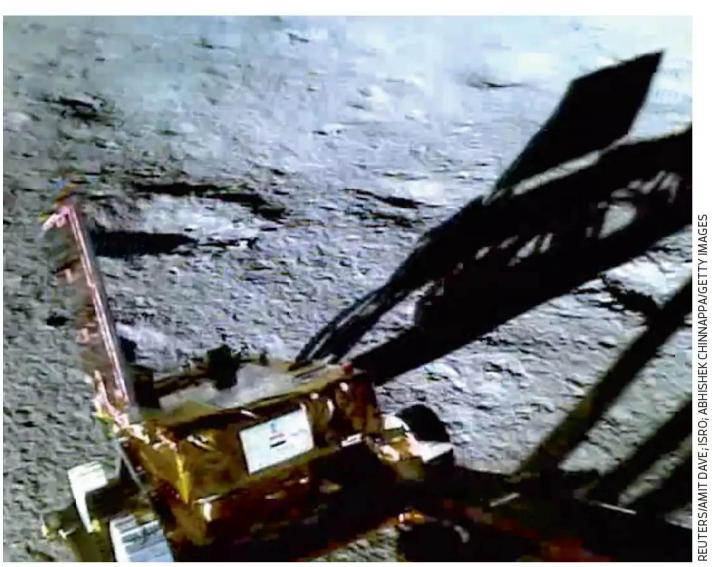
Russia's Luna 25 lander was due to touch down gently but instead slammed into the surface at speed after what was intended to be a short engine firing to reposition it seemingly continued for too long.

Dimitrios Stroikos at the London School of Economics and Political Science says that when ISRO first floated the idea of an Indian moon mission it was "a bit difficult to sell it" to a sceptical public, but that things have changed and public support has grown enormously.

"Now, it's more about 'Great, we did that, we need more of that, what's next? What about human space flight?'," says Stroikos. "These sorts of missions are very highly visible and they serve as a normative indicator of a state's great power, status, modernity and prestige. But it's a great scientific feat as well. [As] we saw with Luna 25, it's very difficult to achieve a soft landing."

Chandrayaan-3 might leave a lasting mark on the moon. ISRO didn't respond to a request for interview, but Pragyan's rear wheels are reportedly stamped with the ISRO logo and a Buddhist symbol, either the Lion Capital of Ashoka or the Ashoka Chakra, and will leave imprints of both on the surface of the moon as it traverses at just 1 centimetre a minute. ▮

India's moon landing was watched by the public (top) and celebrated by employees of its space agency (bottom). Its rover (below right) is now exploring the lunar south pole



REUTERS/AMIT DAVE; ISRO; ABHISHEK CHINNAPPA/GETTY IMAGES

Anthropology

Women and men throw spears equally well using ancient atlatl tool

Jeremy Hsu

THE atlatl, an ancient spear-throwing tool first used thousands of years ago, enables women and men to launch projectiles with similar velocities. The discovery, which comes from experiments involving atlatls, provides more evidence that prehistoric female hunters would have been as capable as male ones of putting meat on the table.

The research started when Michelle Bebber at Kent State University in Ohio began teaching a course in which students spent a day practising throwing javelins and using an atlatl. The atlatl is a hand-held stick with a cup or groove at the end that is designed to launch a long, feathered projectile with a forward-flinging motion.

"The girls would often just naturally pick up the atlatl and whip the [projectiles] really far," says Bebber. "Some of the male athletes would really be putting their all into it and get a little frustrated that the girls were doing this so well."

So, Bebber and her colleagues measured the performance of more than 100 volunteers to see how well they could throw javelins and launch atlatl spears. Some 42 men and 56 women participated, along with 10 people who didn't disclose their biological sex.

Each person threw a javelin 10 times and launched an atlatl spear 10 times and the velocity of the projectiles was measured. The female-launched javelins travelled at between 5.1 and 11.5 metres per second, whereas male-launched javelins achieved between 8.1 and 16.1 metres per second.

The atlatl spear velocities were much more similar: 10.1 to 20.1 m/s for female participants versus 10.1 to 24.1 m/s for male volunteers (*Scientific Reports*, doi.org/gsmkpk). "The atlatl is an equaliser" that could have encouraged "unification of labour" among female and male hunters, says team member Metin Eren, also at Kent State University.

Side-by-side comparisons of the same people using both javelins and atlatls provide valuable information, says Annemieke Milks at the University of Reading, UK. It is possible that javelins may have been harder to learn to use and required more body mass or strength, she says, which may have spurred development of the atlatl.

Milks says physiology isn't the only factor determining hunting capabilities. "[Hunting] skills are not just about our build, ability or strength, but are also about knowledge and understanding of prey, environments and how these intersect with social factors," she says. "We know ethnographically and archaeologically that women hunt, even if those activities are not as widely or frequently practised as they are by men."

Bebber and her colleagues say it is possible that women invented the atlatl or other weapon innovations. "We know that in certain primate species, the females innovate and produce spears to go hunting," says Bebber. "It's interesting to think that perhaps women also were involved in innovating the atlatl." ▮

METIN EREN

Archaeologist Michelle Bebber using an atlatl to propel a spear

Environment

Sled dogs turn Svalbard greener with their faeces

DOGS that pull sleds for tourists are fertilising the Arctic archipelago of Svalbard with their droppings.

Dog sledding has become a popular tourist attraction in Svalbard, which has led to a boom in its dog population.

"When I started visiting there 10 years ago, there were a few dog yards, and now there are dozens of them," says Jesamine Bartlett at the Norwegian Institute for Nature Research in Trondheim.

So, Bartlett and her colleagues decided to investigate if dog yards and other animal settlements have affected local vegetation, perhaps through faeces or leftover food enriching the area with nutrients.

The team analysed satellite observations that measured the wavelengths of light reflected by Earth's surface to determine how much vegetation there was at various sites in Svalbard between 1985 and 2021. The sites included active dog yards, pony stables, cliffs where seabirds live, historical animal settlements and undisturbed zones.

"There has been some level of greening across all sites, probably as a result of climate warming," says team member Elise Gallois at the University of Edinburgh, UK.

But larger increases in vegetation greenness were seen where animals live or lived in the past. The greatest jump was seen at dog yards and former animal settlements, which were 44 per cent and 39 per cent more green in 2021 than in 1985 (EcoEvoRxiv, doi.org/krd3).

"Even relatively minor developments can have drastic impacts on the surrounding ecosystem"

"Even relatively minor developments can have drastic and long-lasting impacts on the surrounding ecosystem," says Gallois.

A greener Svalbard may not necessarily be better, says team member Kristine Bakke Westergaard at the Norwegian University of Science and Technology in Trondheim. More greenery means more nutrients for both native and non-native species, she says, which may change the dynamics between them. ▮

Chen Ly

When will we see widespread vaccination against dengue? The way the four subtypes of dengue virus vary in their prevalence means making a vaccine against it is particularly challenging, says Jason Arunn Murugesu

AMID growing dengue outbreaks around the world, 2023 could turn out to be one of the worst years on record for the infection. The World Health Organization (WHO) has said dengue poses a pandemic-level threat, with outbreaks being reported in the Americas, Asia and Africa. But the way different types of the dengue virus provoke immunity or complications mean that developing an effective vaccine has been difficult.

As of the end of July, more than 3 million dengue cases and 1500 deaths had been reported worldwide in 2023, with Brazil, Bolivia, Peru and Argentina the worst-hit countries. In the Americas, reported cases have already surpassed those from the entirety of 2022. If the situation carries on as it is, the WHO has said there could be more than 4 million cases globally by the end of the year, putting it close to the record 5.2 million reported cases in 2019.

Dengue has no specific treatments and usually resolves over one to two weeks. However, it can cause severe symptoms, known as dengue fever, and can sometimes be life-threatening. A lack of treatment makes developing an effective vaccine vital, says Jorge Kalil at the University of São Paulo in Brazil.

A three-dose vaccine called Dengvaxia is approved by the US Food and Drug Administration and the European Medicines Agency. But it isn't widely used for several reasons, says Martin Hibberd at the London School of Hygiene & Tropical Medicine.

The main problem is that dengue virus has four serotypes, which are groups within a single species of a microorganism that have different surface structures. For dengue, these are called dengue-1, 2, 3 and 4. The serotypes circulate at different levels in each country, fluctuating in their prevalence.

Being infected with any serotype can result in lifetime immunity to that specific subtype, but can also lead to complications if someone is later infected with another serotype, says Hibberd. However, if the same person is infected again with one of the other two serotypes, they usually aren't at the same risk as they were with their second infection, he says.

HABIBUR RAHMAN/ABACA PRESS/ALAMY

Collecting samples to test for dengue in Bangladesh in October 2022

Dengvaxia is based on a yellow fever virus that has been made to express proteins from all four dengue serotypes. The vaccine is strongest against dengue-4 and weakest against dengue-2. When Dengvaxia is given to people who have never been exposed to any dengue serotype, it acts like their first infection. If that vaccinated person then becomes infected with a serotype that isn't dengue-4, they can have a far more severe reaction than if they hadn't been vaccinated.

The dengue vaccine Dengvaxia isn't widely used

TED ALJIBE/AFP VIA GETTY IMAGES

In 2016, the Philippines was the first Asian country to approve Dengvaxia and gave it to 800,000 children. A year later, it emerged that the vaccine can cause more severe dengue complications when given to people who haven't previously been infected but go on to be infected after vaccination. The Philippines subsequently banned Dengvaxia.

The WHO now recommends that Dengvaxia only be used if it is administered after a blood test that shows someone has previously been infected with dengue, so the vaccine wouldn't be their first brush with the virus. Having the vaccine be their second exposure isn't thought to be an issue. "If you had a natural dengue infection previously, then had the Dengvaxia vaccine administered, you would boost that original protection," says Hibberd, and also generate a more protective response against other remaining serotypes.

The serotypes aren't the only issue. Even against dengue-4, Dengvaxia becomes less effective about a year after its final dose, says Hibberd. This, coupled with the need to administer a blood test pre-vaccination and the fact it requires three doses, has led to a very low uptake, he says.

Producing just one vaccine that has an equal response to all four serotypes is difficult, says Anna Durbin at Johns Hopkins University in Maryland. One experimental vaccine is in the final stages of clinical trials and shows some promise, she says.

It is made up of all four dengue serotypes, genetically edited to not cause serious illness. It contains more genetic material of the four serotypes than Dengvaxia and is therefore thought to elicit a stronger immune response against them all.

Early results from a trial in Brazil published last year showed that the vaccine was 89.5 per cent effective against dengue-1 and 69.6 per cent effective against dengue-2. It is unclear how effective it is against the other two serotypes because these weren't widely circulating in the country during the study.

4 million

Number of dengue cases the world is on course for this year

It is too early to tell how long this vaccine's protection lasts, but more results are expected in the next year or two, says Durbin, who was involved in some of its trials. Nevertheless, it involves a single dose, so would be easier to administer than Dengvaxia if approved, she says.

Durbin hopes the new vaccine could play a big role in tackling the virus. "In 10 years' time, I think we're still going to be seeing a lot of dengue fever, but I also think we'll be vaccinating the vast majority of people who need it," she says. ▮

Technology

AI can spot early signs of a tsunami from atmospheric shock waves

Jeremy Hsu

A BETTER early warning system for tsunamis may soon be possible with the help of artificial intelligence. Widely available AI technology can detect subtle disturbances in satellite signals when a tsunami's waves begin to form, which could provide warnings for coastal communities long before the tsunami hits.

"There is no global network for detecting tsunami waves, and installing physical hardware, like buoy-based systems, is expensive," says Valentino Constantinou at Terran Orbital Corporation, a satellite manufacturing company based in Florida. "But we know that small satellite constellations are just proliferating everywhere."

Those GPS satellites and other global navigation satellite systems constantly exchange radio signals with ground stations. Crucially, the speed of the radio signals is affected by the density of charged particles in an area of Earth's ionosphere some 300 to 350 kilometres above the planet's surface. Tsunami-triggered shock waves travelling up into the atmosphere affect the density of these particles, generating small but measurable changes in the satellite radio signals.

In 2017, research groups at NASA's Jet Propulsion Laboratory in California and the Sapienza University of Rome in Italy developed a computer algorithm for measuring changes in the density of these charged particles caused by the formation of a tsunami.

Constantinou and his colleagues transformed the data produced through that technique – a one-dimensional line showing changes in charged particle density over time – into two-dimensional images that can be analysed by off-the-shelf AI models. They then tasked the AI with identifying tsunami-related features within the images.

JOE RAEDLE/GETTY IMAGES

A tsunami caused widespread devastation in Dichato, Chile, in 2010

The researchers trained and tested the AI on data from three earthquake-triggered tsunamis: one that struck Chile in 2010, a 2011 event in Japan and an event that occurred off Canada's west coast in 2012. The team then validated the AI's performance on data from a fourth tsunami, this one triggered by the 2015 Illapel earthquake off the coast of Chile. This revealed how well the AI could distinguish tsunami-related disturbances from normal variation in the ionosphere.

90%
AI's success at detecting a tsunami in one study

One concern the researchers had was that the AI might falsely detect periods of tsunami-related disturbance that didn't exist. To reduce the possibility of this happening, they filtered out ionospheric disturbance patterns that weren't detected by at least 70 per cent of ground stations in contact with the individual satellites passing by overhead (arXiv, doi.org/kqth).

This produced "pretty good results", with a reported detection performance of more than 90 per cent, says Quentin Brissaud at NORSAR, a seismic research foundation in Norway, who wasn't involved in the study.

But he says it remains to be seen if performance based on data from four tsunami events can lead to accurate detection of a more diverse set of tsunamis.

The rarity of huge tsunamis makes it challenging to analyse and predict such events, he says.

A truly effective tsunami detection system would also require international cooperation to share data from satellite constellations, says Constantinou. "There is no one place to grab the data for a global system." ▮

Animal behaviour

Cougars are shifting their hunting tactics to outsmart bears

Corryn Wetzel

COUGARS in Yellowstone National Park are hunting an increasing proportion of their prey on rugged terrain, which may be to reduce the chance that their kills will be stolen by bears and wolves.

In Yellowstone National Park in the western US, the habitat of cougars (*Puma concolor*) – also known as mountain lions – overlaps with that of grey wolves (*Canis lupus*), grizzly bears (*Ursus arctos horribilis*) and American black bears (*Ursus americanus*).

In the 1920s, cougars and wolves were eradicated from the national park and bears were a rare sight. But the numbers of all four animals have climbed over recent decades, increasing competition for similar food sources like deer.

To see how this was influencing the big cats, Jack Rabe at the University of Minnesota and his colleagues tracked 13 cougars using GPS collars. Their analysis, presented at a recent meeting of the Ecological Society of America, included 381 kills by the cougars – primarily deer and elk – from 2016 to 2022. They found signs that bears had visited about 30 per cent of the cougar kill sites, probably scaring the cats off their kill. Wolves visited cougar kill sites around 8 per cent of the time.

Comparing the data with similar tracking data recorded two decades earlier showed that cougars are now hunting a greater proportion of their prey on rough landscapes, including rocky slopes and forests.

"Cougars are definitely better hunters where the ambush territory is better," says Rabe. The cats may be returning to the hunting strategy they relied on before the loss of other predators left an abundance of elk and deer for them to pick off in more open areas.

The shift in hunting tactics is an encouraging sign of the park's health, says Rabe. ▮

Microbiome

Your height may affect your gut

The diversity of bacteria in your gut microbiome may be related to how tall you are

David Cox

A PERSON'S height may influence the bacterial diversity of their gut microbiome. This could be due to taller people having longer gastrointestinal tracts that can house more microorganisms.

Not everyone is convinced, however, with one scientist arguing that a person's genetics or a poor diet during childhood could both inhibit growth and affect the gut microbiome.

Among vertebrates, larger species seem to have more diverse colonies of gut microbes, but it wasn't known if this trend applied to individual people.

Kat Sarmiento at the Institute for Systems Biology in Seattle and her colleagues gathered data from more than 5000 people who took part in a gut-related experiment and more than 3000 people from a wellness programme. All provided information on their height, which ranged from 127 to 218 centimetres, as well as faecal samples needed for gut microbiome sequencing.

They found that the diversity of bacterial species within the participants' guts increased in proportion to their heights.

The researchers liken this to the island biogeography idea, which states that larger islands tend to have greater species diversity than smaller ones. Perhaps taller people have longer gastrointestinal tracts, allowing for greater microbial diversity, they say.

To understand what this might mean for health, the researchers then focused on 130 people who took part in the gut experiment, all of whom had a history of infection with the bacterium *Clostridium difficile*. This usually lives harmlessly in the bowel, but can cause diarrhoea if the balance of bacteria in the gut changes.

By comparing these individuals to the remaining participants in the gut experiment, the researchers found that those with a history of *C. difficile* infection were marginally shorter – with an average height of 168.1 centimetres compared with 171.7 centimetres – and had lower gut diversity (bioRxiv, doi.org/kqtq).

"Shorter individuals would benefit from changing their diet to increase their gut microbiome diversity"

When the researchers looked at data on other aspects of the participants' lives, they found that eating a high-fibre diet seemed to protect against *C. difficile* more than height did. "This suggests that the effects of height can be overridden by diet," says team member Sean Gibbons at the Institute for Systems Biology.

"Our research would suggest shorter individuals would benefit from changing their diet to increase their gut microbiome diversity," says Sarmiento.

Yet Christopher Damman at the University of Washington in Seattle says a person's height doesn't necessarily tally with the length of their gastrointestinal tract. "While the small intestine does correlate with height to a certain degree, the colon – where most of the gut microbiome lies – correlates better with weight and body mass index," he says.

Rather than height affecting gut microbial diversity, people may be shorter as a result of their genetics or poor childhood nutrition, with either of these also potentially influencing their microbiome, says Damman. ▮

Chemistry

Plastic bottles can be recycled into supercapacitors

PLASTIC bottles can be upcycled into parts for supercapacitors, which store energy like batteries but release it much faster.

Plastic pollution is widespread. According to some sources, 38 billion disposable bottles are sent to landfill each year in the US alone. Shengnian Wang at Louisiana Tech University and his colleagues wanted to turn some of them into supercapacitors instead.

The researchers developed a chemical procedure that rearranges the carbon atoms in the clear polyethylene plastic used in bottles into a supercapacitor component.

First, they cut plastic bottles into pieces and reacted them with water, nitric acid and ethanol at a high temperature and pressure. They spun the resulting mixture in a high-speed centrifuge before drying it in an oven. This produced thin sheets of carbon speckled with carbon nanoparticles, less than 2 nanometres across. The small size gives the nanoparticles unusual electrical properties, making them what physicists call carbon "quantum dots".

P TOMLINS/ALAMY

We throw away billions of bottles that could be made into electronic components

When it comes to making energy storage devices with carbon components, sheets and dots both have drawbacks. But using the two in combination makes storage devices more effective, said Wang in a presentation at an American Chemical Society meeting in San Francisco last month.

He and his colleagues discovered that their "ball-sheet carbon structure" supercapacitor charged and discharged as expected and, after charging, it could power a small red LED light. Additionally, charging and discharging it 12,000 times decreased its capacity to store energy by only 2 per cent.

