

New Scientist

WEEKLY 12 March 2022

HONG KONG'S
COVID NIGHTMARE
MARTIN REES: LEAVE
SPACE EXPLORATION
TO THE ROBOTS
THE CITY ANIMALS
UNDERGOING
RAPID EVOLUTION

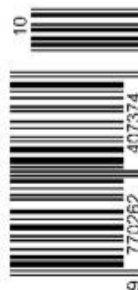
BATTLE *of the* BULGE

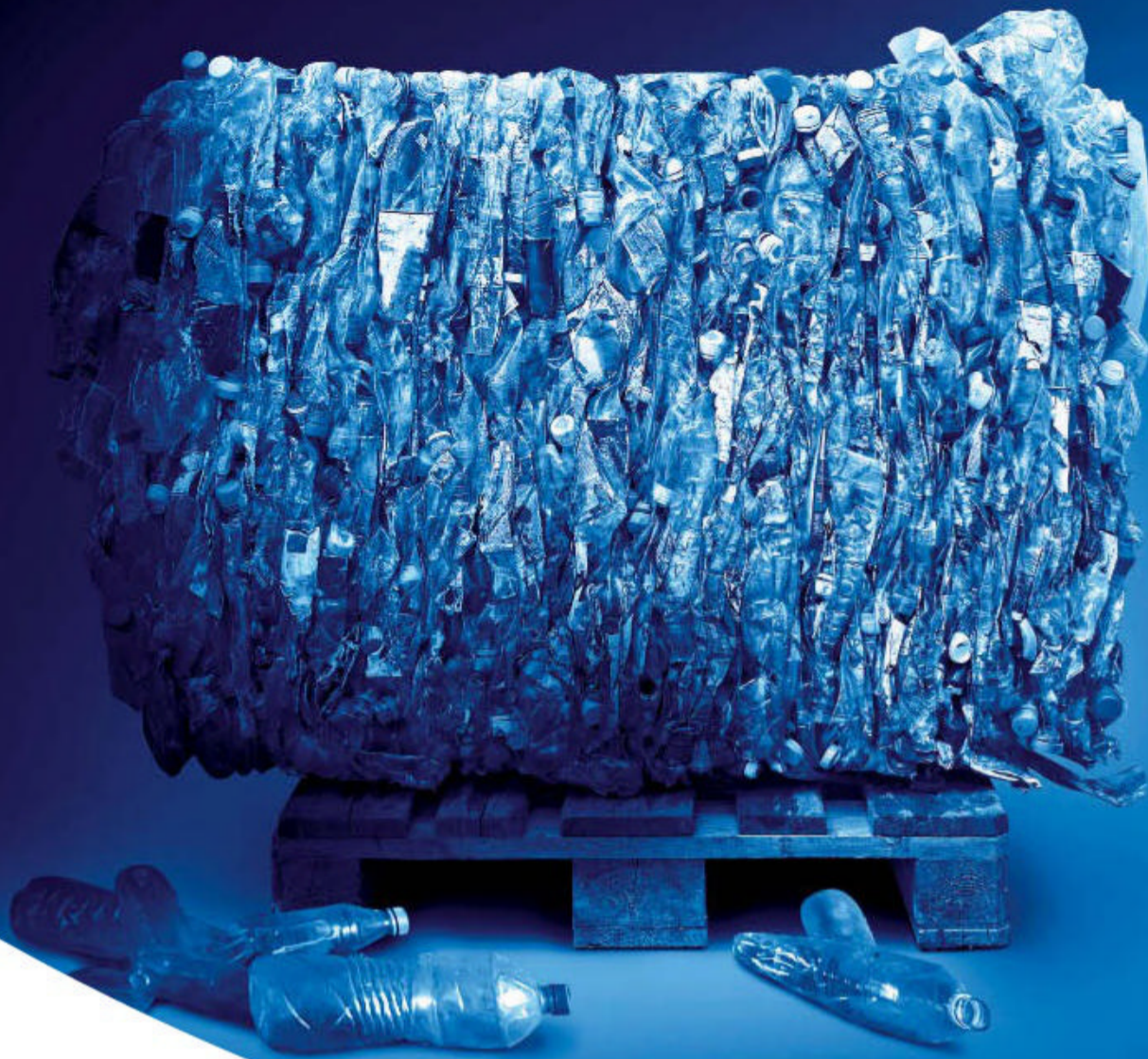
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Virtual event

What we don't know about gravity

We are all familiar with the effects of gravity. But what actually is it? Sometimes we call it a force, other times we speak about it as a manifestation of the curvature of space-time. In this talk, physicist Claudia de Rham unpacks what we do and don't know about gravity. Join us online from 6pm BST on 31 March.

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Academy

How the microbiome shapes our health

Scientists are just beginning to understand the crucial role that microbes in our gut play in influencing the brain, health and well-being. This course explores those links and what you can do to boost your own microbiome. Learn online at your own pace from the world's foremost experts.

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Podcast

Weekly

The team discusses Russia's nuclear weapons and the likelihood of them being used. We hear from Swenja Surminski, an expert on adapting to climate change, on what the world must do amid global warming. Plus, did you know garden moles are non-binary? This is just one amazing fact from new book *Bitch: A revolutionary guide to sex, evolution & the female animal*. Its author, Lucy Cooke, drops in for a chat.

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Podcast

Holey mole! The moles in your backyard are gender non-binary



Video

Beneath the waves Nemo's Garden is an underwater farm in Italy

Video

An underwater farm

Nemo's Garden is a unique underwater facility for terrestrial plants where the gardeners need scuba diving suits. This experiment uses biospheres 10 metres under the water off Noli on the Italian Riviera, and was created to find sustainable ways of growing vegetables and herbs. One advantage is that no pesticides are needed.

[youtube.com/newscientist](https://www.youtube.com/newscientist)

Newsletter

Launchpad

Get reporter Leah Crane's newsletter about all things space delivered free to your inbox each week. In the latest issue, she delves into the hunt for elusive "gravitational glints". These are sections of gravitational waves that have been slowed because they passed through massive objects, such as a star or planet.

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Eleanor Parsons

New Scientist chief subeditor

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| PAST PERFORMANCE | | | | | |
|---|-----------------|-----------------|-----------------|-----------------|-----------------|
| | Nov 16 – Nov 17 | Nov 17 – Nov 18 | Nov 18 – Nov 19 | Nov 19 – Nov 20 | Nov 20 – Nov 21 |
| Net Asset Value | 25.3% | 0.3% | 16.7% | 9.5% | 21.5% |
| Share Price | 34.2% | -1.9% | 21.7% | 10.5% | 19.7% |
| FTSE World Europe ex-UK Total Return Index | 25.0% | -4.6% | 13.7% | 7.3% | 15.7% |

Past performance is not a reliable indicator of future returns.
 Source: Morningstar as at 30.11.2021, bid-bid, net income reinvested.
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Humanity under the lens

Our understanding of the cosmos is a marvel, but we must also ponder our future in it

SOMETIMES it pays to take the long view. Look at the past half-century of cosmology, as UK Astronomer Royal Martin Rees does in our interview (see page 46), and it is plain how far we have come.

The story of the universe's origin in a big bang – an idea not especially favoured when Rees started as a researcher in the 1960s – is now as close to an established fact as science permits. We have also elucidated the properties and phenomena of an unimaginably vast cosmos with ever more acuity. It is a privilege to live in an age when, for the first time, we have a convincing story of most of the grand sweep of cosmic evolution.

These are truly thrilling developments, albeit ones that have, in the nature of science, thrown up more holes in our understanding – holes that instruments

such as the recently launched James Webb Space Telescope are designed to plug.

Yet this progress also gives reason for introspection. Many researchers like Rees find themselves drawn to questions of humanity's future. The discovery of thousands of exoplanets circling other stars, and the realisation that even icy

"If so many planets are out there, how come intelligent life hasn't come our way?"

moons in the outer solar system might harbour warm and wet environments, boosts the belief that if life exists on one tiny blue dot, it might exist elsewhere, too.

So why hasn't intelligent life elsewhere made itself known to us? Perhaps because hubristic missteps give technological

civilisations a limited lifespan – and perhaps also because, as we have learned, space is an unforgiving environment. It is a half-century now since the last person walked on the moon and, as Rees warns, while billionaires such as Elon Musk battle it out to return there, it is folly to think "space tourism" will ever be the norm for our species. Any vestiges of humanity that leave our solar system will probably be very different to us, and most likely the progeny of the pioneers who establish a future beyond Earth, on Mars for example.

For the rest of us, our planet is all there is. The problems we face, not least the tragedy currently unfolding in Ukraine, are a reminder that progress can just as easily be undone. All the more reason to apply our common humanity to solving the problems of the here and now. ■

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Memory cells

Special neurons signal when a new event begins **p9**

Early birds

Were geese domesticated before chickens? **p12**

Net zero

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Space vampire

A nearby black hole is actually one star eating another **p16**

Sea sentinels

Robotic ships could inspect underwater pipelines **p19**



KIN CHEUNG/AP/SHUTTERSTOCK

Health workers at a mobile testing lab in Hong Kong

7.5 million people, says Tsang. “The only reason Hong Kong is using the Chinese vaccines is for a weak government to demonstrate its loyalties to the Chinese Communist party,” he says.

There are several reasons for the low vaccination rates in the oldest people. The main problem, says Owens, is that the government never put its weight behind vaccinating the elderly. Other reasons include some doctors telling vulnerable people not to get vaccinated and unfounded scare stories in local media.

For mainland China, sticking with zero covid is the right approach, says Owens, because it has the capacity to do this. But Hong Kong lacks that capacity, one key reason being the low level of trust in its government, says Tsang.

Two other things contributed to the current crisis. First, until recently, Hong Kong had been extremely effective at protecting the vulnerable, with hardly any flu deaths in the past two years due to covid-19 precautions. There are now more older people than usual who are extremely vulnerable to infections, says Owens.

Second, as the omicron wave began, authorities told people who tested positive to go to hospital for isolation. That took up what little spare capacity there was. Now, more people are dying because they aren't getting proper care.

Contrary to some claims, there is no reason to think a more dangerous variant is to blame in Hong Kong. Owens thinks Hong Kong's omicron wave has already peaked, but could yet result in 7000 or even 10,000 deaths. This means Hong Kong could go from having one of the lowest covid-19 death rates worldwide to perhaps more than 1000 covid-19 deaths per million. ■

Coronavirus

Omicron hits Hong Kong

Covid-19 cases are soaring among largely unvaccinated older groups and hospitals are overwhelmed, reports **Michael Le Page**

COVID-19 cases in Hong Kong are spiking as the omicron variant spreads. But unlike some other places, Hong Kong also has a high number of severe cases, overwhelming hospitals so the number of deaths is soaring.

Part of the reason is that too few of the older people in Hong Kong are vaccinated. The failure to vaccinate the most vulnerable seems to be a result of trying to please China. Hong Kong continues to pursue a “dynamic zero-covid” strategy that focuses on testing.

“As long as Beijing insists on zero covid, Hong Kong will insist on zero covid – even though it makes no sense whatsoever and they know it,” says Steve Tsang at SOAS University of London.