The researchers also built ball-sheet structures using a more pure and less processed plastic. When used in supercapacitors, these had a similar performance level to those made from drinks bottles. ▮

Karmela Padavic-Callaghan

Genetics

How genes affect education

Studies have overestimated the impact of the environment on how long people stay in education. Our genes are more influential to it than we thought, discovers **Clare Wilson**

THE environment that children grow up in may have a much smaller impact than their genes on how long they stay in education. This is the conclusion of a study on twins, which suggests that most previous such research has overestimated the effects of upbringing by failing to take into account two key sources of bias.

It has long been debated whether various aspects of our personalities and abilities are influenced more by our genes or our early environment. Scientists sometimes investigate the question by comparing different kinds of twins. Identical twins share 100 per cent of their DNA, while non-identical twins are assumed to share 50 per cent.

The extent to which identical twins are more similar in any particular trait than non-identical twins reveals how much variation in that trait is down to genetics. The rest is usually assumed to be due to the environment.

Such studies have shown that many aspects of our abilities and personalities have little to do with our environment. But a measure called educational attainment – defined as how many years people spend in full-time education – has often been calculated to have a relatively large environmental component, of around 35 per cent.

These studies usually overlook two factors, however, leading to falsely high estimates of environmental effects, says Damien Morris at King's College London. The biggest overlooked factor is that people tend to have children with someone with a similar level of education as themselves, an idea known as assortative mating.

"It's a source of substantial bias," says Morris. "Parents match very closely on this characteristic, but it has not been taken into account in the traditional twin method."

MEDIA_PHOTOS/SHUTTERSTOCK

Twins are studied to tease out the effects of genes and upbringing on our lives

If assortative mating with respect to any trait does happen, then any full siblings, including non-identical twins, would share more than 50 per cent of the genes that influence that trait, because of the genetic overlap between their parents. This means that the usual twin study methods for calculating the genetic contribution would give a falsely low figure and therefore the environmental contribution would appear falsely high.

Morris and Tobias Wolfram at Bielefeld University in Germany have now investigated whether assortative mating for education happens by using a recent German twin study in which data had been collected, not just for the twins, but also for their parents and another sibling of the twins. They examined data on years of education for nearly 1000 families including identical or non-identical twins, born in the 1990s.

After analysing this data using the traditional twin study design, environmental differences between families were estimated to account for 43 per cent of the variation in years of schooling.

Then, Morris and Wolfram analysed the same data using a method that also included the parents' years of education. Sure enough, there was more similarity between the educational years of each parental pair than would be expected by chance. Taking this into account, the environmental contribution was estimated to be just 26 per cent (*npj Science of Learning*, doi.org/kqpk).

"It is unimaginable to me to think that everything that goes on with parents is only a bit player"

The pair also analysed the impact of a second factor usually overlooked in twin studies. This is the fact that the early environments of twins are more similar than those of non-twin siblings because they are born at the same time. As well as having shared a uterus, twins are more likely to have grown up in the same financial circumstances, gone to the same school and so on.

The researchers estimated how much this effect skews the results of twin studies, by comparing the number of years that pairs of non-identical twins and pairs of one twin and their non-twin sibling spent in education. When this was taken into account as well, the estimated environmental influence fell to 10 per cent.

"This is a very intriguing finding," says Jeremy Freese at Stanford University in California. "The technical prowess and the thoughtfulness in this paper is pretty evident. But it is unimaginable to me, thinking about how college decisions are made, to think that everything that goes on with parents is only a bit player in the story."

Other kinds of studies have given higher estimates for the environmental contribution to years of schooling, says Alexander Young at the University of California, Los Angeles. "Ultimately, we need to triangulate different sources of evidence," he says. ▮

Materials science

Toughest known structure discovered by robot laboratory

Alex Wilkins

A ROBOTIC lab that can 3D print and test mechanical structures without human supervision has discovered the most energy-absorbing one measured so far. The structure could be useful for cushioning impacts.

Keith Brown at Boston University in Massachusetts and his team used an autonomous system they call a Bayesian experimental autonomous researcher (BEAR) to study structures that are tough, and can absorb a lot of mechanical energy without failing. "We built a system that designs mechanical structures, tests them and then uses the results of all previous tests to design and test additional structures," says Brown. "It runs in a closed loop and it's totally autonomous."

BEAR has five 3D printers that can use seven kinds of plastics, a set of scales and a testing machine that compresses each structure it makes and measures its response, as well as a robotic arm and a computer vision system to move samples. The lab performed more than 25,000 experiments, about 50 per day. It ran autonomously, but sometimes researchers intervened, such as for adjusting temperature.

Different structures performed well depending on the plastic used. A structure they called Willow, shaped like a twisted, elongated four-leaf clover, made out of a kind of polyester called PLA, had an average energy absorbing efficiency of 73.3 per cent, meaning it absorbs that much of the energy from an impact. This beat the previous best example the researchers could find records of, balsa wood, at 71.8 per cent efficiency (arXiv, doi.org/kqqz).

Such structures might be relevant for bike helmets, says Devesh Mistry at the University of Leeds, UK, but they will need further testing.

The automated process could also quicken the discovery of new materials, says Iman Mohagheghian at the University of Surrey, UK. ▮

Climate change

The tropics could get so hot that all leaves on rainforest trees die

Michael Le Page

A TINY proportion of leaves in the canopies of tropical forests are dying because they are passing the critical temperature threshold beyond which they can't photosynthesise. Experiments suggest that the proportion of leaves affected in this way will rise exponentially as local temperatures increase.

"We are predicting total leaf death," says Christopher Doughty at Northern Arizona University. "If it was to occur, this would be a major tipping point [for the climate]."

However, his team's findings indicate that this tipping point is likely to be reached only in the worst-case warming scenarios, which are now thought to be implausible. "It doesn't seem like we're going to get to that, but it's possible," he says.

Lab studies show that when the leaves of rainforest trees reach about 47°C (117°F), the cellular machinery that captures energy from sunlight is irreversibly damaged and the leaves usually die.

"It seems high," says team member Martijn Slot at the Smithsonian Tropical Research Institute in Panama. "But leaf temperature can be a lot higher than air temperature."

~47°C

Temperature at which leaves usually die (equal to 117°F)

Desert plants can tolerate temperatures above 47°C, but in rainforests there are only small variations in heat tolerance between species, says Slot.

It was thought that no leaves in tropical forests were at their tolerance limit. But when the team analysed plant temperature measurements from the ECOSTRESS instrument on the International Space Station from 2018 to 2020, it revealed that about 0.01 per cent of leaves in the canopies of rainforests globally are already reaching the threshold.

To confirm this, the team did ground-based studies around the world, placing temperature sensors on leaves in the upper canopy of rainforests.

The group created a model based on these findings and on experiments on warming plants. It showed that the proportion of leaves affected will go up as local temperatures increase, rising more rapidly after reaching a tipping point between 2 and 8°C (3.6 and 14.4°F) of local warming, most likely at 4°C (7.2°F) (*Nature*, doi.org/gsmzcv).

There are several reasons why the rise might accelerate, says Doughty. For instance, the pores of leaves, called stomata, close during high heat and drought to prevent water loss. Without the cooling effect of evaporation through stomata, leaves warm rapidly. In addition, once the most heat-exposed leaves die, others that were sheltered are exposed and die as well.

Continuing deforestation will make it more likely that local temperatures could increase to levels where lots of leaves start exceeding the limit, says Doughty. "Where you have fragmentation of forests, the existing forests get quite a bit warmer," he says.

It is possible that the rising number of trees dying in the Amazon is due in part to this temperature threshold, he says. Studies also suggest that the Amazon has started releasing more carbon than it soaks up, leading to further warming.

"This paper is more evidence that we need to stop and reverse climate change as quickly as possible," says Julia Jones at Bangor University in the UK. ▮

Leaves on rainforest trees can die if they get too hot

GHISLAIN & MARIE DAVID DE LOSSY/GETTY IMAGES

Genomics

The human Y chromosome has been fully sequenced for the first time

Michael Le Page

TWENTY years after the Human Genome Project was declared complete, the Y chromosome has finally been fully sequenced.

Most people have 22 pairs of chromosomes plus two sex chromosomes – either a pair of X chromosomes or one X and one Y chromosome. Having a Y chromosome usually – but not always – results in an embryo developing male characteristics.

The Y is one of the smallest chromosomes and has the fewest genes coding for proteins. Because it normally has no paired chromosome to swap pieces with before sexual reproduction, it is especially likely to accumulate bits of repetitive DNA.

Early methods of DNA sequencing involved breaking DNA up into small pieces, reading their genetic code and then reassembling the pieces by looking for overlaps. This doesn't work with repetitive DNA where lots of the pieces are identical.

BIOPHOTO ASSOCIATES/SCIENCE PHOTO LIBRARY

A human X (left) and Y chromosome seen with a scanning electron microscope

Because of this, the "completed" human reference genome that was announced in 2003 was actually far from complete. "The Y chromosome just kept being pushed aside," says Charles Lee at the Jackson Laboratory for Genomic Medicine in Connecticut. "It's a hard chromosome to complete because of all the repetitive sequences."

In 2021, a team including Karen Miga at the University of California, Santa Cruz, filled in many gaps, and again declared the human genome complete.

What made this possible is a technique, developed by a company called Oxford Nanopore, that reads the sequence of a single DNA molecule as it goes through a tiny hole, producing pieces that are millions of DNA letters long rather than a few hundred.

But the "complete" genome sequenced by Miga and her colleagues was a female one, consisting of the 22 normal chromosomes along with the X chromosome. Only now has Miga's team completed the Y chromosome as well, from a person of European descent.

This complete Y chromosome has 106 protein-coding genes, which is 41 more than in the reference genome. But almost all these extra genes are just copies of one gene called *TSPY* (*Nature*, doi.org/kqpb).

At the same time, Lee's team has sequenced the Y chromosomes of 43 diverse men, including 21 of African origin (*Nature*, doi.org/kqn9). The teams were independent, but did collaborate, says Lee.

Only three of his team's Y sequences are truly complete, he says. The rest still have between one and five gaps. The 43 Y chromosomes show considerable diversity, says Lee. For instance, the number of copies of the *TSPY* gene ranges between 23 and 39.

"The Y chromosome kept being pushed aside. It is hard to complete because of its repetitive sequences"

Unfortunately, the studies reveal little new about the parts of the Y chromosome that include genes, and most biologists have little interest in the repetitive DNA, says David Page at the Massachusetts Institute of Technology.

Whether the repetitive DNA does anything important isn't clear. "I believe there's a lot to learn about repetitive DNA and we just don't understand it yet, and so we've still dismissed it as junk," says Lee. ▮

Animal intelligence

Bees may be able to tell if water contains sugar just by looking

BUMBLEBEES can identify sugary liquids before they even take a sip. This could mean some approaches used to assess bee intelligence need re-evaluating.

"Much of what we know about insect cognition comes from work on bees," says Tomer Czaczkes at the University of Regensburg in Germany. In many such studies, bees choose between artificial "flowers" after being trained to associate one option with a reward such as sucrose water, and the other with plain water or a bitter solution. But it wasn't known if bees could tell the difference at a distance.

Czaczkes and his colleagues have now tested 90 buff-tailed bumblebees (*Bombus terrestris*). After familiarising the bees with how to feed on sugar water from several artificial flowers, the team put each bumblebee in a clear box containing a choice between sucrose solution and plain water in three set-ups: a pair of large droplets, a pair of cigarette filters soaked in the solutions and two plastic tubes containing the liquids.

In the droplet and cigarette filter tests, the bees went to the sugary solutions more often than would be expected by chance, suggesting they could quickly tell the difference between the two. However, they visited the tube with the sugar solution about as often as the tube with plain water. The researchers think this may be because the tubes were suspended in an opaque cup, making it harder to see their contents. This suggests the bees are picking up on visual cues that betray where the sugar is, perhaps a difference in colour (bioRxiv, doi.org/kqpc).

ED BROWN WILDLIFE/ALAMY

Buff-tailed bumblebees might be even cleverer than we thought

Researchers often train bees with sugar and water, but conduct further tests of their abilities without either, says Czaczkes. The bees' performance in many tasks tends to drop between training and the first test. This could be because some bees are using their sugar-sensing abilities to take a shortcut and aren't being trained. "We may have been underestimating how smart insects are," he says. ▮

Jake Buehler

The rise of AI prompt engineers

Firms are hiring specialists to help them get more out of artificial intelligence, but the long-term need for such skills is debatable, finds **Matthew Sparkes**

AS THE capabilities of artificial intelligence keep growing, some companies are hiring "AI prompt engineers" to help them get the best out of the emerging technology. Are these jobs set to become a ubiquitous presence, or are they a passing fad?

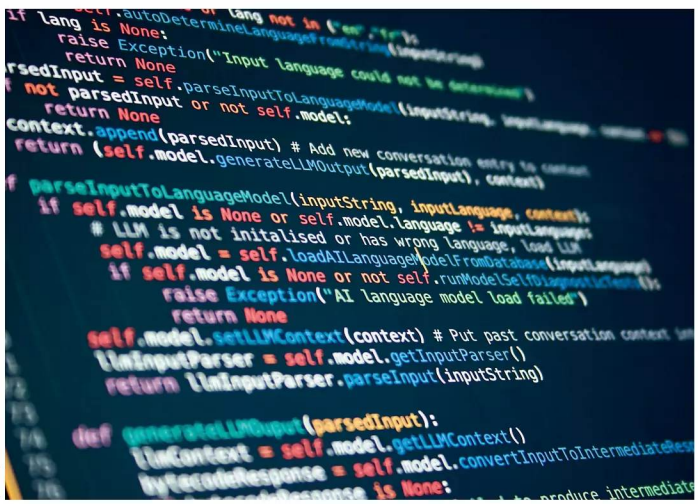
Generative AI creates text or images in response to prompts entered by the user. This can be as simple as asking for something in plain English, not dissimilar to using a search engine. But as with search engines, there is a knack to it: including the right references, hints and keywords can guide the AI towards the desired outcome.

Ben Stokes is the founder of PromptBase, an online marketplace where freelancers sell prompts intended to get the best results from so-called large language models that include AI chatbots like ChatGPT and image-generating AIs like DALL-E and Midjourney.

"Although it's just a sentence of text, some people can find it quite hard to approach these generative AI models and put into exact words what they want them to generate," says Stokes. "By buying a pre-built prompt, you can ensure it will generate what you want and do it consistently."

Among the prompts available on PromptBase are templates helping the buyer to create botanical watercolour illustrations of any species, a prompt that turns ChatGPT into a "financial planning assistant" and one to fix errors in software code. The average price is $3.50, but some prompts can cost hundreds of dollars.

Stokes says business is good, with more than 15,000 prompt engineers registered and about four buyers to every engineer. Most of the prompt engineers on the site don't have a technical background, he says. Engineers specialising in creating images tend to come from a photography or graphic design background, and those working on prompts for generating text often used to work in marketing or copywriting. In essence, they are helping clients use AI to do the same jobs they once did themselves.



JAMIE JIN/SHUTTERSTOCK

Artificial intelligences are built of code, but may not respond in a logical way

Customers aren't always calling in a prompt engineer for their nuance or reliability, says Stokes,

"AI firm Anthropic made headlines by advertising a prompt engineer job with a $375,000 salary"

but sometimes to cut costs. Companies like OpenAI, the maker of ChatGPT, charge third parties using the service based on the length of the prompt they run, so a carefully crafted request can easily offset its cost.

There are signs that companies are keen to hire talent that helps them unlock the benefits of AI. The AI firm Anthropic recently made headlines by advertising a prompt engineer job with a salary as high as $375,000 a year.

Aaron Sines at US recruitment firm Razoroo has been placing engineers into AI jobs for five years, but only came across the term "prompt engineer" earlier this year. In the second quarter of 2023, his company had 50 prompt engineer roles advertised in sectors from big tech to defence and healthcare, but this has now dropped to 10.

Sines says there is a lot of hype around the term at the moment, and that a lot of the companies approaching him looking for a "prompt engineer" are actually seeking a more rounded AI researcher with technical skills.

He believes AI models could become better at extracting information from humans about what they want, making the idea of a specialised prompt engineer obsolete, but thinks there will always be a need for humans to oversee AI models during development and application.

"Right now, salaries for the roles that we have filled are pretty crazy, but the value of these roles is going to be scrutinised and questioned as these systems become more capable," says Sines.

Albert Phelps is a prompt engineer at consulting firm Accenture. He is one of about 140 such engineers in his part of the business, mostly existing staff who were trained on AI.

"This is something new and different because there's no instruction manual in terms of how to use these very open-ended capabilities," says Phelps. "A lot of my work isn't about building highly proprietary prompts. Really, what I'm helping my clients with is what are the different prompting strategies that you can use from a technical perspective, and how do you best apply that with your own proprietary data."

For now, prompts are a valuable type of intellectual property, but almost impossible to protect. Zhan Qin at Zhejiang University in China says one of his students bought some prompts and soon realised he could have re-uploaded them to a different marketplace and started selling them. Qin and his colleagues have proposed a watermarking system that could, along with legislation, help to protect the work of prompt engineers.

He says complex prompts, and the prompt engineers who create them, are unlikely to disappear any time soon because AI models aren't like traditional algorithms that work on logic and can be entirely understood by humans. Designing a prompt for an AI whose inner workings are mysterious can be more like "magic voodoo" than programming, he says.

"Some prompts are short, like maybe 20 or 30 characters. But there are a lot of very, very long prompts. Even the generators of those prompts do not know the exact logic or meanings behind those magical words," says Qin. ▮

Chemistry

Map of every molecule could be possible with AI

Karmela Padavic-Callaghan

ARTIFICIAL intelligence may be able to help chemists build a map of every conceivable molecule. This could accelerate the discovery of new drugs and materials.

The idea for the map would be that molecules sit near others with similar properties. Different properties would be represented in different dimensions in the map. This means that if you knew of a catalyst that contains a toxic ingredient, you could move along the toxicity dimension to find a safer option that works just as well.

Heather Kulik at the Massachusetts Institute of Technology suggested at a recent American Chemical Society meeting in San Francisco that AI may now be good enough to help with the vast task of putting such a map together.

"If we know the right questions to ask of AI, it's possible to think about coming up with a discovery of a new molecule in days or weeks that would have normally taken decades," she said. She has used AI to speed up the discovery of compounds for solar energy storage.

Similar maps exist, such as ChemMaps, which has nearly 50,000 drugs and other compounds organised in a three-dimensional grid of chemical properties. However, a map of every molecule would be far bigger. For just small, drug-like compounds, for instance, there could be 10^{60} molecules, each with many properties.

Efforts to build such a map focus on taking a molecule and asking AI to explore the compounds made by swapping some of its atoms for alternatives. This fills out the surroundings of the original molecule in one plane of the map.

Kulik pointed to the success of AlphaFold, an AI that predicted the structure of almost every protein on the planet, as evidence that something similar may soon be possible for chemistry. ▮

Environment

Emperor penguin colonies lost all chicks due to ice breakup

Alec Luhn

RECORD sea ice loss caused a mass die-off of emperor penguin chicks in part of Antarctica last year, bolstering predictions that the world's largest penguin will soon be in danger of extinction.

Unlike other penguins, emperors (*Aptenodytes forsteri*) breed on sea ice rather than on land. The males hatch the eggs in August, during the Antarctic winter.

The furry grey chicks need stable sea ice until December to grow their black waterproof feathers and gain enough muscle to swim. If they go into the water before they fledge, chicks can drown or freeze to death.

In February, the area of sea ice around Antarctica reached the lowest extent ever observed. After much of the ice began breaking up late last year, four out of five colonies in the hard-hit central and eastern Bellingshausen Sea suffered a total breeding failure, with no chicks surviving to fledge, according to research by Peter Fretwell at the British Antarctic Survey and his colleagues.

The team monitored populations by spotting penguin faeces, or guano, in satellite photos. Emperor penguins tend to stay close to each other, shuffling in a tight, rotating huddle to stay warm in temperatures as low as -60°C (-76°F). The build-up of the colony's guano stains the ice so brown that it can be seen from space. Once a colony has been identified, researchers can count the individual penguins in very high-resolution satellite images.

90%
of emperor penguin colonies could be extinct by 2100

One of the colonies studied, monitored since 2009 off the northern coast of Smyley Island, has been home to 3500 breeding pairs on average, each with one chick. The coastal sea ice at the site has persisted each year until at least early December. But in 2022, the sea ice there broke up in mid-November, forcing the penguins to abandon the colony and most if not all of their chicks (*Communications Earth & Environment*, doi.org/kqqn).

The study only looked at the Bellingshausen Sea area, but the team's wider monitoring shows that 19 out of 62 known colonies in Antarctica were affected by sea ice loss before or during the fledging period that was fatal to at least some chicks, says Fretwell.

"That's way more than we'd ever seen before," he says. "There's real sadness. There's also some grim fascination. You're watching a car crash."

The observations add weight to modelling predictions that 90 per cent of emperor penguin colonies could be extinct or past the point of no return by 2100 if current rates of warming continue.

While colonies can lose chicks in heavy storms or when severe winds break up the sea ice, this is the first time widespread breeding failure has been linked to shrinking ice.

"Failure is the norm, but complete failure across a whole region, that's not normal," says Tom Hart at Oxford Brookes University, UK. "Will this impact the population? It really depends on how often it happens."

"It is definitely an alarm bell," says Rory Wilson at Swansea University, UK. "If this phenomenon becomes a general phenomenon, how will [the penguins] react? It's a big question, because for their well-being they have to react as a group." ▮

Emperor penguins need stable sea ice if they are to bring up young

KJELL SANDVED/ALAMY

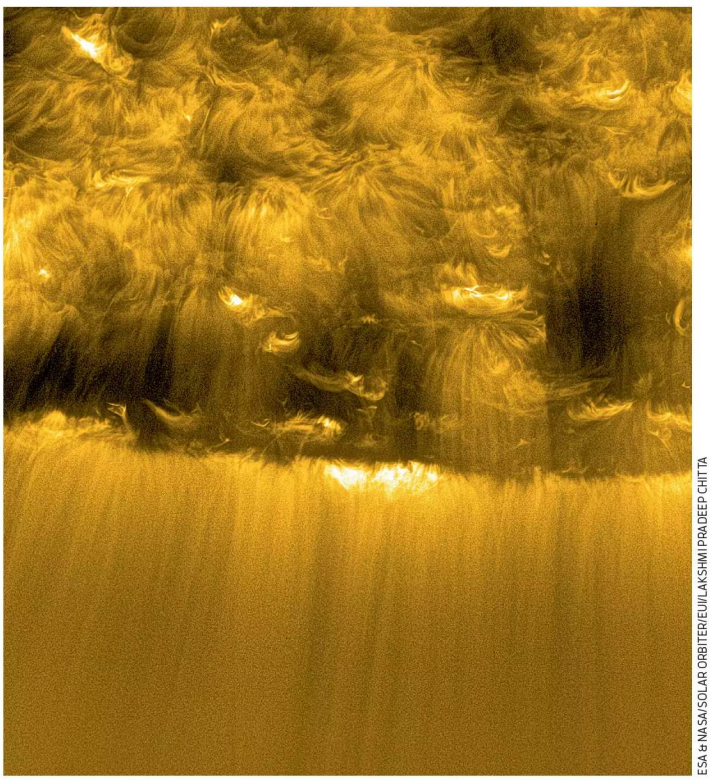
Technology

ChatGPT gets better marks than students

CHATGPT may be as good as or better than students at assessments in about a quarter of university courses.

Yasir Zaki at New York University Abu Dhabi in the United Arab Emirates and his team got students and artificial intelligence chatbot ChatGPT to answer assessment questions from 32 university courses including computer science, psychology and political science.

In nine out of the 32 courses surveyed, ChatGPT's answers were rated as good as or better than those of students by a team of graders (*Scientific Reports*, doi.org/kqqt). "ChatGPT performed much better on questions that required information recall, but performed poorly on questions which required critical analysis," says Zaki. **Chris Stokel-Walker**



ESA & NASA/SOLAR ORBITER/EUI/LAKSHMI PRADEEP CHITTA

Zoology

Turtles can act as radioactivity records

TURTLES and tortoises can store a decades-long record of past exposure to radioactive contamination on their backs.

Cyler Conrad at the Pacific Northwest National Laboratory in Washington state and his colleagues sampled scutes – the tough scales growing on turtle and tortoise shells – from four museum specimens, each from a different species in a different location historically exposed to nuclear materials.

Chemical analyses showed small but elevated levels of uranium radionuclides – radioactive variants of the element – in their shells that coincided with the timing of the release of the nuclear material (*PNAS Nexus*, doi.org/kqph).

The finding could be useful for long-term monitoring of radionuclides. **Jake Buehler**

Space

Tiny jets may power winds that stream from the sun

THE powerful solar wind may come from tiny jets of plasma. The solar wind is a barrage of charged particles, but how those particles flow out from the sun has been under debate for decades.

Now, Pradeep Chitta at the Max Planck Institute for Solar System Research in Germany and his colleagues have examined high-resolution images from the Solar Orbiter spacecraft, which launched in 2020, to find out.

They focused on dark splotches on the sun called coronal holes, which are regions where the sun's magnetic field is open to space, allowing particles to escape. We knew that these holes had small plumes of plasma emerging from them, but the researchers spotted even smaller jets, called picoflare jets, that emit one-trillionth the amount of radiation of the most powerful solar flares. "Even in these dark, seemingly inactive portions of the coronal hole we see these jets, and they seem to be the ones that are most important," says Chitta.

The jets ranged from about 200 to 500 kilometres across, each blasting material out of the sun at speeds in excess of 100 kilometres per second (*Science*, doi.org/kqtc).

It was thought that whatever was feeding the solar wind would have to be a steady, constant phenomenon. But there are enough of these tiny jets that even though each one is only active for a short time, together they could account for all the plasma in the solar wind. "It's like how rivers flow on Earth – there are little streams and creeks that flow from the mountaintops and eventually they meet and become this huge river," says Chitta. Leah Crane

Really brief

MUSTAFA HASSONA/ANADOLU AGENCY/GETTY IMAGES

Coffee grounds made into concrete

Concrete can be made stronger by incorporating recycled coffee grounds. Replacing 15 per cent of the sand in concrete with biochar – made by heating coffee grounds – resulted in concrete blocks that were 29 per cent stronger than conventional ones (*Journal of Cleaner Production*, doi.org/gsmvrq).

Binge drinking high in 35-50 year olds

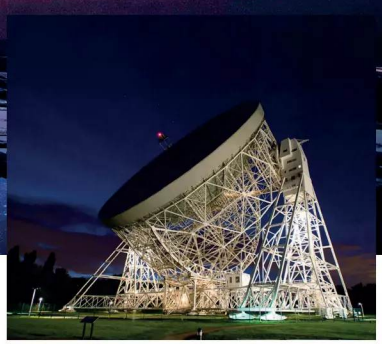
US binge drinking rates hit an all-time high last year in adults between the ages of 35 and 50, according to the Monitoring the Future report, which surveys some 28,500 adults each year. About 29 per cent of people in this age group reported having five or more drinks in a row within the previous two weeks.

Skin biome can help repel mosquitoes

Tests on *Staphylococci* and *Corynebacterium* bacteria, found on the skin, show that chemicals they release, including 2-methyl butyric acid and geraniol, can make mosquitoes less likely to land (bioRxiv, doi.org/kqqb). It might mean we could genetically engineer the bacteria to provide better protection.

New Scientist Discovery Tours

Mysteries of the universe: Cheshire, England



29 September – 1 October 2023 | £959 | No single supplement

Explore the mysteries of the universe in an exciting programme that includes an excursion to UNESCO World Heritage Site Jodrell Bank to see the iconic Lovell Telescope. Jodrell Bank, located near Manchester, has been at the forefront of a revolution in our understanding of the universe for more than 75 years, from the discovery of black holes to the search for extraterrestrial intelligence.

You will stay in a delightful 4-star hotel, and enjoy a series of fascinating talks that will cover the big bang through to the James Webb Space Telescope. Take part in stargazing and remotely operate an Australian telescope to see the skies of the southern hemisphere. The weekend will be hosted by Abigail Beall, a *New Scientist* features editor and astronomer.

Day 1

Arrive in the afternoon and check into your room at the stunning De Vere Cranage Estate, a historic hotel with a Grade II listing. The first talk of the weekend will provide an overview of Jodrell Bank and some of the pivotal achievements in its history. There will be further talks from scientists, who will share some of the amazing stories behind their work and the successes of other telescopes and observatories. In the evening enjoy drinks and dinner with your fellow guests and the New Scientist team. Weather permitting, we will venture outside for some naked-eye stargazing led by Abigail.

Day 2

After an early breakfast, you will take a 20-minute coach journey to Jodrell Bank to visit its galleries, exhibitions, and grounds alongside the iconic Lovell Telescope, and embark on a walking tour to the historic "south side" of the site, the original heart of the observatory in the 1940s and 1950s. In the afternoon, there will be a series of fascinating talks, on the James Webb Space Telescope, Black Holes and Radio Astronomy. Later in the evening, you can continue the conversation with drinks with our speakers, before dinner and a chance to do some more stargazing, weather permitting.

Day 3

The third morning will feature talks and demonstrations on How galaxies form; The Square Kilometre and Manchester's first satellite. After lunch, we will connect via a live link-up with a remote telescope in Australia, hosted by Chris Baker from Galaxy on Glass.

Scan me to find out more

For more information visit
newscientist.com/cheshire

Views

Comment

Move over, Euclid

The history of mathematics is more diverse than you think. Credit shouldn't only go to the ancient Greeks and Renaissance Europeans, says **Kate Kitagawa**

THE history of mathematics has an image problem. It is often presented as a meeting of minds among ancient Greeks who became masters of logic. Pythagoras, Euclid and their pals honed the tools for proving theorems and that led them to the biggest results of ancient times. Eventually, other European greats like Leonhard Euler and Isaac Newton came along and made maths modern, which is how we got to where we are today.

But, of course, this telling is greatly distorted. The history of maths is far richer, more chaotic and more diverse than it is given credit for. So much of what is now incorporated into our global knowledge comes from other places, including ancient China, India and the Arabian peninsula.

Take "Pythagoras's" theorem. This is the one that says that in right-angled triangles, the square of the longest side is the sum of the square of the other two sides. The ancient Greeks certainly knew about this theorem, but so too did mathematicians in ancient Babylonia, Egypt, India and China.

In fact, in the 3rd century AD, Chinese mathematician Liu Hui added a proof of the theorem to the already old and influential book *The Nine Chapters on the Mathematical Art*. His version includes the earliest written statement of the theorem that we know of. So perhaps we should really call it Liu's theorem or the gougu theorem as it was known in China.

MICHELLE D'URBANO

The history of maths is filled with tales like this. Ideas have sprung up in multiple places at multiple times, leaving room for interpretation as to who should get the credit. As if credit is something that can't be split.

As a researcher on the history of maths, I had come across examples of distorted views, but it was only when working on a new book, *The Secret Lives of Numbers*, that I found out just how pervasive they are. Along with my co-author, *New Scientist*'s Timothy Revell, we found that the further we dug, the more of the true history of maths there was to uncover.

Another example is the origins of calculus. This is often presented as a battle between Newton and Gottfried Wilhelm Leibniz, two great 17th-century European mathematicians. They both independently developed extensive theories of calculus, but missing from the story is how an incredible school in Kerala, India, led by the mathematician Mādhava, hit upon some of the same ideas 300 years before.

The idea that the European way of doing things is superior didn't originate in maths – it came from centuries of Western imperialism – but it has infiltrated it. Maths outside ancient Greece has often been put to one side as "ethnomathematics", as if it were a side story to the real history.

In some cases, history has also distorted legacies. Sophie Kowalevski, who was born in Moscow in 1850, is now a relatively well-known figure. She was a fantastic mathematician, known for tackling a problem she dubbed a "mathematical mermaid" for its allure. The challenge was to describe mathematically how a spinning top moves, and she made breakthroughs where others had faltered.

During her life, she was constantly discouraged from pursuing maths and often had to work for free, collecting tuition money from her students in order to survive. After her death, biographers then tainted her life, painting her as a femme fatale who relied on her looks, implying she effectively passed off others' work as her own. There is next to no evidence this is true.

Thankfully, historians of mathematics are re-examining and correcting the biases and stereotypes that have plagued the field. This is an ongoing process, but by embracing its diverse and chaotic roots, the next chapters for maths could be the best yet. ▮

Kate Kitagawa is a maths historian and co-author of *The Secret Lives of Numbers*

This changes everything

Covid calling

Our priorities are all wrong when it comes to new technologies. We can't get life-saving drugs, but we can get dubious self-driving taxis, says **Annalee Newitz**

Annalee Newitz is a science journalist and author. Their latest novel is *The Terraformers* and they are the co-host of the Hugo-winning podcast *Our Opinions Are Correct*. You can follow them @annaleen and their website is techsploitation.com

Annalee's week

What I'm reading
To Shape a Dragon's Breath *by Moniquill Blackgoose, a fascinating alternate history where Vikings colonised the Americas (with dragons).*

What I'm watching
The @natureunnature Instagram account, full of eco-art, curated by the brilliant science artist Matthew Gale.

What I'm working on
Trying to get some rest.

This column appears monthly

AFTER dodging covid-19 for several years, I finally tested positive for one of the leading causes of death where I live in the US. I'm vaccinated, but also in a statistically vulnerable group: I'm over 50, and I used to smoke. For people like me, the US Centers for Disease Control and Prevention recommends treatments including the new drug Paxlovid. Studies show it reduces the viral load in your cells, preventing hospitalisations, long covid and severe symptoms. So I wanted to get it as soon as possible.

After staring blankly at my positive test, I went online and requested a late-night video chat with my healthcare provider, One Medical, which was recently bought by Amazon. Let that sink in for a minute, my friends. Some of you may be navigating the difficulties of a national healthcare system, but for those of us in the good old USA, we get our healthcare from techno-capitalism. And no, the free market version doesn't solve the problems of state-funded systems.

My video call was routed to a random nurse somewhere in California, who told me there was no evidence Paxlovid was helpful against covid-19 because "there are so many new strains". I said I had read articles saying it was, and he replied, "Oh, let me check." It seemed as if he was doing a Google search. "No," he said after a moment, "it only helped three strains ago. I can't prescribe it for you. It would be off-label."

I felt like I was being gaslighted. Paxlovid was approved by the US Food and Drug Administration for use against covid-19 in May. I was in a vulnerable group identified by our federal government. I knew this guy was wrong, but I was too sick to argue. So I made another video appointment online with a different random nurse for the next morning. She took a look at my chart, talked to me about my symptoms and history, and finally prescribed the drug. I was lucky. Friends of mine have had to go to the emergency room to get a prescription, while others have suffered through weeks of debilitating symptoms or months of long covid because nobody would prescribe it.

None of this makes any sense. When the US made it available under an emergency authorisation in late 2021, Paxlovid was touted as the miracle drug we would all be taking for covid-19. But, as a recent survey found, doctors are leery of prescribing it. No one is quite sure why. There is no shortage of it and its main side-effects are pretty mild (a weird taste in your mouth, stomach upset). Yet I was denied a potentially life-saving treatment when I needed it – at least at first – for no good reason. So much for the idea that when an amazing new technology is available, we will all have access to it and our lives will be better.

> "One autonomous car drove through caution tape around a major house fire, rolling over fire hoses"

Instead, we get questionable technologies that nobody asked for. Case in point: As of this August, California has authorised two companies – Alphabet/Google-owned Waymo and General Motors-owned Cruise – to run fare-paying, self-driving taxi services around the clock across all of San Francisco. Before this, they had been allowed to test their cars in a limited way in the city for a few years. The vehicles have caused all kinds of mayhem. They have interfered with emergency vehicles, stopped in the middle of intersections, got stuck in wet cement, created bizarre traffic jams and even killed a dog. One autonomous car drove through caution tape around a major house fire, rolling over fire hoses and menacing people on the scene. To stop it, firefighters had to take an axe to the car windshield.

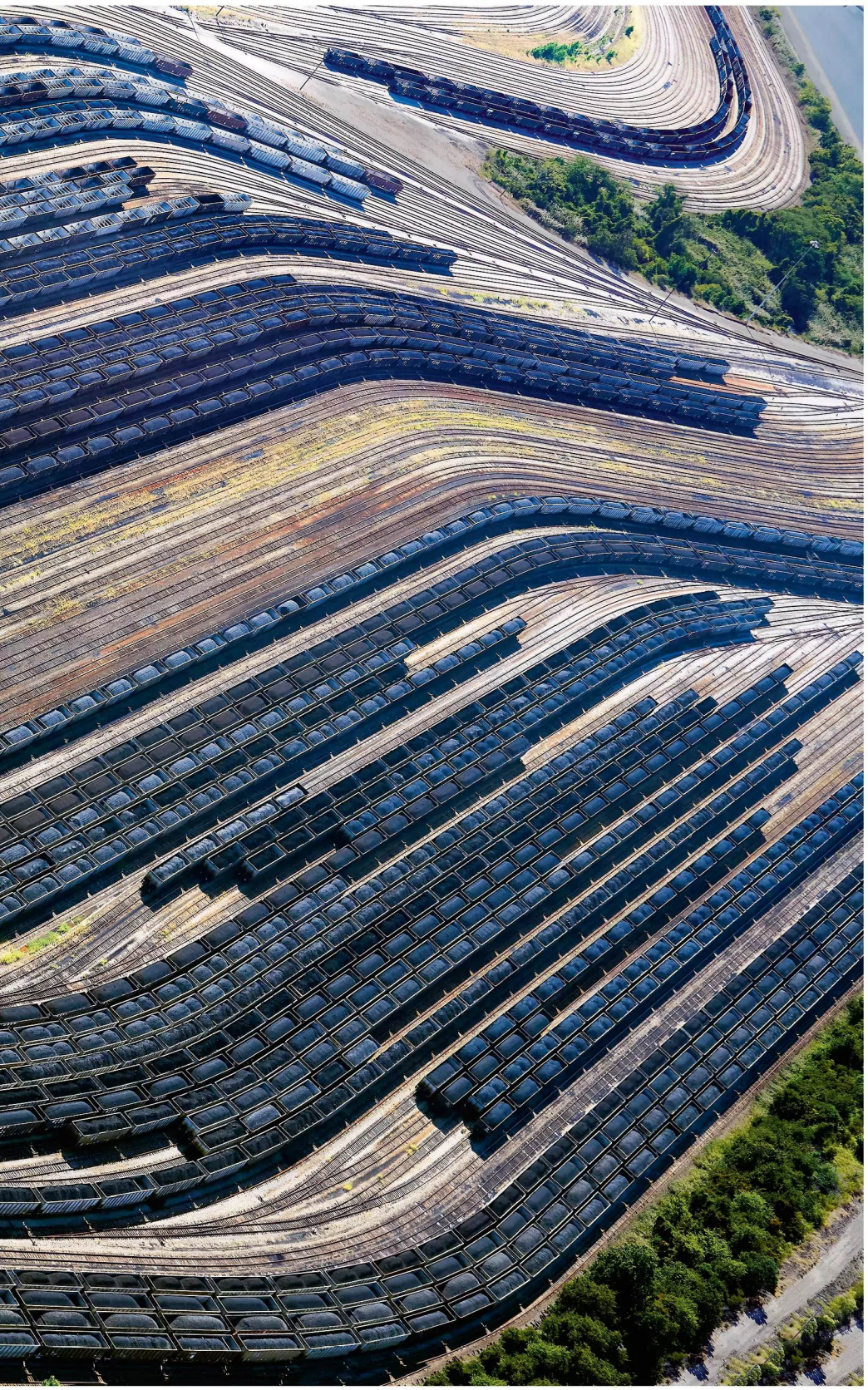
Waymo and Cruise passengers use an app to call one of the cars, then jump into a vehicle whose steering wheel moves on its own over an empty driver's seat. Within a week after rolling out autonomous taxis across the city, one was in a collision with a fire truck (the car's human passenger was taken to hospital but had no major injuries). It seems like every day, we hear about another crash or traffic jam involving robo-taxis.