Hong Kong has reported nearly half a million cases this year, with most occurring in the last week or so. The total number of deaths has shot up to more than 2000, with scenes at hospitals reminiscent of the early pandemic. “We've got people who are not able to get into hospital,” says David Owens, a family doctor in Hong Kong. “This is a public health disaster.”

In stark contrast, New Zealand, which also pursued a zero-covid strategy until recently, has so far reported only five deaths during its omicron wave, and 71 covid-19 deaths for the entire pandemic.

The difference is vaccination. In New Zealand, the highest rates of vaccination are among the oldest. Nearly 100 per cent of people aged

80 or over have had at least two doses. The main vaccine being used is the Pfizer/BioNTech one.

In Hong Kong, vaccination rates are highest in those under 60. Only 30 per cent of people aged 80 or older are vaccinated. Plus most of those over 60 had Sinovac

“We've got people who are not able to get into hospital. This is a public health disaster”

Biotech's CoronaVac vaccine, which is less effective against omicron than the Pfizer/BioNTech one. In younger groups, most had the Pfizer/BioNTech vaccine.

Hong Kong could afford to buy the best available vaccines for its

Will bitcoin help or hinder Ukraine?

With access to traditional banking services in Ukraine disrupted, cryptocurrencies can help people there access money – but the same is true in Russia, finds **Matthew Sparkes**

CRYPTOCURRENCIES are playing a role on both sides of the conflict caused by Russia's invasion of Ukraine. Their ability to cross borders regardless of rules or regulations is helping Ukrainian refugees move money out of the country, but may also provide a way for Russian elites to sidestep severe economic sanctions.

The Ukrainian government, in desperate need of equipment, tweeted a call for donations in bitcoin and Ethereum immediately after the invasion last month. As of 8 March, Ukraine's bitcoin wallet had received about £7.8 million, while its Ethereum wallet had received £4.5 million.

Unlike funds raised by non-governmental organisations and charities, these were available to the Ukrainian government within minutes.

Before the war broke out, Ukraine was already well placed to raise funds in this way. Last month, its parliament officially legalised cryptocurrency, although it stopped short of adopting any as legal tender, as El Salvador has done.

Dmytro, a computer programmer from Lviv who works for a cryptocurrency mining company and asked that his surname be withheld for security reasons, told *New Scientist* that he had managed to escape the fighting in Ukraine thanks to bitcoin.

He woke on 24 February to news of the invasion and found cash machine payouts limited by emergency laws, and huge queues to withdraw money. International bank transfers had also been banned.

He managed to transfer all his available money into bitcoin and escape with his girlfriend over the border to Poland.



CHINE NOUVELLE/SIPA/SHUTTERSTOCK

He would otherwise have been conscripted into the army, he says. "Bitcoin saved my life."

Dmytro is now in Poland, using his technical skills to oversee a group of 50 volunteers subverting Russian propaganda online and encouraging Russians to protest against the war. "They have their propaganda, but we have our truth. And as soon as people know the truth, they will definitely go to protests," he says. "This way, we can stop the war as soon as possible."

93%

Drop in value of the rouble against the US dollar this year

Russians have also been converting their money to bitcoin as the value of the rouble plummeted after global sanctions strangled Russia's economy. Demand for bitcoin has been so high that it has been trading there at a premium above global prices.

There are fears that Russia's wealthy elite and those connected

Soldiers move supplies at a railway station in Kyiv, Ukraine

to Russian president Vladimir Putin will use similar tactics to remove their money from the country to circumvent sanctions.

But George Lopez at the University of Notre Dame in Indiana says that any Russian oligarch using a Swiss bank – long a favourite storage option because of the country's strict banking privacy laws – and hoping to cash in millions of dollars worth of bitcoin would be likely to appear on the radar of numerous watchful Western governments.

He believes that, while countries such as North Korea have been able to establish complex global networks to work around sanctions so they can move funds and goods using bitcoin, Russia has had no time to prepare. "Every bank is very, very suspicious of reasonably large transfers from anybody who's trying to convert into euros or dollars who hasn't been a prior customer," he says.

Russian companies are now isolated from the global banking system, and will also find it difficult to deal with foreigners using bitcoin payments, says Lopez, because the receiving party will eventually have to convert into their own currency, which would trigger financial investigations. Put simply, large amounts of unexplained money are getting harder to put into banks under current scrutiny.

European Central Bank president Christine Lagarde urged the European Union to push ahead with its Markets in Crypto-Assets legislation that was designed to regulate the trade in cryptocurrency, to aid efforts to prevent Russian cash disappearing into bitcoin. Ukraine's vice prime minister, Mykhailo Fedorov, has also called for cryptocurrency exchanges to freeze Russian accounts.

However, although some exchanges such as Gopax have blocked accounts belonging to Russians on official sanction lists, there are few willing to take stronger action, leaving the libertarian-leaning industry standing alone while companies such as Apple, Nike and Ford withdraw services and products from Russia.

The value of the rouble against the US dollar dropped 45 per cent from the start of the year to 8 March. And while there have been reports of bitcoin soaring since the day of the invasion – it was up 9 per cent as of 8 March from the day of the invasion – it had seen a large fall in the preceding week.

It is hard to ascribe any movement in bitcoin's price solely to the invasion of Ukraine, but in this crisis, cryptocurrencies are proving to be a more stable bet than the Russian rouble. ■

Neuroscience

Special brain cells may signal when to start a new memory

Clare Wilson

A NEWLY discovered kind of brain cell involved in memory formation seems to mark the boundary between distinct events as we experience them. The neurons, called boundary cells, fire when new events happen, such as if we see someone walking into a room.

"It has long been appreciated in psychology that memory is not continuous, that it's formed in chunks. But this has never been observed at the single neuron level," says Ueli Rutishauser at Cedars-Sinai Medical Center in Los Angeles.