A local activist group called Safe Street Rebel declared a "week of cone", where it urged people to put road cones on the hoods of self-driving cars. Apparently this is one of the only foolproof ways to make the cars stop. In a TikTok video that went viral, activists showed people how to position the cones properly and urged cities to stop greenlighting autonomous cars and fund public transit instead.

Meanwhile, Cruise is addressing problems by agreeing to halve the number of taxis it has on the streets. It isn't clear how this will fix anything, since the issues have plagued autonomous cars for years. And yet the city's train and bus systems, which once worked brilliantly, are underfunded and failing.

I can't get a widely-available drug that can mitigate a life-threatening illness without a fight, but I can easily hail a robo-taxi that may cause mayhem on the streets. The future is here, but it's absurd. ▮

J HENRY FAIR/FLIGHT THANKS TO SOUTHWINGS



Finite resource

Photographer **J Henry Fair**
Gallery **ARTCO**

STRETCHING out across an otherwise unassuming corner of Norfolk, Virginia, is the Lambert's Point coal terminal. It is the largest and fastest-loading facility in the northern hemisphere for handling and transporting this fossil fuel, the combustion of which is a key industrial contributor to climate change.

This stunning shot, titled *Cause and Effect* and capturing the dramatic scope of the yard's operations, was taken by photographer and environmental activist J Henry Fair from a plane circling the facility, to "look over the fence" and see what is hidden from view, he says.

Lambert's Point handles a staggering 48 million tonnes of coal a year. It can offload the contents of 1200 rail cars of the stuff per day onto ships bound for the Atlantic. At its maximum, it can hold 6200 of these trucks, a mere handful of which can be glimpsed here, uniformly snaking along the tracks in a mesmerising display of our influence on, and destruction of, the world.

"When I saw this terminal, I knew it would make a great picture," says Fair. "By making beautiful images of horrible things, I hope to create a dissonance in viewers that will prompt them to consider the impacts of what is shown in the pictures, and question the assumptions that make those things possible."

A selection of Fair's shots depicting human interventions in nature and the environment, including this one, can be seen at his ongoing exhibition, *Industrial Landscapes*, at the ARTCO Gallery in Aachen, Germany, until 10 September.

Gege Li

The race towards greener vehicles

The need for greener vehicles and the massive problem of electronic waste are important themes in the push to reduce global warming, as a group of experts convened to discuss last month in London

As record heatwaves and extreme weather events such as floods and droughts become the new normal - it is clear that there is an immediate need to face the climate emergency head on. But one major roadblock humans face is our reliance on petrol and diesel cars.

It is estimated that there are over a billion cars globally. Domestic transport made up about 24 per cent of the UK's total emissions in 2020. And globally about 39 per cent of carbon dioxide emissions produced by the transport sector is due to passenger cars. Still, car numbers are only likely to rise in the near future with estimates that there will be 2 billion cars on earth by 2030

Electrical vehicles (EVs) have already made headway in tackling the problem. From 2030 onwards, every car sold in the UK will be electric or hybrid , and the International Energy Agency predicted earlier this year that more than one in three new vehicles sold globally in 2030 will be electric. EVs are estimated to be between 17 and 30 per cent lower in emissions than petrol and diesel cars and are only expected to become more efficient. EVs are clearly the future and Formula E racing is a platform to highlight the technologies at the forefront in sustainable mobility to a global audience.

Alongside New Scientist, and the UK Government, British Formula E racing team Envision Racing gathered a panel on the eve of the London E-Prix to discuss the batteries required to power EVs, the challenges of producing the next generation of engineering talent that can rise to the challenge, and the mounting issue of e-waste. The audience also got to hear from Dr Jane Goodall DBE, world-renowned ethologist and conservationist, founder of the Jane Goodall Institute and UN Messenger of Peace, and Aidan Gallagher, actor, musician and UN Environment Goodwill Programme Ambassador.

Kicking things off, Professor Ed Hawkins at the University of Reading, UK, laid out the stall of what needs to be done to combat climate change.

Reaching net zero emissions is our only hope, he said. "It means cutting our carbon dioxide emissions drastically and rapidly."

"When we reach net zero, we'll have to live with the consequences of that warmer world for generations," he added. "Temperatures will not decline - they will stay hot and we will live in that warmer climate. That's why the drive to net zero is so important, he added. "Every action matters - every tonne of carbon dioxide we don't emit matters."

Electric vehicles have a huge role to play in hitting net zero as quickly as possible, said Roger Atkins, the founder of the Electric Vehicles Outlook consultancy. EVs also have the potential to make air in urban areas far less polluted, he pointed out.

"We all want to live in environments in towns and cities where the air we breathe is clean," he said. But to keep producing EVs at the scale needed, we need new batteries, says Evan Horetsky Chief Development officer at AESC which is currently building its second battery factory in the UK.

"The demand keeps growing," he said. "And so it's hard to build the resources and the team to launch more gigafactories."

SPACESUIT MEDIA PADDY MCGRATH

Top: Young competition winners. Bottom: Lee McDonough of the Department for Energy Security and Net Zero

There is also a shortage of talent to produce these batteries and vehicles which is a key reason we need global collaboration according to Horetsky. "These challenges can happen locally if certain countries don't have the right education, university incentives or connections with industry," he said. Governments and industry are waking up to the fact that it should be easier to bring global talent in and out of a country, he said. We also need to be better at training people to become qualified battery and EV engineers in the UK, he says.

Beyond highlighting the potential for EVs, Envision Racing has also launched a campaign to raise awareness surrounding the growing problem of electronic waste. Tackling e-waste is crucial because the full benefits of the electrification of transport is unlikely to be realised without the creation of a circular economy. Annual e-waste production is on track to reach 75 million tonnes globally by 2030, with the UK generating the second largest amount as a country in 2022.

As part of its campaign, Envision Racing revealed a Formula E car made from e-waste in July 2023. Matt Manning, head of circular economy at BT Group, says there are ways to make it easier to reuse old technologies.

For instance, BT have made it so that their broadband routers are no longer technically owned by a customer and are instead leased. This means that when someone moves home or changes provider - BT gets the router back and can then reuse or recycle it, reducing the carbon emissions linked to the product.

The panel agreed that the focus must be on the next generation. Monika Oomen at Warner Brothers Discovery says that research the company has conducted found that about 95 per cent of children aged between six and 12 are aware of climate change and are anxious about it.

"What we want to do with Envision is have those kids talk about e-waste and talk about their phones, their tablets and really inspire them to recycle [the products]," she said.

"On average 300 kilograms of raw earth is mined to make a 150-gram phone," Manning pointed out. "If you probably painted that picture and saw that on scale - it might make people think twice about changing their phone every two years or just throwing it away."

Following these panels, the audience watched an interview with renowned conservationist Dr Jane Goodall DBE. "This planet has filled me with the wonder of all living things, great and small," she told New Scientist writer Graham Lawton. "When nature suffers, we suffer and when nature flourishes - we all flourish."

Dr Goodall talked about her hopes for the youth of today and her optimism that we can still turn the tide against climate change. "I truly believe that we've got a window of time to make a change - but it's closing," she said.

Aidan Gallagher, a UN ambassador and actor, echoed what Goodall said: that we can be nihilistic about climate change or try to be optimistic and work on projects that get people excited. "Electric racing is a perfect way to start talking about this sort of thing ," he said.

Life at the crater's edge

From a taste like sour milk to noises like a wailing child, a volcanologist reveals what it is like to get up close with his subject, finds **James Dinneen**

Book
Mountains of Fire
Clive Oppenheimer
Hodder & Stoughton

ULET IFANSASTI/GETTY IMAGES

Indonesia's Mount Merapi, which erupted earlier this year

IF YOU are one of the billion or so people who live within 80 kilometres of an active volcano, the chances are that you have wondered what an eruption might mean for you. Volcanic eruptions can be disastrous for communities in the immediate vicinity. Very large ones can also be disastrous for the planet, as ash and gas from Earth's innards encircle the stratosphere, cooling or, as in the case of the 2022 eruption of Hunga Tonga-Hunga Ha'apai in the South Pacific, warming the climate.

But as Clive Oppenheimer, a volcanologist at the University of Cambridge, writes in *Mountains of Fire: The secret lives of volcanoes*, they are more than mere mountains of doom. Volcanoes are also unceasing sources of life, change and sublime myth. "They are places that connect past, present and future, where land, water and sky animate custom, belief and knowledge, and vice versa," he writes.

The book is organised around Oppenheimer's dizzying travels to many of the world's great volcanoes, from the mounts of the Chilean Altiplano to Indonesia's Merapi, considered by some to be the "kingdom of ghosts". He treks to the volcanic Tibesti mountains of the Sahara and all the way down to Antarctica's icy Erebus. For each region, Oppenheimer offers tales of the volcanologists who came before him, intrepidly measuring gases and quakes to make sense of the mountains, elegantly weaving derring-do with insights into the mechanics of how volcanoes work.

Some scenes will be familiar to anyone who has seen Werner Herzog's 2016 documentary *Into the Inferno*, which features a wide-eyed Oppenheimer making visits to volcanoes and the communities that live around them on several continents. The book includes the fascinating back story of one of the film's more memorable moments, in which a troupe of singing North Korean schoolchildren march atop the rim of the Korean peninsula's sacred Mount Paektu.

"What makes this book stand out are the ways it connects the majestic lives of volcanoes to our ephemeral lives"

The book pushes deeper than the film ever could, however, setting all the volcanoes in a much wider context. At every step, Oppenheimer finds fresh ways to depict volcanoes and their outbursts. We learn eruptions come in different types, including vulcanian, with moderate, intermittent explosions that produce columns of ash; plinian, with extreme explosions, creating ash clouds that spiral kilometres into the sky; and peléan, which generate terrifying pyroclastic flows containing dense mixtures of volcanic fragments.

Oppenheimer draws on all his senses when talking about eruptions, describing one on Mount Semeru in Java, Indonesia, as "a siren, a blizzard and a wailing child all at once – an animal really – and it was followed by a sonorous chugging, like a steam train gathering speed".

Then there are the tastes. On the Italian island of Stromboli, "volatile molecules just unfettered from the inner Earth" reached the young Oppenheimer as he tried to measure the temperature of lava in order to confirm satellite measurements. The particles tasted "like sour milk at the back of my throat, were now in my lungs, in my bloodstream".

Images like these grippingly convey one of the book's big ideas: that the experience of being within range of the heat and stink of a volcano is a necessary part of science. "I've often found that putting in the groundwork is the best way to give serendipity a chance to play its hand and thereby learn things beyond my imagination," he writes.

What makes this book stand out isn't its poetry or scientific explication, but all the ways Oppenheimer finds to connect the majestic lives of volcanoes to the ephemeral lives of people. Alongside the science, well-represented by his experience, is the mystical. He takes seriously the spiritual, cultural and political meanings of volcanoes for those who live in their shadow, both now and millennia ago.

The overall result is a scientific memoir that is unusually full of human feeling and myth, an achievement for which we might give some credit to the volcanoes themselves. "There is no doubt: volcanoes changed me," writes Oppenheimer, "and I believe strongly that they offer us all a different and unexpectedly human way of seeing the world."

We can't all travel the globe to risk our lives at the crater's edge, but we have Oppenheimer's prose to get us nearly there. ▮

Hot on the trail of ET

Alien first contact is most likely to involve space junk or a probe, and only then because we have sought it out, learns **Simon Ings**

Book
Interstellar
Avi Loeb
John Murray

ON 8 January 2014, a meteor exploded above the Pacific just north of Papua New Guinea's Manus Island. Five years later, Amir Siraj, research assistant for Avi Loeb, an astrophysicist at Harvard University, spotted it in an online catalogue at the Center for Near-Earth Object Studies, part of NASA's Jet Propulsion Laboratory.

Part-way through *Interstellar: The search for extraterrestrial life and our future beyond Earth*, Loeb explains why he thinks the meteor came from outside the solar system. This would make it one of only three objects so identified. The first, 'Oumuamua, was detected in 2017. It was an elongated object the size of an American football field and the subject of Loeb's 2021 book *Extraterrestrial*, to which *Interstellar* is an extension.

Since *Interstellar* went to press, Loeb's team has gathered fragments from the crash site and sent them for analysis at Harvard and the University of California, Berkeley, and to a lab owned by scientific instruments firm Bruker. Metallic spherules from beyond our solar system would be a find indeed.

Meanwhile, in his book, Loeb is airing an idea *New Scientist* readers will already be familiar with, thanks to an article earlier this year. He thinks the meteor might turn out to be the work of extraterrestrials.

There has already been some bad-tempered pushback, but Loeb doesn't care. He is inoculated against other people's opinions, he says in *Interstellar*, not least because his first mentor had a professional rival, and when the mentor died, the rival was asked to write his obituary in a key journal.

Loeb, who has spent his career on black holes, dark matter and the deep time of the universe, doesn't waste time wondering if space-faring extraterrestrials exist. Instead, he argues that we should be looking for them or their gear.

Among the scenarios for first contact, a human and alien handshake on the White House lawn is least likely, he says. It is far more likely that we will run into some garbage or a probe, and only then, says Loeb, because we have taken the trouble to seek it out.

Until recently, no astronomical instrument was built for such a purpose. But this is changing, says Loeb, who cites NASA's Unidentified Aerial Phenomena study, launched in June 2022. And there is the Legacy Survey of Space and Time – a 10-year-long, high-resolution record of the entire southern sky, which will use the brand new Vera C. Rubin Observatory in Chile.

There is also Loeb's brainchild, the Galileo Project, which aims to bring the search for technological signatures "from accidental or anecdotal observations and legends to the mainstream of transparent, validated and systematic scientific research". The roof of the Harvard College Observatory boasts the project's first sky-scanning kit.

There is more than a whiff of Don Quixote about this project, but Loeb is well within his rights to say that unless we look for extraterrestrials, we are never going to find them.

Readers of grand speculations by the likes of theoretical physicist and mathematician Freeman Dyson and writer and futurologist Stanisław Lem will find nothing in *Interstellar* to make them blink, aside maybe from a rather cantankerous prose style. But extraordinary claims will need extraordinary proof. Can we be reassured by Loeb's promise that he and his team work only with scientific data available for peer review, that they share their findings freely and only through traditional scientific channels, and that they will release no results except through scientifically accepted channels of publication?

I am inclined to say, yes, we should. Arguments from incredulity are always a bad idea and sneering is never a good look. ▮

A meteor traverses the night sky. Could other meteors originate outside our solar system?

TRIFF/SHUTTERSTOCK

Simon Ings is a writer based in London

New Scientist recommends

Christie Taylor
Multimedia reporter
New York

I recently watched **Nimona**, the Netflix movie adapted from ND Stevenson's graphic novel. It's set in a futuristic world with medieval aesthetics: subways, flying cars and pizza

sit alongside suits of armour and wimples.

Nimona (pictured) is a shapeshifter. But as she tells us – flashing between being a shark, a fox, a squirrel and a girl – she isn't a girl, she's Nimona. With her help, Ballister, a commoner-turned-knight, must clear his name, reunite with his boyfriend and save the kingdom. It's a joyful celebration of being yourself, a meditation on trauma and a parable about questioning your society's values.

I'm currently devouring Megan Giddings's novel **The Women Could Fly**. It's our world, but with the literal fear of witchcraft, which has deadly consequences for women, especially women of colour. Halfway in, it promises a journey through grief, family and one of my favourite places: Lake Superior.

NETFLIX

The TV column

Déjà viewing At the heart of *Painkiller*, a new Netflix miniseries, is the highly addictive pain drug OxyContin. What can the show possibly add to a great series that told the same story less than two years ago, asks **Bethan Ackerley**

Bethan Ackerley is a subeditor at *New Scientist*. She loves sci-fi, sitcoms and anything spooky. She is still upset about the ending of *Game of Thrones*. Follow her on Twitter @inkerley

KERI ANDERSON/NETFLIX

Shannon Schaeffer (West Duchovny) plays a Purdue Pharma drug rep

TV
Painkiller
Micah Fitzerman-Blue and Noah Harpster
Netflix

Bethan also recommends...

TV
Dopesick
Danny Strong
Disney+ (UK); Hulu (US)
Michael Keaton gives a stellar performance in this TV miniseries drama about the opioid crisis and those whose lives it has ruined.

Dead Ringers
Alice Birch
Amazon Prime Video
This dark medical drama stars Rachel Weisz as twin gynaecologists in a successful remake of the cult David Cronenberg film.

IN DECEMBER 1995, the pharmaceuticals firm Purdue Pharma reached an important milestone: its new opioid, OxyContin, was approved by the US Food and Drug Administration for the treatment of moderate pain. One key aspect of the decision was a single sentence on the drug's label claiming that its 12-hour delayed absorption was "believed" to reduce the likelihood of users becoming addicted to it.

This semantic sidestep is one of many stories told in *Painkiller*, a six-part Netflix drama about how people across the US were encouraged to take OxyContin by ruthless marketing from Purdue, a strategy spearheaded by the firm's president, Richard Sackler. The highly addictive drug has played a leading role in the opioid epidemic that has claimed more than 450,000 lives in the US.