Much about how memories form is still unclear, but several insights have emerged from studying people who need electrodes put into their hippocampi – two curved structures on either side of the brain – because they have epileptic seizures that start in these regions. The hippocampi and surrounding areas of the brain are crucial for making new memories.

To work out exactly which part of the brain is malfunctioning, people with epilepsy may stay in hospital for several days with electrodes implanted to record brain activity. Rutishauser's team asked 19 such people to watch carefully constructed film sequences while the recording took place, listening to around 30 cells per person.

About 7 per cent of the neurons were boundary cells, whose firing peaked when new things happened (*Nature Neuroscience*, DOI: 10.1038/s41593-022-01020-w). Rutishauser speculates that activity in these cells signals that the brain should begin to form a new memory, rather like starting a new folder.

The findings "make a lot of sense", says Rodrigo Quian Quiroga at the University of Leicester, UK. "They suggest a mechanism by which the hippocampus is signalling what scenes to put together and what scenes not to put together." ■

Environment

Amazon rainforest nears tipping point to savannah

Adam Vaughan

THE Amazon rainforest is nearing a tipping point that will see it transform into savannah, according to researchers who have found that the biodiversity hotspot has lost resilience to drought and other stressors in the past two decades.

Previous studies have warned that the world's largest rainforest, which acts as a vital brake on climate change, is approaching a critical threshold. But most past research has relied on projections using models, not real-world observations.

Now, Tim Lenton at the University of Exeter, UK, and his colleagues have used two sets of satellite data covering between 1996 and 2016 to measure the greenness of the Amazon over time, watching for how it recovered after impacts such as drought and fires.

They found that since the early 2000s, 76 per cent of the region had become less

resilient, or less able to restore itself to a stable state after being affected by such events.

Importantly, says Lenton, the signal of this growing instability was picked up without immediately obvious changes such as huge drops in the forest's biomass or tree cover.

"Why do we care about it? It's worth reminding ourselves that if it gets to that tipping

"If we lose the Amazon rainforest then we get a significant feedback to global climate change"

point and we commit to losing the Amazon rainforest then we get a significant feedback to global climate change," says Lenton. He says a shift to savannah, a grassy ecosystem with much less biomass, would unlock about 90 billion tonnes of carbon dioxide stored in the trees and soil. Humanity emits about 40 billion tonnes a year.

The team looked at vegetation cover using one satellite data set that measures

the optical depth of vegetation using microwaves, and a second one that used infrared instead.

The loss of resilience was faster in parts of the rainforest that have received less rainfall and those that are closer to the biggest signs of human activities, such as large farms and major roads, say the researchers (*Nature Climate Change*, doi.org/hjxm).

Lenton says he cannot put a precise date on how far off the rainforest's tipping point might be, but he expects the transition to savannah to be a process that would take decades.

Other Amazon experts say the research adds to a growing body of evidence that the rainforest is approaching a tipping point.

The shifts aren't consistent throughout the rainforest. The south-eastern part of the Amazon, dubbed the "arc of deforestation", has already changed to the point at which it is now a carbon emitter rather than a carbon sink.

Matt Finer at the Amazon Conservation non-profit organisation says the research could offer a guide for which remaining parts of the forest to prioritise for protection. "The western and north-east Amazon appear the most resilient, reinforcing the critical need to protect these areas now and in the future from current and looming threats like mining, new roads and agriculture expansion," he says.

Carlos Nobre at the University of São Paulo, Brazil, says the research is "concerning" and "solid data-based" work. "It demonstrates that the resilience of the Amazon tropical rainforest has been very rapidly decreasing over the last 20 years," he says. ■

Burning rainforest south of Novo Progresso, Brazil



CARL DE SOUZA/AFP VIA GETTY IMAGES

Genetics

Mouse pups born from unfertilised eggs through genetic manipulation

Alex Wilkins

A GENETICALLY altered mouse pup born from an unfertilised egg survived to adulthood and reproduced, demonstrating a type of reproduction thought to be impossible in mammals.

In many plants and some animals, offspring can develop from unfertilised eggs or ova in a process called parthenogenesis. In normal sexual reproduction in animals, an egg and a sperm – each containing one set of genetic material – fuse, giving the embryo two copies of each gene. To avoid conflicts between two versions of the same gene, certain genes are switched off in either the maternal or paternal-derived DNA, in a process called imprinting.

To make an unfertilised egg develop into an embryo, it needs to have two sets of DNA from its mother. The pattern of imprinting is the same on both sets, so some genes can clash or fail to activate.

Yanchang Wei at Shanghai Jiao Tong University in China and his colleagues created unfertilised mouse eggs with double the normal number of chromosomes by adding back in DNA ejected in early stages of egg development.

Then, they used the gene-editing tool CRISPR to target seven imprinted gene regions previously identified as important in embryo development, and to change the so-called epigenetic marks, which turn genes on or off. This made the second copy of the mother's DNA appear as if it were male, "tricking" the egg into developing into an embryo. The researchers didn't respond to requests for comment.

"It's going to turn out to be an important piece of the jigsaw about the mechanism of very early embryo development and the way that the two parental genomes are regulated," says Tony Perry at the University of Bath, UK. "Secondly,

it's an important technical demonstration of the kind of potency of these [CRISPR tools]."

In 2004, another team fused two unfertilised mouse eggs at different stages of maturity and targeted a couple of imprinting regions, which also led to the birth and development of a mouse. But

"It's an important piece of the jigsaw about the mechanism of very early embryo development"

unlike the efforts by Wei's team, that wasn't true parthenogenesis as the embryo was derived from two different egg cells that were combined, says Perry.