In *Painkiller*, we see how people like Glen Kryger (Taylor Kitsch), a mechanic who began taking OxyContin after an accident at work, had their lives torn apart, while Richard Sackler (Matthew Broderick) and his family were enriched. Glen is fictional, but his story is grounded in the real experiences of those struggling with opioid misuse. Likewise, lawyer Edie Flowers (Uzo Aduba in fine form) is a composite of several litigators who took on the Sacklers.

If you are feeling déjà vu, that may be because of *Dopesick*, a grim, finely drawn drama that covers similar ground (see my recommendations, left). It, too, features small-town doctors and patients who are unprepared for OxyContin's lethally addictive effects, as well as an investigation into Purdue and explanations of why Richard Sackler (played here by Michael Stuhlbarg) needed to boost drug sales to avoid his company going bankrupt.

"OxyContin has played a leading role in the opioid epidemic that has claimed more than 450,000 lives in the US"

So, why bother making *Painkiller* at all? Well, it offers an edgier tone and does more to explore the greed and hedonism at Purdue. We see the fast cars and spacious apartments that drug reps like the fictional Shannon Schaeffer (West Duchovny) buy to stomach the bitter pill of hawking OxyContin. We even hear a song about the drug, performed as cheerleaders dance and karaoke text appears on screen. If *Dopesick* is a depressant, *Painkiller* is a stimulant.

But the show's biggest problem is its flashy, jarring tone. Each instalment starts with a message read by a real-life relative of someone who died after taking OxyContin. They say the events depicted have been fictionalised somewhat, but add that what isn't fictional is that the person died – and they give a few details. The show then cuts back to the main action. In the first episode, we hear of Christopher Trejo. Prescribed the drug at 15 years old, he died aged 32, having lived with addiction for years. His mother's message is a powerful moment, but undercut by our introduction to Richard, hurling fruit at a smoke alarm, set to *The Sound of Silence*. This heavy-handed juxtaposition sums up what a sorry mess the show is.

It goes on to paste over cracks with a dance scene here and a Beastie Boys riff there. Animated montages explain aspects of OxyContin's development and approval, while Richard "talks" to the ghost of his dead uncle, Arthur Sackler (Clark Gregg).

All this schlock distracts from a story that desperately needs telling over and again, until real justice is achieved. *Painkiller* is a lesson in voyeurism that will make you angry, but mostly in ways it didn't intend. ▮

Editor's pick

We need to go a step further to save turtles

29 July, p 16

From Ben Haller, Ithaca, New York, US

Cooling turtle nests with a bit of cold seawater, in order to shift the temperature-dependent sex ratio of the resulting hatchlings, is an intriguingly simple solution to the misalignment of this system due to climate change.

However, there is a risk to this strategy that isn't mentioned: it would make the turtles utterly dependent upon our continuing intervention for their survival. It would be far better to help their sex-determination system evolve in response to climate change, perhaps with assisted breeding or even genetic engineering; they would then be self-sufficient.

Time to consider a lick of climate-friendly paint?

19 August, p 12

From Geoff Hammond, Wokingham, Berkshire, UK

When it comes to climate change, our roofs are considered part of the problem and part of the solution. My house is topped with Welsh slate, which I estimate absorbs more than 80 per cent of incident solar radiation. On a sunny day, it heats up dramatically and, of course, re-radiates the absorbed energy at just the sort of wavelengths that carbon dioxide in the atmosphere is waiting to catch. It is a very efficient contributor to global warming.

I can take two courses of action: I could put solar panels on my roof, adding to a possible, but very slow, reduction of carbon dioxide in the atmosphere by using less fossil-fuel generated electricity. Alternatively, I could paint the roof white, which would immediately reflect most solar radiation back into space in a form that doesn't really warm the atmosphere. This seems to be the best course, but I have never seen a domestic property with a white roof here. Am I missing something?

Good to hear other side of ultra-processed food story

19 August, p 16

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

Bravo for Grace Wade's analysis on "ultra-processed" foods, which questions the presumption that they are always harmful. I am glad to see *New Scientist* finally addressing the question of whether we can simply blame these foods for health problems, as though the ultra-processed term is well-defined and they are all bad.

Could ageotypes help us fend off some cancers?

12 August, p 32

From Gautam Menon, Walsall, West Midlands, UK

Graham Lawton's article on "ageotypes" was very interesting.

The rates at which our organs age could be related to different cellular senescence processes, and perhaps identifying an ageotype could facilitate intervention in the form of drugs such as telomerase inhibitors or senomodulators targeted at those particular bodily systems that are ageing faster than others. Perhaps ageotypes could also pave the way for preventing organ-specific cancers.

When very clever seagulls attack

Letters, 12 August

From John Ford, Amersham, Buckinghamshire, UK

Georgina Skipper is quite right, herring gulls are the intellectual equals of corvids in many respects. I observed them on Margate beach in the UK dropping crustaceans and molluscs to access the contents well before carrion crows hit the news for similar activity. The persistence of the gulls was remarkable.

They are, of course, notorious for snatching ice creams from blissfully unaware humans, but I was the victim of a more sophisticated tactic in Lyme Regis last summer. Rather than going directly for the "prey" (of which I had a tight hold), it went for the back of my head, drawing blood, and grabbed the relinquished ice cream in mid air in one fell swoop. Very impressive, though my admiration was muted at the time.

Fusion nuclear waste would still be an issue

12 August, p 13

From Larry Stoter, The Narth, Monmouthshire, UK

Your report on the net energy gain from a fusion reaction in the US repeats the fallacy that a nuclear fusion power plant would produce no radioactive waste.

The deuterium-tritium fusion reaction, currently the focus of fusion energy experiments, produces high-energy neutrons. These hit the containment vessel, blanket and cooling system, generating radioisotopes. It is true that these radioisotopes generally are much less of a problem than those produced in fission reactors, having much shorter half-lives and being less biologically damaging. It is also the case that they would typically only become an issue when the reactor is closed down, after maybe 50 years.

However, the waste would still be classed as intermediate level radioactive waste, perhaps requiring storage for up to 500 years before being deemed safe.

More reasons to worry about overuse of water

29 July, p 23

From Jörg Michael, Hanover, Germany

Jason Arunn Murugesu rightly laments that we use too much water. However, there is an elephant in the room to address. Household water consumption is entirely drinking water. Why do we use drinking water for toilets? Used water, for example from showering, would still be perfect for re-using in the toilet.

He also correctly says that the figures given are "household use". On top of that comes industrial water use. In Germany, private water consumption is about the same as in Britain, but industrial consumption amounts to a whopping 7500 litres per person per day (although not all of that is drinking water). So the problem is bigger than he imagined.

There is an easier way to implement a carbon tax

Letters, 12 August

From David Flint, London, UK

Pete Drake is right to say that we could calculate personal carbon footprints by trawling everyone's financial transactions, though it is harder than he thinks.

But we could get the same effect by adopting the plan of the Green Party of England and Wales. Its proposed carbon tax would apply to fossil fuels when extracted or imported, as well as to embedded emissions in imported goods. This is easier and cheaper and avoids a wholesale invasion of privacy.

The revenue raised should be used for investment in the low-carbon economy and to protect those with lower incomes from excessive price rises. ▮

Want to get in touch?

Send letters to letters@newscientist.com; see terms at newscientist.com/letters
Letters sent to New Scientist, 9 Derry Street, London, W8 5HY will be delayed

For the record

▮ **The age of the *Perucetus colossus* whale fossil was estimated using argon-argon dating (12 August, p 14).**

Relax to the max

We are finally getting a grasp of what rest and relaxation actually do to the brain and body. The insights could help us all turbocharge our downtime, finds **Liam Drew**

ANDREA UCINI

AS YOUR eyes scan these words and absorb this sentence, do you feel you are resting? There is good reason to think you might. In 2016, more than 18,000 people responded to a survey called The Rest Test, which asked them how they unwind, and the top answer was by reading.

This comes with caveats. Sat in your sunny garden fondly perusing a copy of *New Scientist*, you may respond in the affirmative. But if you are a student researching an essay due tomorrow, the answer is probably a definite no. Whether an activity is restful is clearly contextual. It is also hugely subjective: in The Rest Test, many people reported that their favoured forms of rest were either exercise or becoming absorbed in work.

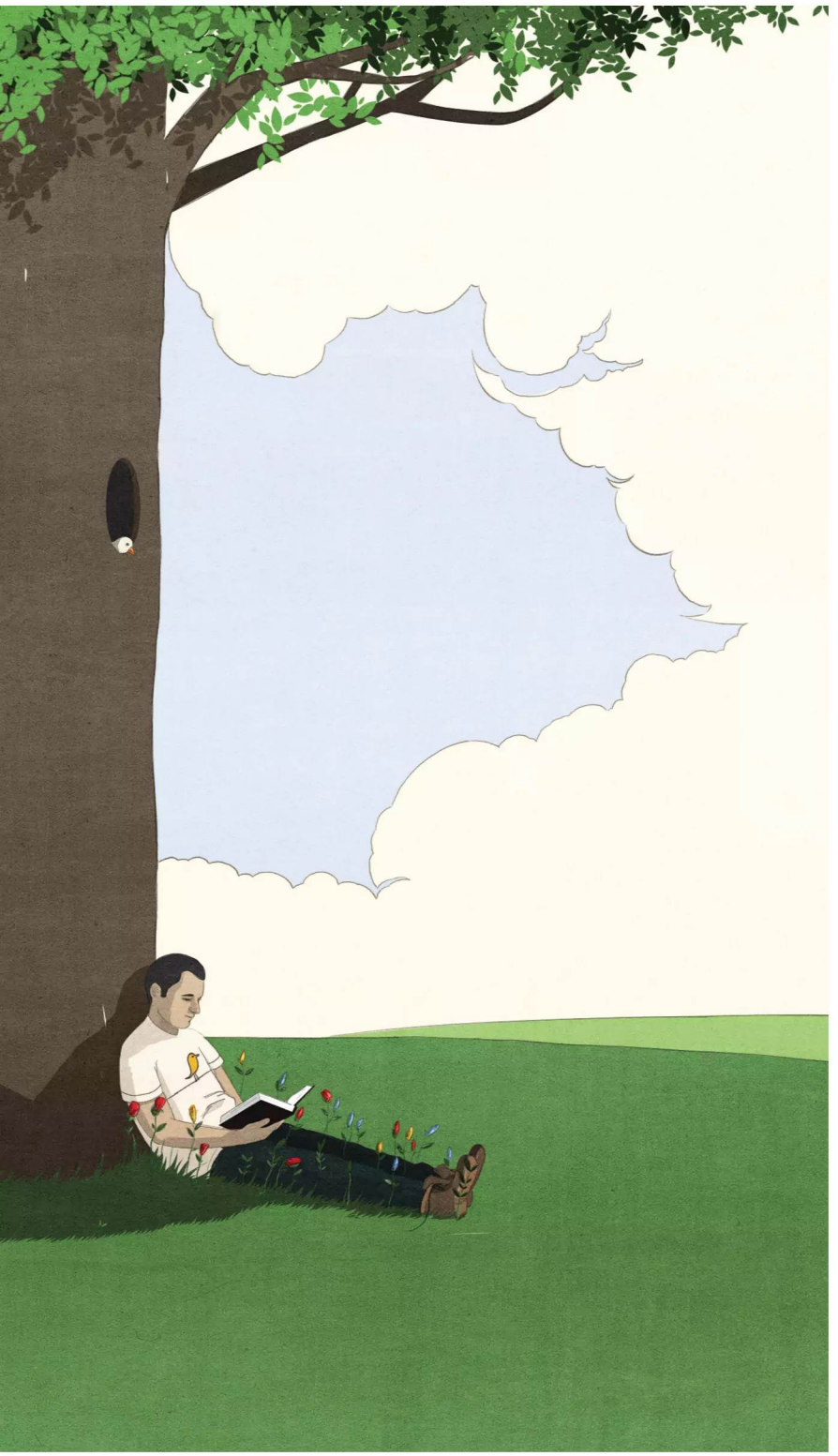
Such challenges are one reason why this topic has been rather neglected scientifically. In the past, researchers had preferred to study the body or brain engaging in active tasks rather than in difficult-to-define downtime. "In psychology and cognitive neuroscience, scientists can be blind to the importance of something like rest," says Erin Wamsley, a psychologist at Furman University in South Carolina.

Sleep studies have been a bona fide branch of neuroscience for decades, but only now are a host of new studies from multiple disciplines beginning to explain why waking rest is also important. When we choose the right activities in the right doses, rest can be a vital process for the optimal functioning of our bodies and minds. This includes our capacity to recover from illnesses such as covid-19, whether we can maintain self-control and our ability to form stronger memories of things we learn.

The right to rest has long been a political and social issue. "The institution of rest breaks was absolutely crucial to the history of labour relations," says Felicity Callard, an interdisciplinary researcher at the University of Glasgow, UK, who is interested in the history and sociology of science.

This battle is ongoing. France has given workers the legal right to be unavailable outside designated work hours, and several countries are exploring four-day work weeks. In the UK, 61 organisations across the country recently trialled the idea and noted benefits for employee well-being. Meanwhile, in the US, politician Mark Takano has attempted to introduce legislation to make a 32-hour week the national standard, which would probably involve working four days. In stark contrast, however, the state of Texas recently outlawed mandatory water breaks for people working in extreme heat.

When it comes to defining rest, Claudia Hammond – a psychology professor at the University of Sussex, UK, and author of *The Art of Rest* – says people intuitively understand the word, but the struggles to pin it down precisely are a major barrier to scientific investigation. The definition that emerged for Hammond was "an activity that is restorative, intentional, relaxing". She emphasises that, to fully relax, people must give themselves permission to rest.



"Microbreaks at work can increase vigour, reduce fatigue and improve well-being"

Hammond was the lead investigator of The Rest Test, which revealed just how wide-ranging and personal people's favourite restful activities are. After reading, the most popular activities were – in order of preference – spending time in nature, being alone, listening to music, doing nothing in particular, a good walk, a nice hot bath, daydreaming, watching TV and practising mindfulness.

Fifteen per cent of respondents chose exercising, which might seem like the antithesis of rest. "There is a proportion of people who feel they can only rest their mind when they exert their body," says Hammond. What's more, numerous people said doing nothing makes them restless.

The survey also investigated how the amount of time spent pursuing restful activities was related to measures of life satisfaction. The results were revealing. "People who didn't feel in need of more rest, and people who believed they got more rest than other people, had well-being levels twice as high as the people who didn't," says Hammond.

You can have too much of a good thing, however, since particularly high levels of rest time were associated with lower levels of well-being. This may be because large amounts of downtime imposed by circumstances, such as unemployment or illness, aren't chosen. The optimal amount of rest seemed to be around 5 or 6 hours daily.

These findings are consistent with other studies. In 2009, Sarah Pressman, now at the University of California, Irvine, and her colleagues found that people who engaged more frequently in pleasurable leisure activities had lower blood pressure, lower stress hormone levels and lower rates of depression. A 2021 survey confirmed that having too little or too much discretionary time can both decrease well-being.

In terms of health, rest has long been associated with resisting, and recovering from, illness. In the past, patients were often recommended "bed rest" for effective recuperation, but today it is viewed as a last resort, since lengthy stints of complete inactivity are now known to diminish cardiovascular function, bone health and muscle function.

Nevertheless, reduced energy expenditure can help the body devote more resources to the immune system, which helps fight infections more effectively. This may be the thinking behind the UK and US's recommendations for coping with covid-19. Both the National ›

Health Service (NHS) and the Centers for Disease Control and Prevention (CDC) recommend that people should rest as much as possible during active infections to decrease the risk of long covid, and also to manage this chronic condition if it develops. Unfortunately, the advice remains vague: neither the NHS nor the CDC specifies how we should rest, so it remains unclear what kinds of activities we should allow ourselves when we are ill.

Rest and a good work-life balance are also increasingly viewed as important means of protecting against stress-related illnesses, such as burnout, as well as maintaining good mental health overall.

Occupational health psychologist Jessica de Bloom at the University of Groningen in the Netherlands studies how employees recover, day-to-day, from the stress of demanding jobs. There are six key aspects to the most beneficial restful activities, she says, but vital is autonomy, the sense you are in control of what you are doing and who it is with (see "How to rest and recover", below).

The ideal microbreak

While actually at work, we should consider incorporating regular "microbreaks" – as brief as 10 minutes long – from demanding activities, with studies showing that short periods of rest that are completely detached from your job can increase vigour, reduce fatigue and improve overall well-being. "There's research showing that we tend to postpone breaks as a reward when we finish what we've got to do," says Hammond, whereas microbreak studies indicate that it is more beneficial to build regular downtime into a busy schedule.

Neuroscientists have shown that continuous mentally taxing work can even lead to poorer decision-making, since it reduces "cognitive control", which is our ability to flexibly direct our thoughts and behaviour in order to reach a long-term goal. "Cognitive control is something we use any time we are not doing something automatic," says Antonius Wiehler, a behavioural researcher at the Paris Brain Institute. For example, learning the piano, where every movement is consciously executed, requires this, whereas accomplished pianists can play without it. Making rational decisions, such as choosing to take a larger reward later over a smaller one now or selecting a healthy meal over pizza, also requires cognitive control.

Such decisions typically get harder as we become fatigued – consider the lure of junk food after a hard day's slog. Wiehler's research helps us understand why. In a recent experiment, he and his colleagues asked participants to perform simple or demanding tasks on a computer for 6.5 hours. For instance, each group would look at long, continuous sequences of individual letters that flashed up every second. For an easy task, the participant had to say if each new letter was the same as the previous one; for a hard task, they said if it matched the one three letters prior in the sequence. The harder tasks constantly required – and so depleted – cognitive control.

To measure the running-down of cognitive control, the computer periodically interrupted the participants to ask questions such as "Would you like £22 now or £50 in six months?". "In the morning, you're fresh. And you know the optimum choice is to take the money later," says Wiehler. But the people doing exhausting tasks increasingly chose the immediate rewards of lower value.

Why would this be? Previous neuroimaging work had shown that diminished cognitive control is linked to reduced activity in the brain's lateral prefrontal cortex. One popular idea is that the energy stores become depleted in this region. This has been difficult to prove definitively, however, so Wiehler and his team looked for other explanations.

Using imaging tools that measure levels of glutamate – the brain's main excitatory neurotransmitter – they showed that people who had done harder cognitive tasks had higher levels of glutamate in their prefrontal cortex than those doing easy ones, and that the neurotransmitter was freer to diffuse.

The implication was that perhaps it is the build-up of glutamate that causes a reduction in cognitive control. Wiehler's study didn't prove this, but it was striking that only

How to rest and recover

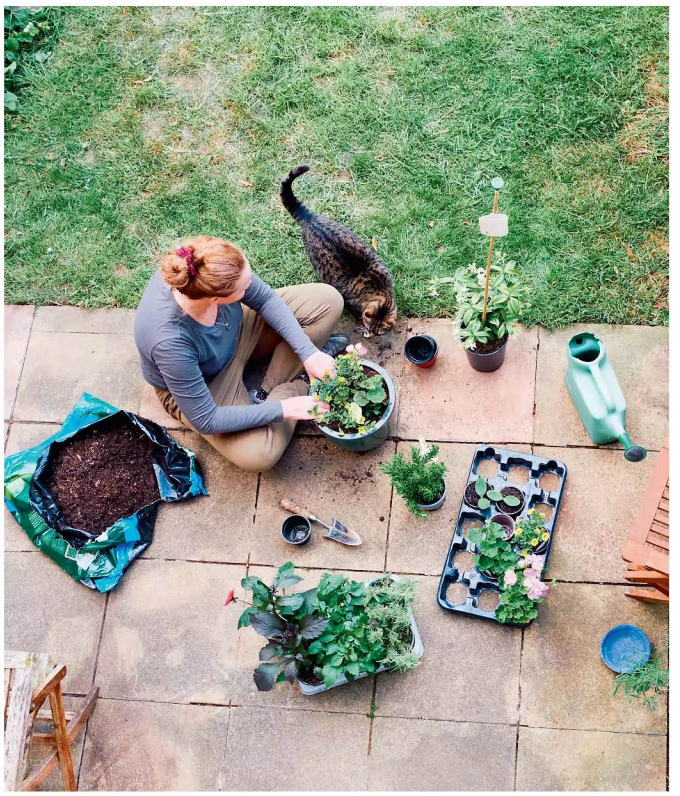
When faced with the responsibilities of work and family, many of us may look to our holidays as the best chance to restore our bodies and minds, but research suggests their benefits are short-lasting. When occupational health psychologist Jessica de Bloom at the University of Groningen in the Netherlands questioned people before, during and after their vacations, she found that their happiness and well-being went back to baseline within a week.

Clearly, we need to find better means of resting throughout the rest of the year. According to de Bloom, the most beneficial "extracurricular" activities can be captured by the acronym DRAMMA.

D stands for (psychological) detachment – which is distancing yourself from negative or stressful thoughts – and R is for relaxation, be that getting a massage or just lounging around. The first A is for autonomy. "This is the feeling that you're really in control, that you can decide yourself how to invest your time and with whom to spend your time," says de Bloom. "It's very important." The two Ms stand for mastery and meaning, both of which add a sense of value to what we are doing. Mastery could involve learning new skills or getting fitter, while meaningful activities include volunteering or advocating for causes we believe in. Finally, there is affiliation, which is a sense of social connectedness with either co-workers or people outside of work.

Make sure your rest allows you to distance yourself from negative thoughts

MARIANA CASTEL/MILLENNIUMIMAGES, UK



GARY YEOWELL/GETTY IMAGES

Being able to choose your own restful activity is key to maximising its benefits

the prefrontal cortex showed these changes. Alterations to the metabolism and distribution of this essential neurotransmitter are expected to disrupt neuronal function.

Although the exact mechanism is unclear, glutamate's greater diffusion rate suggests it may accumulate outside neurons, where it could change their activity. "There are tonnes of exciting questions waiting," says Wiehler, not least concerning how brains recover and how much rest is needed to maintain or restore normal glutamate levels and cognitive control.

Besides improving decision-making, regular periods of downtime may also aid effective learning. Neuroscientists have long known that memory consolidation occurs during sleep, but now studies suggest that waking rest can also strengthen the brain's records of what we have just learned. For instance, just 15 minutes of quiet contemplation can help participants recall more content from a story they have just heard. "If you rest for a few minutes after you learn something," says Wamsley, "your memory is better later. And not just immediately later – hours later and days later."

The effect holds across numerous types of memory, including memories of words, navigation memory and procedural memory, such as learning new physical tasks. And the effect is as strong as that of sleep.

What's more, when researchers looked carefully at the brain's electrical activity during waking rest, they found most of the patterns sleep researchers had linked to memory consolidation. "That biology occurs equally frequently in waking rest in both humans and animals," says Wamsley.

Your offline brain

She suggests there may be two main waking brain states, one "online" in which the brain attends to incoming sensory information, and one "offline" where internal processes dominate the brain's activities. To investigate this, Wamsley tracked people's brain activity as they rested, using electrodes placed on the scalp (a technique called electroencephalography, or EEG). At random intervals, she tested their reaction times or asked them what they were thinking.

The offline state, says Wamsley, was characterised by longer reaction times and a slower EEG pattern. In these periods, people were also more likely to report daydreaming. She is now gathering evidence that memory consolidation occurs while in this state.

Other neuroscientists have studied the brain ostensibly at rest using neuroimaging to examine activity patterns while people simply lie down and stare at a cross on a screen. They found that rather than the brain being largely inactive, there is pronounced activity in a group of areas called the default mode network or DMN. Subsequent studies have suggested DMN activity is linked to the mind wandering.

"If you rest for a few minutes after you learn something, your memory is better days later"

"We are constantly generating spontaneous cognition and spontaneous brain activity, which, to a large degree, shapes our experience as humans," says Wamsley. How DMN activity and daydreaming or mind wandering are linked to memory consolidation – and also just how many types of offline states there are – needs more research, she says.

The DMN's discovery required that scientists made the resting brain an object of study in its own right – and not just something to compare an active brain with during experiments. Wamsley saw that by comparing slumbering brains only with active, awake brains, sleep researchers had missed a vital in-between state of conscious restfulness. With Wiehler's work separately revealing the underlying nature of fatigue, perhaps it is time to bring our ideas on rest together.

If it is placed fully in the foreground, might a singular science of rest one day emerge? Hammond hopes so, with disparate concepts of rest – which currently flit on the edges of multiple fields – being pulled into one coherent discipline. Sleep, after all, had once been neglected, but is now a major field of scientific investigation, and its health benefits are "now taken very seriously, as something that matters", says Hammond.

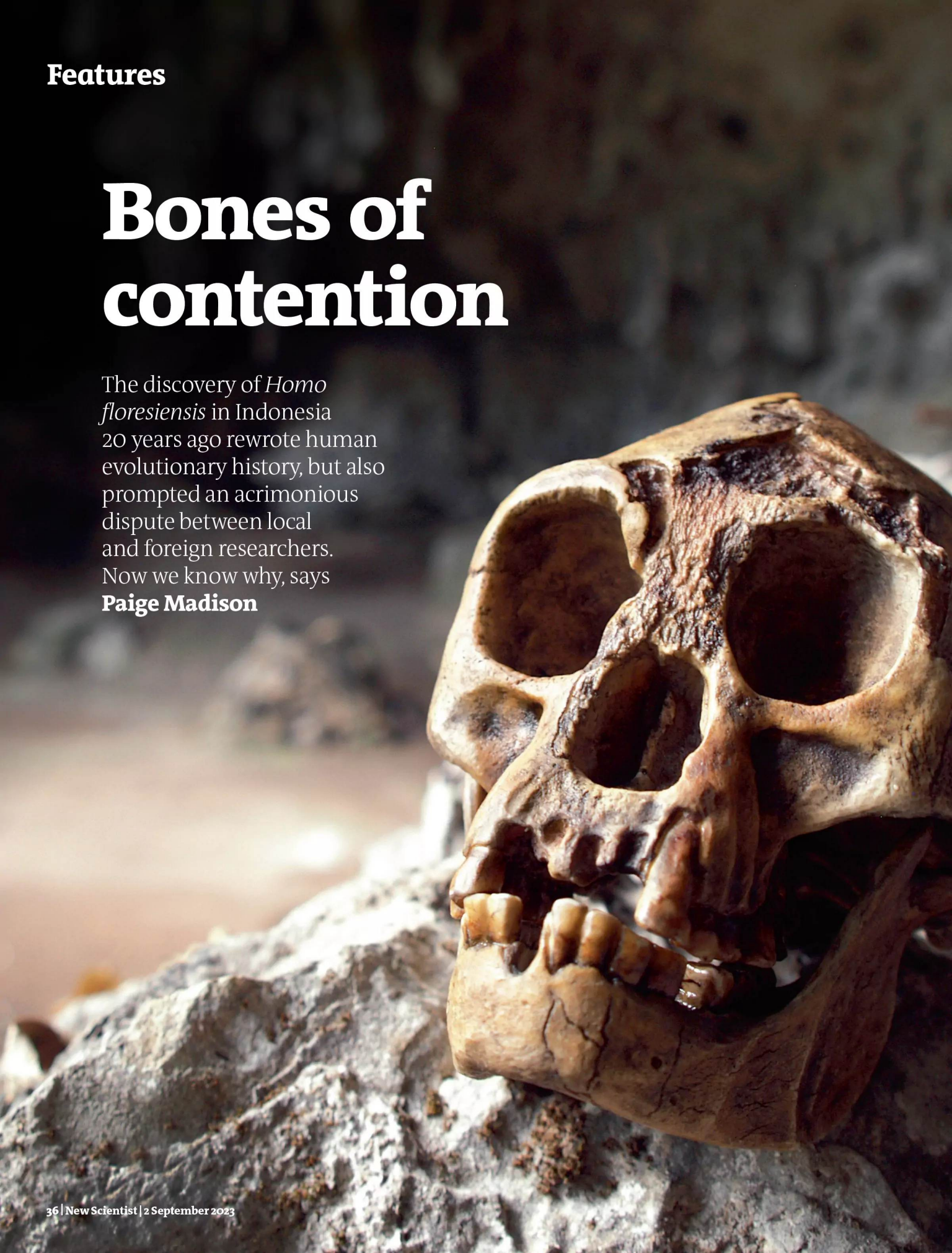
"Rest, in the last five years, feels as though it has risen to the top of so many different debates," says Callard. "It intersects with debates around burnout, quiet quitting and people refusing hustle culture at work."

Hammond suggests that younger generations may instigate a greater valuing of rest and balance. When she was recently invited to address students at her former school, Hammond expected to be asked to share advice on having a successful career – but no. "I said, 'What would you like to talk about?'" she says. "They said, 'Oh, could you talk about rest and kindness?'" ▮

Liam Drew is a freelance science writer based in Tunbridge Wells, UK

Bones of contention

The discovery of *Homo floresiensis* in Indonesia 20 years ago rewrote human evolutionary history, but also prompted an acrimonious dispute between local and foreign researchers. Now we know why, says **Paige Madison**



JAVIER TRUEBA/MSF/SCIENCE PHOTO LIBRARY

The skull of *Homo floresiensis*

ON A Tuesday in early September 2003, Benyamin Tarus struck bone. Digging through a cave floor on the Indonesian island of Flores, his trowel sliced into the left eyebrow ridge of an ancient human skull.

It soon became clear that Benyamin had uncovered evidence of an extinct, diminutive human relative unlike anything scientists had seen before. It was given the name *Homo floresiensis* and nicknamed the hobbit.

The find was described as "the most significant discovery concerning our own genus in my lifetime" by one researcher, and justifiably so. *H. floresiensis* promised to overturn established ideas about the shape of our prehistoric family tree and the importance of big brains for the success of ancient humans. As importantly, the bones showed that south-east Asia had been a hotbed of ancient human evolution.

You might expect that Indonesian researchers would have been as excited as anyone by the discovery on their doorstep. You would be wrong. After *H. floresiensis* was announced to the world, a leading Indonesian archaeologist condemned the international reporting of the discovery as "unethical". A few days later, he surprised his colleagues by helping another Indonesian researcher take possession of the bones. When they were returned several months later, some were damaged beyond repair.

It has long been a mystery to many people why the Indonesian scientists reacted so strongly. My research can help. I have spent six years digging into the *H. floresiensis* story and talking to Indonesian scientists. Not only do I now have a greater appreciation of the scientific importance of the find, I also understand why it proved so controversial.

Obtaining an Indonesian perspective on *H. floresiensis* is challenging: in a country made up of over 17,000 islands, diversity rules. The islands are populated by people of distinct ethnicities, religions and languages. This variation is a source of pride, reflected in the national motto, *bhinneka tunggal ika* ("unity in diversity").

This diversity is reflected at Liang Bua, the cave where *H. floresiensis* was unearthed. When I visited during the 2017-2019 field seasons – the latter being the most recent, because the covid-19 pandemic prevented researchers from working together – the site buzzed with the activity of people from vastly different backgrounds. University-educated archaeologists from the country's capital, Jakarta, mixed with highly skilled excavators – like Benyamin – who live in villages a short walk from the cave. Among this diversity, a single, unifying characteristic was on display: a shared sense of purpose and experience.

And for good reason. Archaeological excavations have been a part of Indonesian life for more than 130 years. For instance, the first known fossils of *Homo erectus* – generally viewed as an ancestor of our species, *Homo sapiens* – were discovered on the Indonesian island of Java in the 1890s.

For decades, Indonesians received little credit for such finds, being viewed as mere labourers. In a country that had been largely under Dutch control since the 17th century, it was the European colonialists who directed excavations and became famous for the discoveries made there.

Archaeological independence

Understandably, many Indonesians resented this. After the country gained independence in a revolution during the 1940s, some Indonesian researchers were determined to free the country's archaeological heritage from foreign control. They included Raden Pandji Soejono, who worked at an institute in Jakarta that is now part of Indonesia's Organization for Archaeology, Language, and Letters, and Teuku Jacob, who worked at Gadjah Mada University in Yogyakarta.

For many years, they were successful. Their excavation teams began digging at Liang Bua in the 1970s and discovered a rich collection of artefacts for archaeologist Soejono to analyse. They unearthed several ancient skeletons in the cave, all belonging to *H. sapiens*. These were sent to the lab of Jacob, who was one of Indonesia's leading palaeoanthropologists.

Few people are aware of this early research at Liang Bua, much of which was never published. I had to explore the archives of Indonesian research centres to read the field reports from the excavations – all, naturally enough, written in Indonesian. Within those reports are important details, including Jacob's thoughts on an idea he became increasingly convinced was true: that the ancient *H. sapiens* who lived on Flores were unusually short in height. Such conclusions never made major headlines. But that was hardly the point. More important to Soejono and Jacob was that the excavations were finally under Indonesian control.

That changed at the turn of the century. Funding for excavations at Liang Bua had dried up and Soejono reluctantly admitted he would have to seek foreign help. He worried about ›

the consequences. I found an account from the time in a local Indonesian publication in which Soejono expressed concern that scientists from abroad "will try to dominate the situation".

A startling discovery

By 2001, excavations were under way again. Soejono was now working with Michael Morwood, an archaeologist at the University of New England in Australia. Just a couple of years later, the team made the discovery that would shake up palaeoanthropology – and apparently convince Soejono and Jacob that they had been right to worry about working with international researchers.

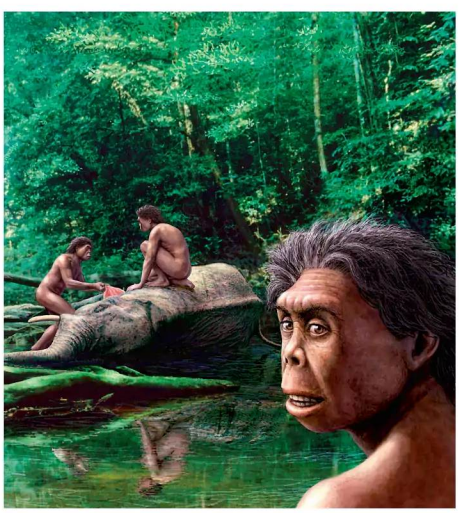
It was an all-Indonesian team on site that day 20 years ago when Benyamin struck bone. The excavators soon realised they had discovered more than a skull: it was an almost complete skeleton. Archaeologist Wahyu Saptomo was the supervisor of that excavation pit. "We moved a little this way," he recalls, gesturing excitedly 30 centimetres to the right "and dug: bone." Moved a little another way, he adds, gesturing left, and "more bone".

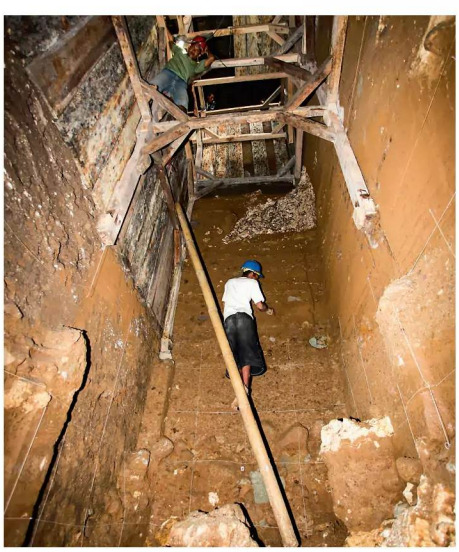
The Indonesian archaeologists told me that they worked into the night for three days to get the chunk of earth containing the skeleton safely out of the cave, lighting the deep pit with gas lanterns that filled their eyes with smoke. They then carefully carried the find across Indonesia to Soejono's institution in Jakarta, where he and Morwood were working.

It was clear almost immediately that the skeleton was unusual. It belonged to an individual that was little more than a metre tall, though its worn wisdom teeth revealed it was an adult. To learn more, the team needed to consult a palaeoanthropologist. Soejono was keen to recruit Jacob, his long-time colleague and partner on research at Liang Bua, but Morwood insisted that was impossible. A contract he and Soejono had signed years earlier required any new finds from the cave to be analysed by scientists from either Soejono's institution in Indonesia or Morwood's institution in Australia – not the university where Jacob worked. Tense discussions resulted in the arrival of Peter Brown, a palaeoanthropologist from the University of New England.

Brown spent 10 days examining the skeleton and eventually concluded that it belonged to a very unusual human with a small body and – more significantly – a small brain. It was inconceivable, he argued, that the skeleton belonged to our species. He suggested placing it in a new species: *H. floresiensis* was born.

> "This creature was beyond any area where we thought early humans ever got. It was completely unexpected"





TOP: MAURICIO ANTON/SCIENCE PHOTO LIBRARY; BOTTOM: LIANG BUA TEAM

The conclusion was astonishing. It had long been assumed that human evolution had led to steadily increasing brain volume through time. But the evidence from Liang Bua seemed to suggest that *H. floresiensis* had survived until just 18,000 years ago – hundreds of thousands of years after small-brained hominins were thought to have vanished.

That wasn't all. Stone tools and blackened bones at the cave indicated that *H. floresiensis* had a sophisticated set of behaviours and controlled fire to cook its food. Perhaps most surprising of all was that *H. floresiensis* had existed in south-east Asia rather than somewhere in Africa, where all other small-brained hominins we knew about had lived.

"This creature was beyond any area where we thought early humans ever got," says Chris Stringer at the Natural History Museum in London. "It was completely unexpected."