In all, Wei and his team edited 227 unfertilised eggs, resulting in 192 embryos. Only 14 of these were carried to term, of which three resulted in live pups (*PNAS*, doi.org/hj2v). A single

mouse survived to adulthood.

The pups were underweight compared with normal ones and had genetic abnormalities. This suggests there are still imprinting regions involved in embryo development that we don't totally understand, says Perry. It may also be that the gene editing didn't work as fully as it should have.

Perry says it is unlikely that this method could be used to develop human embryos in this way any time soon. "The state of knowledge about imprinted genes in humans is much less [than in mice]," he says. "We can't do experiments on them in the same way that we can in mice." Last year, Perry and his colleagues discovered 71 previously unknown imprinted genes in early mouse embryos.

However, even one pup surviving to adulthood through targeting imprinted genes represents a significant advance. ■

Health

Half of people in US have diminished IQ due to leaded petrol

MORE than 170 million adults in the US may have a slightly lower IQ after inhaling fumes from vehicles run on leaded petrol when they were children. The harm is thought to be worst among those born in the 1960s and 1970s, when use of this fuel was at its peak.

Other high-income countries are probably similarly affected, says Aaron Reuben at Duke University in North Carolina, one of the team that looked at this issue. "Patterns of lead use in gasoline throughout the last century were very similar across developed countries," he says.

Lead began to be added to petrol in the 1920s to make car engines



UNIVERSAL IMAGES GROUP VIA GETTY IMAGES

A petrol station in San Francisco in 1977

run more smoothly. If the substance enters the brain, it can disrupt nerve signalling and, at higher levels, kill brain cells. Young children are particularly susceptible as the metal can disrupt brain development.

Using data from a national

survey, Reuben and his colleagues analysed the circulating lead levels of more than 11,600 children aged 1 to 5 from blood samples drawn between 1976 and 2016. They also estimated blood lead levels for the period from 1940 to 1975

based on leaded petrol use during that time. This information was then fed into an established formula of how lead exposure influences IQ.

The results suggest half the current US population had elevated lead levels in their blood as children. Across the country, the researchers estimate that this may have caused an average IQ drop of 2.6 points. People born in the mid-to-late 1960s may have lost an average of 5.9 points (*PNAS*, doi.org/hj2t).

In the 1970s, the harms of lead exposure became clearer. Leaded gasoline was eventually banned for use in road vehicles in the US in 1996 and in the UK in 2000. ■
Clare Wilson



ATEM Mini Pro model shown.

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Animal behaviour

Geese may have been the first birds to be domesticated

Michael Marshall

THE first domestic geese may have lived 7000 years ago in what is now China. That may make them the earliest bird to be domesticated.

The finding extends the history of goose domestication and potentially the history of domestic poultry as a whole, says Masaki Eda at Hokkaido University Museum in Sapporo, Japan.

Eda is part of a team that has excavated an archaeological site in east China called Tianluoshan, which was a Stone Age village between about 7000 and 5500 years ago. Its inhabitants “were basically hunter-gatherers”, says Eda, but they also grew rice.

The researchers have now identified 232 goose bones at Tianluoshan and say there are multiple lines of evidence that some of the geese were at least partially domesticated.

7000

Age in years of bones from early domesticated geese

Four of the bones belonged to immature geese that were less than 16 weeks old, with the youngest probably less than 8 weeks old. This implies they must have hatched at Tianluoshan, says Eda, because they were too young to have flown in from elsewhere. However, no wild geese breed in the area today and it is unlikely they did so 7000 years ago, he says.

Some of the adult geese also seem to have been locally bred, based on the chemical make-up of their bones, which reflects the water they drank. These locally bred birds were all roughly the same size, indicating captive



BLICKWINKEL/AGAMIM, GUYTALAMY

Chinese geese (*Anser cygnoides domesticus*)

breeding. Finally, the researchers carbon-dated the bones and found that the locally bred geese lived about 7000 years ago.

Taken together, the findings suggest the geese were at an early stage of domestication, says Eda (*PNAS*, doi.org/hj2w).

“It’s a major study in our understanding of poultry domestication,” says Ophélie Lebrasseur at the Centre for Anthropobiology and Genomics of Toulouse in France.

“The main thing that stood out for me is the fact

Goose bones found at Tianluoshan, an ancient site in China



MASAKI EDA

they actually did radiocarbon dating on the bird bones,” says Julia Best at Cardiff University in the UK. This makes the dating much more reliable than if the researchers had simply dated the surrounding sediment.

If geese were domesticated 7000 years ago, that would make them the first bird to be domesticated, says Eda. The other candidate is chickens, but there has been a dispute over when and where this first happened.

A study published in 2014 reported that chickens were domesticated in northern China as early as 10,000 years ago, based on DNA from bones. However, the bones weren’t directly dated and “a lot of the things they claimed were chickens were pheasants”, says Best. Firm evidence of domestic chickens only appears from around 5000 years ago, she says.

This implies geese were domesticated before chickens, says Lebrasseur. “With the evidence we currently have, I think it is true,” she says – but she adds that the domestication of birds is understudied, so the story could well change as more evidence emerges. ■

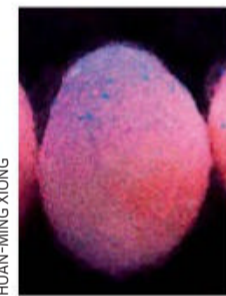
Materials

Quantum dot diet makes silkworms fluorescent

Alex Wilkins

SILKWORMS that eat nanometre-sized particles called quantum dots produce fluorescent silk.

Researchers have previously used gene editing to make fluorescent silkworms, but these methods can be costly and introduce random genetic mutations that are harmful to the worms. Instead, Huan-Ming Xiong at Fudan University in Shanghai, China, and his colleagues extracted carbon quantum dots – nanometre-sized semiconductors that emit specific wavelengths of light – from mulberry leaves and fed them to silkworms.



HUAN-MING XIONG

A glowing cocoon made by a silkworm after eating quantum dots

Xiong and his team tested dozens of different carbon dots on the silkworms to find candidates with good fluorescence, biocompatibility and safety for the animals. “It is very lucky for us that we can make red-emissive carbon dots from mulberry leaves, because silkworms like to eat them,” says Xiong.

Once the silkworms had eaten the quantum dots, the researchers observed that the worms, as well as their silk, eggs, cocoons and moths, gave off a strong red glow when irradiated with visible light. The second generation of silkworms no longer glowed (*Advanced Materials*, doi.org/hj2z).

The mulberry leaf method appears to be more sustainable compared with other techniques, says Antonios Kelarakis at the University of Central Lancashire in Preston, UK. “It is a readily scalable method that does not require any change of practice or financial investment from the producer.” ■

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Field notes Keadby 2, Lincolnshire, UK

The UK's last gas power plant As many people question the UK's reliance on gas power, **Adam Vaughan** visits what is likely to be the last conventional plant in the country as it transitions to net zero



CLIMB the stairs to the roof of the cooling tower at Keadby 2, a new gas power plant in the east of England, and you are rewarded with a story of the UK's energy past, present and possible future.

Straight ahead is a mound built from the ash of a coal plant that closed in 1984, a fuel the UK has now almost entirely ditched. Behind stands an array of 34 fast-spinning turbines in England's biggest onshore wind farm. Off the coast are some of the UK's largest offshore wind farms. And this Lincolnshire site could soon be home to a pair of pioneering low-carbon power stations, if energy firm SSE gets its wish.

However, perhaps the most extraordinary thing on this flat stretch of land, which was reclaimed from the sea, is the power station infrastructure beneath your feet. Keadby 2 will almost certainly be the UK's last large traditional gas power plant.

Construction began in 2018 and has been a "hard slog", says one SSE staffer, not least because of the pandemic, with a covid-19 outbreak on-site early last year briefly pausing work. But the 893-megawatt plant is now in testing mode and due to start commercial operations in October, producing enough electricity for 840,000 homes.

Alistair Phillips-Davies, SSE's chief executive, is keen to point out that the company is also investing in renewables. "[But] if the wind isn't blowing or the sun isn't shining, you still need some flexibility there," he says. "That's the reason we built this."

Yet some question the project's wisdom after months of record gas prices and with high gas prices now projected to last for years. Russia's invasion of Ukraine has compounded those price shocks and triggered



The gas turbine at the heart of the Keadby 2 power plant

a wider rethink about reliance on gas. "As SSE, you would look and think, 'Is this going to be a stranded asset, with everything going on?'" Gas prices are very volatile," says Jess Ralston at the Energy and Climate Intelligence Unit, a UK-based think tank.

Most power stations are built to last decades. Yet even before the war in Ukraine, the UK government effectively gave this one a 13-year shelf life by declaring that the country's power system must be decarbonised by 2035. The plant

will emit about 350 grams of carbon dioxide per kilowatt-hour it generates – more efficient than the average UK gas plant at 394g CO₂/kWh, but still much higher than average UK electricity generation, which was 181g CO₂/kWh in 2020 and must fall to 50g by 2030 to meet climate targets.

"This will have to be retrofitted in some way, shape or form with a mixture of carbon capture and storage, and/or be converted to hydrogen [by 2035]," says Phillips-Davies. To cut emissions, the plant could even start blending in hydrogen to replace a fifth of the gas it burns by the end of the 2020s, he says.

But Phil MacDonald, the head of climate think tank Ember, says hydrogen is so much less energy dense than natural gas that the volumes involved in blending it would be tantamount to greenwashing, because the carbon emissions savings would be so small. "Blending is a real red herring," he says. Phillips-Davies rejects the notion that the savings would be too small to be worthwhile, saying "the issue is we're on a transition".

SSE says the plant will run 50 to 60 per cent of the time

in the coming years, to support the electricity grid. But Phillips-Davies says it will gradually be squeezed out by new and lower-carbon power stations, two of which he hopes to build here.

One is Keadby 3, a gas power station that would capture and store up to 95 per cent of its carbon emissions. If built by 2027, as SSE hopes, it would be a world first. The second is Keadby Hydrogen, swapping the car park here for the world's first hydrogen power station. Both are welcome and highly ambitious, says Ralston.

The plans are more than just ideas – planning permissions have been sought and millions already spent on development, says Phillips-Davies – but they are unlikely to happen without government financial support.

Power plants with carbon capture and storage (CCS) don't have a good track record globally, says MacDonald. One complication is that pipelines and a seabed storage facility for the carbon dioxide need to be built. And it remains to be seen if enough hydrogen can be produced, using either natural gas with CCS, or renewables and electrolyzers. Phillips-Davies prefers the latter, but thinks the former will be needed to source enough hydrogen.

This vision of the UK's energy future may never arrive. Energy-storage technology could mature faster than expected to be the reliable backbone for renewables instead, says MacDonald.

But Kayleigh Wilcox, an SSE engineer who used to work at nearby Ferrybridge, a coal power station that was closed despite a CCS pilot, is hopeful this future materialises. "The industry has felt like it's shrinking," she says. "[But now] it looks like a lot of us might have a career for a while." ■

893

Power output of the Keadby 2 plant, in megawatts

350

Carbon intensity of the plant, in grams of carbon dioxide per kilowatt-hour generated

2035

Year the plant must be switched off or decarbonised

Cryptography

Code designed to protect against quantum hackers is 'useless'

Matthew Sparkes

ONE of three cryptography algorithms vying to become a global standard against the looming security threat posed by quantum computers has been cracked in a weekend using a standard laptop. The algorithm is now widely believed to be unfit for purpose.