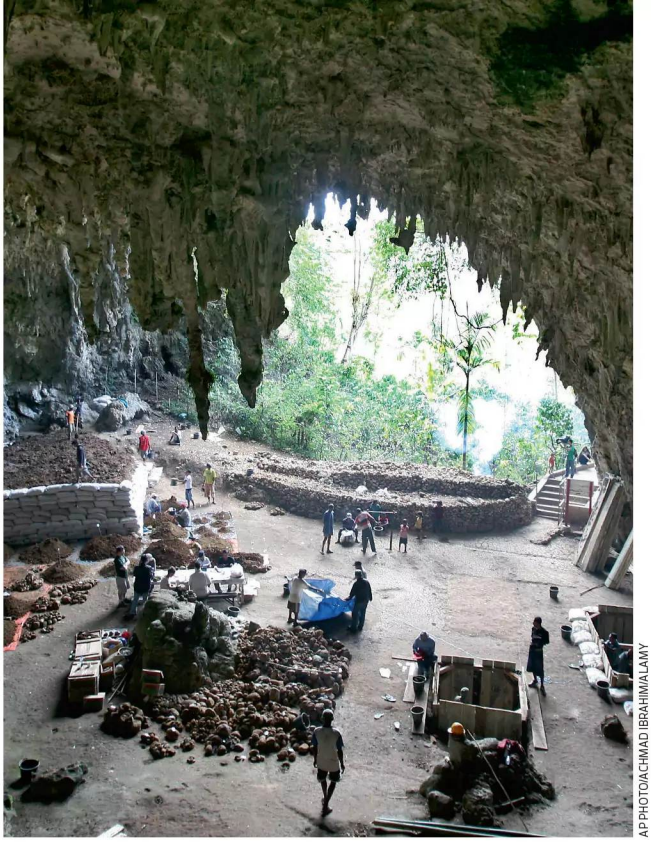
In other words, *H. floresiensis* suggested that Indonesia had international significance for understanding human evolution. The discovery should have been a moment of triumph for Indonesian researchers like Soejono. But he didn't see things that way.

In October 2004, the Liang Bua team published its findings in two research papers. Neither had an Indonesian researcher as the lead author – rather, Morwood had this role for one and Brown for the other. The papers were unveiled in two press conferences, in London and Sydney. There was no press conference in Indonesia.

Soejono was incensed. In my research, I came across an article published in an Indonesian newspaper after news of the discovery broke – overlooked by many interested in the *H. floresiensis* story because it was written in Indonesian. It quoted Soejono blaming the Indonesian government for failing to provide "sufficient funds". Morwood later said there had been a plan to hold a press conference in Indonesia, but it fell through.

Jacob was no less annoyed. In particular, suggest news reports from the time, he was unimpressed that Brown had studied the *H. floresiensis* bones without examining the other ancient human remains unearthed in Liang Bua and elsewhere on Flores during the

***Homo floresiensis* (top) was first uncovered by Benyamin Tarus (bottom), seen in Liang Bua cave**



AP PHOTO/ACHMAD IBRAHIM/ALAMY

The entrance to Liang Bua cave, where *Homo floresiensis* was found, photographed in 2008

20th century. As researchers around the world began excitedly debating the significance of *H. floresiensis*, Soejono and Jacob reverted to their decades-old practice of working together. They packed the *H. floresiensis* bones into a suitcase, which Jacob then carried 425 kilometres east across Java to his own laboratory in Yogyakarta – without Morwood and much of the *H. floresiensis* team's knowledge. When news of this act broke, the international media accused Jacob of theft.

A few months later, Jacob announced he had finished analysing the bones and was ready to return them to Jakarta. Holding his own press conference – in Indonesia – he declared that the remains belonged to an unusually small member of our species, albeit one with some unusual bone pathologies that gave it the deceptive appearance of otherness. "This is not a new species," said Jacob. His viewpoint seemed bizarre to many researchers – but Jacob presumably saw the logic, given that he was merely continuing his earlier work that claimed Flores had once been home to a population of unusually small *H. sapiens*.

A thousand crumbs

An intellectual disagreement was one thing. But when the bones arrived back in Jakarta, some of the fragile remains were now broken. The hip bone had been shattered "into a thousand crumbs", said Brown, and others were damaged. Jacob denied direct responsibility, saying the damage must have occurred while the remains were being transported from his lab in Yogyakarta back to Jakarta. But the conservator who came from the UK to work on the bones the following year, Lorraine Cornish at London's Natural History Museum, later told me there was evidence that Jacob's team had caused some of the damage by trying to mould and cast the delicate specimen.

Left with the wreckage, the Liang Bua team tried to put the bones back together and mend relationships. Morwood regretted the lack of an Indonesian press conference and I was told by members of the research team that he privately vowed to do better. Excavations were paused in an attempt to ease tensions, only resuming in 2007.

Twenty years on from the moment *H. floresiensis* emerged from Liang Bua, it is possible to view the discovery with more clarity. It remains a startlingly unexpected find, but curiously enough, the species no longer stands alone as a bizarre outlier in the human family tree. In the years since *H. floresiensis* came to light, we have learned of two more species of small-brained human that were present on our planet at the same time as our species. *Homo naledi*, discovered in South Africa, was revealed to the public in 2015, while *Homo luzonensis*, unearthed in the Philippines, made headlines in 2019.

Researchers are now also more comfortable with the idea that small-brained hominins were capable of sophisticated behaviour: it has been suggested, for example, that stone tool production predates our own genus.

That said, another reason why *H. floresiensis* is more acceptable today than it was in 2003 is that the researchers working at Liang Bua have walked back some of the claims made about the species at the time of its discovery. In 2016, they pushed *H. floresiensis*'s extinction back to around 50,000 years ago, which is more in line with the accepted date for the disappearance of other ancient human species, as well as the arrival of modern humans in what is now Indonesia. The researchers also abandoned the idea that *H. floresiensis* controlled fire: "charred" bones that Morwood had identified were blackened naturally by soil minerals.

I never had the opportunity to talk to Jacob or Soejono, who died in 2007 and 2011 respectively. The passion they shared for scientific independence, forged in the years immediately following Indonesia's revolution, burns a little less fiercely in the younger generations of Indonesian researchers – some of whom coordinated the excavations on the ground in 2003 but chose not to engage with the controversies that followed.

Those younger archaeologists – including Wahyu as well as Thomas Sutikna and Jatmiko (who, like many Indonesians, has one name) – have themselves recently retired. They are, however, still involved with the Liang Bua excavations, along with co-team-leader Matt Tocheri at Lakehead University, Canada (Morwood died in 2013). Together, they have been training a new generation of Indonesian scientists.

Observing the team in recent excavation seasons revealed a group focused on exploring Liang Bua's past in all its complexity. The cave sediments preserve a near-continuous record spanning 200,000 years, offering a rare opportunity to understand how *H. floresiensis* differed from *H. sapiens* in its interactions with the environment. In other words, the Liang Bua researchers today are less interested in rewriting the global story of human evolution. Rather, they are motivated by a desire to understand the nuances of Indonesia's ancient prehistory. In a sense, their work is now more aligned with the research conducted at Liang Bua shortly after Indonesia gained its independence almost 80 years ago. Jacob and Soejono would perhaps have approved. ▮

Paige Madison is a science writer based in Bozeman, Montana

"We're exploring the habitability of the moons of Jupiter"

The JUICE mission can finally tell us whether conditions on Jupiter's icy satellite worlds are conducive to life, physicist **Michele Dougherty** tells Becca Caddy

DECADES-LONG space missions are planned down to the second. The exact routes the craft travel through the solar system are meticulously mapped out, based on years of design and testing. If you want to deviate from these, you had better have a compelling reason.

But that is precisely what happened in 2005, during NASA's Cassini mission to Saturn. Upon seeing something unusual, Michele Dougherty, a physicist at Imperial College London, asked for a closer look at one of Saturn's moons, Enceladus. What the probe saw was incredible: massive plumes of water vapour erupting from cracks at the moon's south pole.

Today, with Cassini long gone, Dougherty is looking forward to making further unusual discoveries, as the principal investigator on the Jupiter Icy Moons Explorer (JUICE) mission operated by the European Space Agency (ESA). This project, which launched in April, has a clear goal: to better understand whether Jupiter's moons have the right ingredients to harbour life.

Jupiter has between 80 and 95 moons, but JUICE will focus on three of its four biggest. It will fly by Europa, Ganymede – the largest moon in the solar system – and Callisto, before going into orbit around Ganymede.

Dougherty tells *New Scientist* why we need to be open to the unexpected secrets that could lurk beneath the icy exteriors of these worlds and how she plans to reveal them.

Becca Caddy: How did it feel to change the course of the Cassini mission?
Michele Dougherty: That was quite scary. My team and I saw something in our data that didn't make sense. One way we could describe it was if there was an atmosphere on Enceladus, but at first I was concerned we hadn't calibrated our data properly. The spacecraft was moving very quickly, so it took a while for us to get the high-resolution spacecraft trajectory data.

Then we saw the same signature on a second flyby, so I took a chance and said: "We're seeing an atmosphere, can we go close?" It took a bit of persuasion, but the majority of the team said yes. It was a very nervous time for me. If we had changed the spacecraft's planned route and hadn't seen anything, I wouldn't have been held in the regard that I am now held.

Luckily, what we found was spectacular. It turns out it wasn't an atmosphere, but an outgassing of water vapour at the south pole. Now, thanks to this discovery, there's a focus on Enceladus as a place where life might form, so it was a really positive outcome. But it was a bit chancy. ›

NABIL NEZZAR

Was it tough when the Cassini mission finished?
By the end, we were all exhausted. We simply couldn't keep it up anymore. Part of me was almost relieved. I was watching it end at NASA's Jet Propulsion Laboratory. A graph shows a signal from the spacecraft as a spike in the data. As long as you see the spike, the spacecraft is talking to Earth.

The spike disappeared, and then it came back again. No one had told the spacecraft that the mission was ending. It had been trained to keep talking to Earth and moved so it could continue. The spike came back, very briefly. Then the spacecraft began to tumble towards Saturn, where it would burn up. And, as relieved as we were, that's also 25 years of your life done. For me, that was the most emotional part of the mission.

How does your experience of JUICE compare with Cassini so far?
I was fortunate to get involved in Cassini around the time of its launch. For JUICE, I led the science definition team, where we came up with the idea, so it's been my baby for 15 years. I've been involved in designing and building it, and persuading ESA to fly it. So, the launch was worse for JUICE. It was nerve-wracking. I couldn't wait for it to be over.

Has that worry alleviated now it is in orbit?
Once JUICE was up there, I suddenly remembered what it felt like to have an instrument in space. You wake up every morning and check your email to make sure everything's OK. There's always a slight frisson of fear. But I know there will be problems with the instruments, there always are. Something won't work and we'll have to check something out. It happens with space instruments.

But you calm down after the first month. You can't live like that forever. And if something goes wrong, you deal with it. That's what you must do if you have an instrument in space.

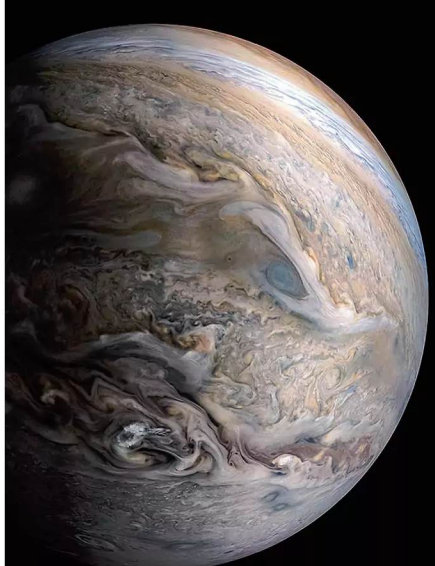
What are you hoping to find with the JUICE mission?
The main driver is to explore the potential habitability of the moons of Jupiter. That's the case that we made to ESA when they selected us 15 years ago. In some ways, we're halfway through the mission. In 15 years, we'll be getting our last bits of data.

Which moons will you be looking at specifically, and what will you be looking for?
We aim to better understand the ocean on Europa. We also want to understand the surface of Callisto, which is extremely odd, and its internal structure. We don't think it's differentiated, meaning there's no solid core with different layers above it like at Europa and Ganymede. And although we don't quite understand why, we're almost certain there's a liquid water ocean under the surface, and we want to characterise that.

For me, though, the real focus is Ganymede. We want to understand if its ocean is global. How deep is it? What's the salt content? The other exciting thing about Ganymede is that it will allow us to understand a whole new class of planetary bodies called water worlds. We think that some exoplanets have numerous water worlds in orbit around them.

Your team is responsible for JUICE's J-MAG, which is a magnetometer. Why is it important to have this instrument on this kind of mission?
One of the most important things we've managed to discover in the past 20-odd years, and I think Cassini really helped consolidate this, is that the instruments my team and I build are useful for not only understanding

"It's what we don't know we're going to find that I'm most interested in"



The JUICE mission will study three moons of Jupiter, including Europa

NASA/JPL-CALTECH/SWRI/MSSS

ESA-CNES-ARIANESPACE/OPTIQUE VIDEO DU CSG/S. MARTIN

ESA/ATG MEDIALAB

ESA/STEPHANE CORVAJA

The European Space Agency's JUICE probe (left) launched in April this year (right). It is now on its way to study three of Jupiter's moons (artist's impression above)

the environments on planets or moons. They allow us to see inside those planetary bodies.

Take Ganymede, for example. It is the only moon in the solar system with its own internal dynamo field, a magnetic field caused by liquid metals moving around, like we have on Earth. So, we can study that with our instrument, but we need to separate all sorts of different magnetic fields, from Ganymede and Jupiter.

We like to describe it as trying to find needles in a haystack, but they're changing shape and colour all the time. That's why we need to go into orbit to see.

How close will JUICE get to Ganymede?

That's one of the great things about the JUICE launch: the Ariane 5 rocket launch was so precise that we didn't need to use any extra fuel to get us on the right trajectory, so we saved a lot of fuel. That means we can get closer to Ganymede than we planned. We'll start off orbiting at 500 kilometres, and we will reinstate the 200-kilometre phase, which we had taken out because we were concerned we weren't going to have enough fuel to do it.

Are you expecting to find life on these moons?

When we made the case to ESA to choose JUICE, I told the team they weren't allowed to mention the word "life". We are talking about potential habitability, yes. But the most important realisation we've made is that the icy moons in our solar system potentially have the ingredients to harbour life.

Our understanding of how life forms and evolves is that you need these different ingredients. You need liquid water – that's the first thing we look for. You need a heat source. You need organic material. And then you need those three ingredients to be stable enough over a long enough period of time that something can happen. Those are the ingredients we're searching for.

And that's why we get so excited when we realise there's liquid water under the surface of some of the moons. Experiments were carried out in the deep oceans on Earth, where the temperatures are really low and the pressures are very high. Where there are thermal vents down in these deep oceans, bacteria have been found. So that's what you need: heat, water and organic material.

Which places in the solar system are likely to have these ingredients?

In the past, the focus has always been on finding liquid water and looking at Mars because it's close to the sun. But following the Galileo [an earlier mission to Jupiter and its moons] and Cassini missions, we now realise there's liquid water elsewhere in our solar system, beyond the snow line – where if there was water on the surface, it would be ice. From my perspective, at Saturn, we've got Enceladus and Titan. At Jupiter, we've got Europa, Ganymede and Callisto. Those five potentially have the ingredients – Uranus and Neptune's moons might do as well.

Do you have your sights on those last two?

I see us as explorers. I don't mind where we go next. I will be very old before we get something to Uranus. But that's OK. We're on the path to exploring our solar system.

What are you most excited to find with JUICE?

I want to find out more about the ocean on Ganymede. Assuming all goes well, we'll do that. That's going to be our focus.

But it is what we don't know we're going to find that I'm most interested in. Just as we had something unexpected crop up during the Cassini mission, that's what I hope is going to happen on JUICE. I can't predict what that will be. I'm just looking forward to something I'm not expecting. ▮

Becca Caddy is a freelance writer based in Yorkshire, UK

The back pages

The science of cooking

How the cookie crumbles

Whether you prefer yours fudgy or crisp, nothing beats a chocolate chip cookie. **Sam Wong** explains how to get your perfect texture

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

What you need

225g or 2 sticks of butter
150g or ¾ cup brown sugar
150g or ¾ cup white sugar
275g or 2¼ cups plain flour
1 tsp baking soda
1 tsp vanilla extract
2 eggs
1 tsp fine salt, plus flaky salt for sprinkling
250g or 8 oz chocolate chips or chopped-up chocolate bars

The science of cooking appears every four weeks. Share your cooking successes with us on Twitter and Instagram @newscientist, using the hashtag #NewScientistCooking

Next week

60-second psychology

A CHOCOLATE chip cookie, fresh from the oven, cannot fail to be delicious. You don't need any scientific knowledge to bake great cookies, but it is illuminating to learn how the ingredients combine to affect the flavour and texture – and how you can tweak the recipe to suit your taste.

Most recipes start with creaming butter and sugar together. This isn't just about combining the ingredients – it is about getting air into the mixture. If you do this for several minutes with an electric mixer, your cookies will be light instead of dense, and you will get more cookies out of the batch.

It is common to use both white and brown sugars. They don't just taste different; they have different effects on cookie texture. While caster and granulated sugar are almost pure sucrose, brown sugar contains molasses, a byproduct of sugar refining, which makes it slightly moist and acidic. It also contains some glucose and fructose, which are more hygroscopic than sucrose, meaning they absorb moisture. This means cookies made with only brown sugar won't be as crisp as those made with white sugar.

The acid in brown sugar reacts with the alkaline baking soda to produce carbon dioxide. Cookies made with only brown sugar rise higher in the oven and don't spread as wide.

Next, eggs and vanilla extract are mixed in, followed by flour, baking soda, salt and chocolate. Eggs provide protein and fat, helping create the fudgy texture in the centre of a cookie. They are also the main source of moisture in the dough: the water they contain will hydrate the proteins in flour, allowing them to link up into strands of gluten.

VASYL DOLMATOV/GETTY IMAGES

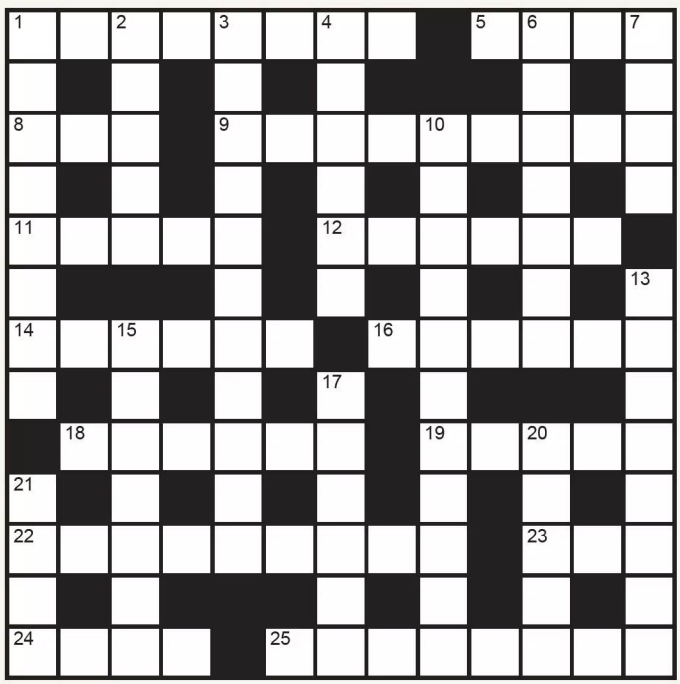
Some bakers recommend letting the dough rest in the fridge for a day. During this time, some of the proteins and starches start to break down into smaller molecules. When baked, these molecules recombine in what's known as the Maillard reaction, creating a browner crust and improving the cookie's flavour. In my experience, however, once you start thinking about cookies, waiting a day to eat them isn't humanly possible.