A range of algorithms for encryption – the process of bundling data up into impenetrable files for safe transmission – are currently verified and approved as secure by the US National Institute of Standards and Technology (NIST), and consequently they are used around the world. But these algorithms are set to be made obsolete in coming years by the arrival of quantum computers.

Once developed, these machines promise to vastly exceed the power of classical computers at certain types of

problems. One example is quickly finding the prime factors that serve as the multiplicative building blocks of a number – for instance, 3 and 7 are the prime factors of 21. This seemingly innocuous ability will fundamentally break encryption currently used in email, banking and cryptocurrencies.

A total of 69 algorithms believed to be resistant to the increased code-breaking ability of quantum computers were submitted to NIST's Post-Quantum Cryptography competition. These have now been whittled down to four finalists for the task of encryption and three for signing signatures, which are used to verify identity, for example when making a financial transaction.

Rainbow is one of the final three signature algorithms. A signature scheme is used to mark a message using a secret key known only to

that person. It can then be verified as a legitimate message by a recipient using the sender's public key, which is made available to everyone.

Ward Beullens at IBM Research Zurich in Switzerland was able to take a Rainbow public key

"This weakness would allow an attacker to falsely 'prove' they are someone else"

and discover the corresponding secret key in just 53 hours using a standard laptop. This weakness would allow an attacker to falsely "prove" they are someone else.

Beullens says that this kind of attack, detailed in a study published by the International Association for Cryptologic Research, makes Rainbow "useless" as a method to verify messages. He had previously

developed less serious attacks against Rainbow, to which the creators responded by increasing the complexity of the private and public keys at the expense of efficiency, he says.

"I think my previous attack was also quite serious, and I think it was already obvious that Rainbow was not going to be standardised," says Beullens. "The common feeling among cryptographers seems to be that [the other two finalists in the signature competition] are much more secure."

Dustin Moody at NIST told *New Scientist* that the attack against Rainbow had been verified and that it is now unlikely to be chosen as the final signature algorithm when a decision is made later this month. Unfortunately, it has already seen limited real-world use, including by a cryptocurrency called ABCMint. ■

Archaeology

Easter Islanders relied on freshwater springs under sea

UNDERSEA springs may have been crucial for the survival of the people who built the massive stone statues for which Rapa Nui – also known as Easter Island – is famous. Their ancient settlements and the platforms on which the monolithic statues were placed were all located on the coast close to such springs, surveys have shown.

These sources of fresh water were critically important, allowing Rapa Nui communities to survive long droughts, said Robert DiNapoli at Binghamton University in New York during a virtual talk at the Ocean Sciences Meeting 2022 last week. "The



environment is really marginal."

The island gets a lot of rainfall, but it is unpredictable and there are often droughts. The only sources of fresh water on Rapa Nui are three small lakes, but these are far from settlements and dry up during long, rain-free periods.

This had led some researchers to suspect that places along the shore where groundwater flows out into the sea were vital to the island's inhabitants, who first settled there in around AD 1150.

During low tide, some of this fresh groundwater flows out of

The statues of Rapa Nui (Easter Island) were built near underwater springs

the rocks into the sea in places, which may explain why Europeans, upon discovering the island in 1722, sometimes described locals drinking "seawater".

Now, DiNapoli's team has mapped "submarine groundwater discharge", as it is known, by testing water samples and using drones with thermal sensors. The groundwater shows up as blue in thermal images because it is cooler than the seawater.

The surveys were done during a drought. The springs were still discharging a fairly large amount of water into the sea near the sites of ancient statues and settlements. ■

Michael Le Page

Astronomy

Our closest black hole is actually one star eating another

Alex Wilkins

STRANGE signals coming from 1000 light years away were once thought to be produced by the closest black hole to Earth, but further investigation shows they are actually from a pair of stars in a rare “vampire”-like system, where one star strips the other of its mass.

Two years ago, astronomers observed odd spectral lines from the star system HR 6819 and concluded that the likely source was a black hole four times bigger than the sun, affecting two orbiting stars.

Now, they and a larger team led by Abigail Frost at KU Leuven in Belgium have observed the system using more detailed spectroscopy at the Very Large Telescope in Chile and interferometry, which can measure positions very precisely.

The researchers wanted the extra data so they could test whether the system was in fact just two stars very close together. A three-object system, of two stars and a black hole, would require one of the stars to be on a wide orbit far from the second star and the black hole. “What these two data sets allowed us to do was to distinguish between the two [scenarios],” says Frost.

The team observed nothing on a wide orbit, eliminating the scenario with a black hole (*Astronomy & Astrophysics*, doi.org/hjfr). “This is a really good example of how the scientific method works,” says Frost. “You propose an idea, someone else has another idea and you discuss it amongst yourselves and you think, ‘OK, how could we push this further and actually decide which is the best explanation?’”

Not only were the stars close together, but one of them appeared to be sucking material from the other, creating what is known as a Be star. Understanding the evolution of such stars could help us learn about how they become neutron stars or produce gravitational wave events. ■

Animal behaviour

How a rodent’s fear shapes the rainforest

Jake Buehler

A GAME of cat and mouse is playing out in Panama’s rainforests, with large rodents called agoutis using their keen sense of smell to avoid ocelots that hunt them. The fear the rodents have for these predators and the ways it directs their behaviour have ripple effects that could alter the diversity of plants around them.

Most research on this “ecology of fear” has been centred on temperate ecosystems, says Dumas Gálvez at the Smithsonian Tropical Research Institute in Panama City. To see how the phenomenon could play out in the tropics, he and Marisol Hernández at the University of Panama looked to Central American agoutis (*Dasyprocta punctata*) and ocelots (*Leopardus pardalis*).