Place six to eight balls of dough on a parchment-lined baking sheet. In the oven, the butter melts and more of the sugar dissolves, making the cookies spread out. Evaporating water swells the air bubbles in the mixture, and baking soda reacts with the acids in brown sugar. Both of these contribute to the cookies' expansion. Once the proteins and starches harden, the cookies can't get any larger.

Bake for 10 to 12 minutes at 180°C (350°F), or until light golden brown. They will still be soft, but as they cool down, some of the dissolved sugar recrystallises, crisping them up. A sprinkle of flaky salt as they come out of the oven improves the flavour. ▮

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

Cryptic crossword #117 *Set by Rasa*



Scribble zone

Answers and the next quick crossword next week

ACROSS

1 Playful species of canine catching a ball (3,5)
5 Ideas initially offered, as before, in footnotes (4)
8 Gas mixture just lacks fluorine (3)
9 Oily patches surrounding key mineral supplements (4,5)
11 Mark showed his age, we hear (5)
12 Resolve bother with a change in polarity (6)
14 Display resistance on battery unit (6)
16 Possibly fine nickel in press (6)
18 At first, geologists go off to cave (6)
19 Audibly expressed maximum annoyance (5)
22 Quietly, slithering swimmers went back for delta wave producer (4,5)
23 In retrospect, name sign of spring (3)
24 Group of students coordinate place for the labyrinth (4)
25 Heavy object put two holes in doctor's shirt (8)

DOWN

1 Confidently walks south with happy dogs? (8)
2 Choice word breaking Kate's heart on a vessel (5)
3 With some repetition, arrange pieces of slate tiles (11)
4 Marshal lets in recruit (6)
6 Rod-shaped things I set under reversing taxi, poorly (7)
7 Clean those surfaces! Actor Hoffman's dropping in (4)
10 Applier messed up, including trademark on US test strip (6,5)
13 That woman piped out insecticide and fungicide on a farm (5,3)
15 For example, Sue, Chase or Bob finally examine an upturned flower (7)
17 Medieval explorer's fed me fruit (6)
20 High-tech two-state system left outside lab at the rear (5)
21 Nervous inside aged gyroplane (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #217
set by Bethan Ackerley

1 Phoresis is the process in which an organism attaches itself to a host for what purpose?

2 Herbert Hall Turner coined the name of which unit of distance?

3 Ascorbic acid contains which three elements?

4 Which of the following isn't a pitcher plant family: Droseraceae, Sarraceniaceae or Nepenthaceae?

5 Quantum chromodynamics describes which fundamental force?

Answers on page 47

Headscratcher
set by Zoe Mensch
#237 Golden oldie

"Hmm... is your name Rumpelschtumpel?"

"What?! How did you...?" cried the little imp. "But no matter. To get the gold, you will also need to enter the four-digit code on the padlock."

"A teensy clue?" pleaded Prince Hopeful.

"Fine, since you asked so politely, I'll offer you this. Take the last three digits of the year I was born, let's call that number ABC. Then reverse that so the digits are in the order CBA. Find the difference between those two numbers, which we shall call XYZ. Then reverse that answer to ZYX and add XYZ and ZYX together. Simple as that!"

"And you'll tell me when you were born, won't you?" hoped Prince Hopeful.

"About 5.30pm on a Wednesday," cackled Rumpelschtumpel, bounding away.

Any tips for Prince Hopeful?

Solution next week

Cooling off

Earth was a hothouse 201 million years ago, leading to the Triassic-Jurassic mass extinction event. How did it recover? Why was there no runaway greenhouse effect?

David Bortin
Whittier, California, US
A "runaway greenhouse effect" on Earth, such as the one that befell Venus long ago, would be initiated if carbon dioxide, methane and other greenhouse gases were to reach atmospheric concentrations so high (probably around 30,000 parts per million) that thermal radiation from the "hot body" planet couldn't keep up with the influx of heat from the sun.

Earth would first become so hot as to be uninhabitable, then too hot even for liquid water. When the oceans boil, that added water vapour – another greenhouse gas – would create an irreversible "runaway" effect.

That didn't happen at the end of the Triassic Period, and it isn't imminent now. (Not

"There was a 'perfect storm' of global warming, ocean acidification and lowering of oxygen concentration"

that this is anything for us to worry about, since we will all be extinct long before it gets to that point anyway.)

What seems to have triggered the less-than-runaway greenhouse effect around 201 million years ago was a series of supermassive volcanic eruptions that either caused or were caused by the breakup of the pre-continental landmass called Pangaea.

These eruptions released so much carbon dioxide, hydrogen sulphide and methane that a "perfect storm" of global warming, ocean acidification and lowered oxygen concentration transformed the environment too rapidly for organisms to adapt. Most terrestrial flora and fauna, and probably an even larger fraction of marine species, became extinct.

As with other extinction events (so far!), equilibrium is naturally and gradually retrieved, and the extinctions just expose ecological niches where the newly fittest can evolve and thrive.

Mike Follows
Sutton Coldfield, West Midlands, UK
Earth's climate tends towards an equilibrium global mean surface temperature based on a range of boundary conditions such as the composition of our atmosphere and our distance from the sun.

There are many mechanisms of climate change that can nudge the global mean surface temperature away from this equilibrium.

The hothouse Earth at the end of the Triassic was most likely caused by volcanic eruptions of basalt rock over an area of 10 million square kilometres, known as the Central Atlantic magmatic province (CAMP).

The initial CAMP eruptions brought low-temperature magma to the surface. This released more sulphur dioxide, which created sulphuric acid particles that reflect sunlight. The resultant global cooling caused the mass extinction of 60 to 70 per cent of extant species.

The acid would have been rained out. Later eruptions were hotter and released more carbon dioxide, which led to an enhanced greenhouse effect and hothouse Earth conditions.

A warmer world is wetter, so more carbon dioxide is dissolved in rainwater, creating acid rain. This increases the weathering of rocks, which increases the concentration of bicarbonate and other ions that are flushed into the oceans.

In the oceans, calcium reacts with the bicarbonate ions to form calcium carbonate, which forms the bodies of coccolithophores and other marine plankton as well as coral polyps. When these organisms die, they fall to the ocean floor as marine snow, ending up as limestone.

Besides, with more carbon dioxide dissolving in the ocean, the population of photosynthesising phytoplankton increases, as does the flux of marine snow. The mass of terrestrial green plants also increases and, when they die, some form peat bogs. In other words, carbon is removed from the atmosphere and buried, which leads to cooling.

The late James Lovelock perceived Earth as a cybernetic system, with life nudging the climate towards the most suitable temperature. My hunch is that life speeds up this return to equilibrium, though it is still interminably slow.

At the end of the Triassic, the supercontinent called Pangaea was breaking apart, and this will also have influenced the climate. The polar Boreal Sea was kept warm by ocean currents passing through the Laurasian Seaway from the equatorial Tethys Sea.

A team of scientists, including Stephen Hesselbo at the University of Exeter in the UK, postulates that a plume of magma lifted the crust to create the North Sea Dome in the middle of the Laurasian Seaway 174 million years ago. This constricted the poleward flow of heat and led to the subsequent global cooling.

DOT GRAHAM

Why did this pink geranium produce red flowers after a piece broke off?

This week's new questions

Seeing red **A piece of my pink-flowering geranium broke off when the pot fell over. We put it in a vase, where it made new flowers that were red, not pink. What is going on?** ***Dot Graham****, Macclesfield, Cheshire, UK*

Straight to the point **Why is the east coast of Madagascar so straight?** ***Ben Twist****, Edinburgh, UK*

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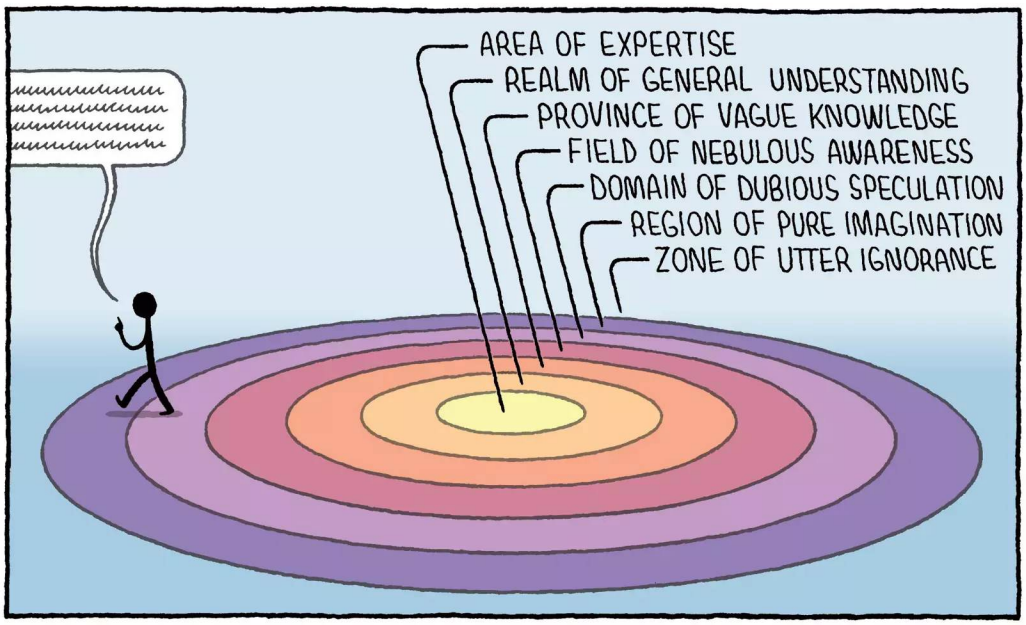
Tom Gauld
for New Scientist



Bottoms up

Can all animals get drunk? If not, what enables this in those that can?

Mark Thompson
Tewkesbury, Gloucestershire, UK
Yes, and they frequently do! Deer, squirrels and bears have been known to appear drunk when eating fermented fruit. As with humans, this is actually ethanol poisoning. And some insects seek out alcohol.

The pen-tailed tree shrew eats nectar from the flowers of the bertam palm, which has one of the highest alcohol levels recorded in natural food – close to 4 per cent. However, these shrews can really hold their own: despite boozing nightly on the high-alcohol nectar, they display no effects of intoxication.

Studies have also shown that many bats are fine to fly after eating fermented fruits and nectar. For example, leaf-nosed bats' flight and echolocation skills were unaffected by the consumption of ethanol.

"Deer, squirrels and bears sometimes appear 'drunk' when eating fermented fruit. This is actually ethanol poisoning"

But it is best leave the drinking and flying to them. You'd be bats to give it a go!

John Elliott
Stockport, Greater Manchester, UK
I clearly remember a charming moment in my garden when I found a hedgehog that had just feasted on a rotting apple. It was very still, oblivious to my presence, and evidently very happy. I don't remember how long it stayed, but after a good rest it wandered off to resume its chores.

Simon Dales
Oxford, UK
Any animal can get drunk. How well they can hold their drink is dependent on what they habitually eat.

Lions should lose any drinking game because antelope contain little alcohol. But *Drosophila melanogaster* (the fruit fly that is the beloved plaything of geneticists) is evolved to eat rotten fruit. Lab ones have gene variants. One is *lush*, that makes it seek alcohol, and one with reduced resistance is called *cheapdate*.

Sticking point

Why does runny honey stop dripping when there is still plenty left on the spoon? (continued)

Eric Kvaalen
Les Essarts-le-Roi, France
David Muir says that it is a question of viscosity. Viscosity slows the flow of honey, but can't stop it. On the other hand, surface tension can. Even a drop of water can stay suspended indefinitely without falling because the surface tension holds it. In order to fall, the surface would have to get larger, at least temporarily, and the surface tension is strong enough to prevent this. ▮

Answers

Quick quiz #217 *Answers*

1 Travel
2 The parsec
3 Carbon, hydrogen and oxygen
4 Droseraceae, though it is a family of carnivorous plants
5 The strong nuclear force

Quick crossword #140 *Answers*

ACROSS 9 Neptune, **10** Lamarck, **11** Greylag, **12** Carotin, **13** Acetylene, **15** Nares, **16** Astilbe, **19** Echidna, **20** Imago, **21** Toadstool, **25** Rotifer, **26** Faraday, **28** Isolate, **29** Curette

DOWN 1 Enigma, **2** Sphere, **3** Pull, **4** Dengue, **5** Black eye, **6** Amaranthus, **7** Cratered, **8** Akinesia, **14** Yellow flag, **16** Acid rain, **17** Traction, **18** Enter key, **22** Affect, **23** Oddity, **24** Leyden, **27** Rare

#236 Picky eaters *Solution*

Georgia should take one case of fizzy drink.

No matter what her sibling takes on their turn, Georgia will be able to leave one each of two different items after her second turn, which ensures that she gets the last item. For example, if Georgia takes a case of drink and her sibling takes one grocery bag, then Georgia can take two grocery bags on her second turn, leaving one case of drink and the sack of potatoes. Her sibling can only take one of these, so Georgia will be able to take whichever remains for her final turn. Any other choice for Georgia's first turn will allow her sibling to put things in their favour.

Nit-picking literature

Little things bother some people. Elizabeth Kowaleski Wallace wonders why little things failed to bother Robinson Crusoe, the hero of Daniel Defoe's 1719 novel, who spent 28 years documenting his plight as a castaway on a tropical island.

"[W]here are the mosquitos, the wasps, the worms, or the pests that should be ravaging Crusoe's island?" asks Wallace, pausing not at all before saying: "For that matter, where are the beetles, the honeybees, or the ladybugs that would surely have formed a significant part of his island's ecosystem?"

Wallace lays forth her suspicions, and muses on their significance, in *ISLE: Interdisciplinary Studies in Literature and Environment*, in a paper called "'The true state of our condition,' or, where are Robinson Crusoe's insect companions?".

Wallace alleges that Crusoe must have encountered "a number of pernicious critters, all eager to bore into his flesh". These would have included, she says, "sandflies, biting ants, and biting midges ('no see ums')". Wallace goes on to list a tormentor's row of likely Crusoe companions: "biting spiders", bedbugs, weevils, fleas, aphids, army worms, stink bugs and flies.

This novel, everything-but-nits-picking reading of Defoe's novel exemplifies the drive evident in the best (but also, of course, in a few of the worst) literary critics and scientists.

Wrong cocktail

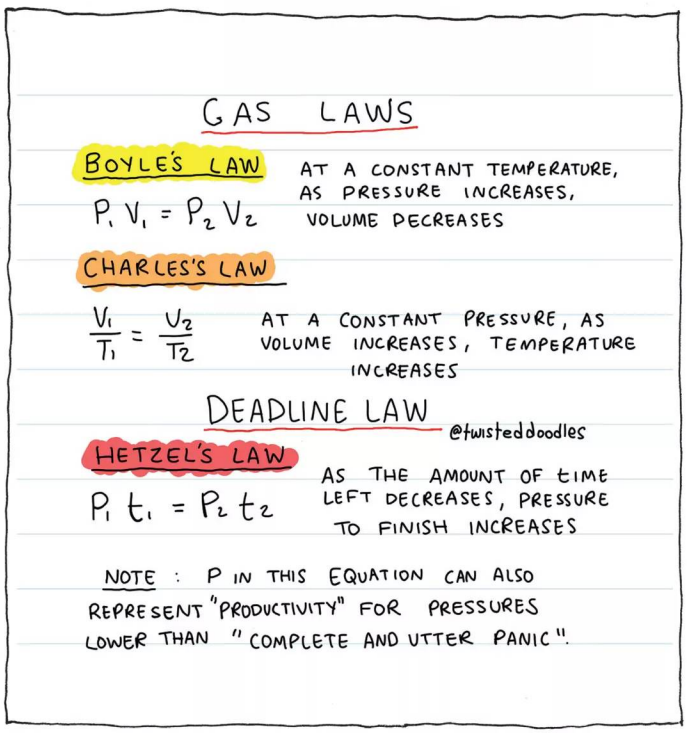
When is a cockatiel a cocktail? When it is a typographical error.

This particular error – Feedback trusts it is an error – occurs in a study called "Avian gastric yeast (macrorhabdosis) in cockatiel, budgerigar and grey parrot: a focus on the clinical signs, molecular detection and phylogenetic evaluation" published in the Iranian journal *Veterinary Research Forum*.

It says: "In two cockatiels in addition to regurgitation, grinding and throwing food out of the mouth, vomiting and diarrhea were also observed. In one of the cocktails all the symptoms (regurgitation, grinding, throwing food out of the mouth, vomiting, diarrhea, melena, undigested seeds in the dropping and bloody vomiting) were observed."

If you happen across an equally wonder-inducing, equally clear error in a scientific, medical or technical paper, please send reliable documentation of it to feedback@newscientist.com.

Twisteddoodles *for New Scientist*



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Send it to feedback@newscientist.com
or New Scientist, 9 Derry Street, London, W8 5HY
Consideration of items sent in the post will be delayed

Baby radar

Adults who know that radar tracks aeroplanes and missiles might be delighted to learn that sometimes radar is used to track babies. Human infants.

Zheng Peng and his colleagues at Eindhoven University of Technology in the Netherlands took a look at the newest techno-methods for what is called "Continuous sensing and quantification of body motion in infants".

They distinguish four kinds of methods: "camera-based, radar-based, mattress-based, and signal-reusing technologies". The last of those, as the name implies, interprets signals – sounds and whatnot – that are already being gathered from the infants.

"Radar-based systems offer the advantage," says the report, "of detecting large and subtle motions regardless of light conditions." But, it mentions, "certain limitations need to be addressed". Specifically: "Radar systems can be vulnerable to noise... Furthermore, the safety of using electromagnetic radiation with infants needs to be further investigated." These and additional problems lead the team to offer this judgement: "Due to the limited research available on radar-based infant motion detection, its suitability is still uncertain."

As to mattresses... Mattress-based technology goes by a lovely name – "ballistography". Infant ballistography is, in essence, the study of forces generated by a baby's body. Parents, always, have conducted ballistographic research.

Technologists intend to one-up the parents. Peng's team give an example: "Mattress-based sensing technologies utilize [ballistocardiography] sensors to measure the pressure generated by infants, including their body motion, chest motion, and heartbeats."

But the race to superiority has, up to this point, been dominated by the parents. Here, too, an example makes clear what the technologists are up against: "The sensitivity of the mattress is primarily restricted to motion perpendicular to it, with limited sensitivity to motion parallel to the mattress."

Generously lettered

Astronomers are known as a generous bunch. Astronomer Virginia Trimble was moved by the implied plight of the unnamed person, mentioned in Feedback on 15 July, who is known to list these credentials with his signature: BSc (Honors), MASc, PhD, MTMS, MGDMB, MCIM, MSME, MAIST, MISIJ, MSigmaXi, MIFAC, MACS, MASM, MMRS, MACerS, MECS.

Trimble writes: "He is missing (at least) one distinction: Sigma Xi (The Scientific Research Organization) for about the last five years has elected from among its thousands of members (MSigmaXi) about a dozen fellows each year, entitled to sign themselves as FSX (Fellow of Sigma Xi). If only I knew who that MASc, PhD, etc was, I would be happy to nominate him for Fellowship, as soon as I rotate off the Sigma Xi fellowship committee. Yours sincerely, Virginia Trimble (FSX, etc)." ▮

Marc Abrahams

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