Agoutis, like many rodents, are prolific seed spreaders. They hoard seeds and retrieve them from buried caches later,

An agouti gnawing on a palm seed on the forest floor

but many of these will be abandoned and allowed to sprout. This benefits plants by dispersing them in a forest.

To see if fear of ocelots disrupted the agoutis’ seed-shuttling habits, Gálvez and Hernández attached strings and numbered flags to palm seeds so their locations could be spotted after being cached by agoutis. The pair set the seeds out in the forest in Metropolitan Natural Park in Panama City, both in areas with high and low densities of ocelots.

Where ocelots were plentiful – that is, spotted by trail cameras every week – the palm seeds were moved 50 to 300 per cent less than in areas of lower ocelot density, depending on the season. The agoutis also didn’t return to caches as often in areas with a large number of ocelots (*Behavioral Ecology*, doi.org/hjq6).

The rodents have a keen sense of smell and were probably reacting to the odours of the ocelots’ faeces and urine, says Gálvez. The team confirmed this in a forest near Gamboa,

Panama, by setting out palm seeds and trail cameras. In some locations, the seeds were placed next to a rag soaked in ocelot urine and a small pile of faeces. The agoutis were more cautious near the ocelot scents, taking longer to remove the seeds compared with those in places not marked with ocelot waste.

“Much of the formidable effect predators have on ecosystems is driven by the fear they inspire”

The researchers think this could have knock-on effects on forest vegetation. Seed beetles can infect and kill a palm seed left on the ground. In areas with hesitant agoutis, beetles “have a longer window to infect those seeds before the agouti comes and takes the seeds away”, says Gálvez.

This hasn’t been directly confirmed, but the team expects that the beetles’ effects could influence forest plant diversity. If fewer palms get a foothold, that may allow a wider range of plants to compete in places of high ocelot density.

Fear-spurred ecosystem cascades have been identified before, says Liana Zanette at Western University in Ontario, Canada. She has seen it in her own work on raccoons, which don’t eat as many seashore creatures when exposed to the sound of barking dogs. “A large part of the formidable effect that predators play in ecosystems is driven by the fear that predators inspire in prey,” she says.

Because of the downstream influence on the food web, she says that restoring fear may play a crucial role in restoring disturbed ecosystems. ■



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“The funding I received through the Medical Research Foundation will be transformative for my research.” Dr Myrsini Kaforou

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Zoology

Bonobo infants get stressed out by the arrival of a younger sibling

Alice Klein

BONOBO infants become highly stressed when they get a younger sibling and they don't recover for seven months, according to a study that monitored levels of a stress marker in their urine.

In humans, many firstborn children struggle with the arrival of a sibling because "they've lived in a world where they have pretty unlimited access to parental time and attention, and now they're having to share it", says Matthew Sanders at the University of Queensland in Brisbane, Australia, who wasn't involved in the work.

To explore whether this transition is also difficult for older siblings in related species, Verena Behringer at the German Primate Center in Göttingen, Germany, and her colleagues studied bonobo infants when they gained a sibling. They picked bonobos because, similarly to us, additional offspring are often born while older siblings are still dependent on their mother for care.

The researchers studied 20 female and six male bonobos between 2 and 8 years of age living in the wild in Salonga National

Park in the Democratic Republic of the Congo. They observed the infants' behaviour when their mothers gave birth to younger siblings and also collected regular samples of their urine.

The bonobos made more body contact with their mothers for a short period after their siblings were born, possibly to try to regain attention or because they were curious to see the new infant, says Behringer. The level of a stress hormone called cortisol in their urine also jumped to five times its normal level on average after the sibling was born, and stayed high for seven months before returning to the baseline (bioRxiv, doi.org/hjpd).

This stress response wasn't because older offspring had to stop nursing when their younger siblings were born, since most had already weaned. "Instead, we speculate that the overall change in their environment, such as less attention by the mother, change in their social environment and other new situations may be responsible for the increased stress levels," says Behringer.



SEAN W. LEE/GEORGE WASHINGTON UNIVERSITY

A young bonobo and her mother in Salonga National Park

The researchers didn't investigate whether higher levels of stress affected the long-term health of the older offspring, but they did notice that a marker of immunity in the bonobos' urine called neopterin dropped sharply when their younger siblings were born.

Cortisol levels in human children haven't been measured following sibling births, but

observational studies have noted that they can become clingy, whiny, attention-seeking or withdrawn, which may be indicators of stress.

"You're generally talking about a period of months for children getting used to having another sibling around," says Sanders. "But it doesn't end there because sibling influences are amongst the most important developmental influences in our lives and represent the longest relationships people are likely to have." ■

Technology

Robotic ships could inspect undersea cables and drills

ENGINEERS are developing a fleet of 85-metre-long vessels that will deploy underwater vehicles for tasks like pipeline inspection while their operators remain onshore.

The US Navy has previously repurposed a cargo vessel to pass through the Panama Canal largely uncrewed. The new fleet, however, is being developed to be robotic from the outset, a first for vessels of this size.

Norwegian shipbuilding firm VARD is constructing six multipurpose offshore vessels (MPOVs) for marine robotics company Ocean Infinity, based in Southampton, UK. The vessels have a "moonpool", an opening in the hull to launch and recover remotely operated vehicles (ROVs).

The vessels may initially have some crew on board, but the eventual aim is for them to be fully automated when the fleet launches in 2025.

"Their tasks could include checking the integrity of subsea cabling and pipe networks,

geotechnical seabed drilling activity, and maintenance of offshore installations, including light construction work for floating wind infrastructure," says Dan Hook at Ocean Infinity. Such jobs currently require crews of between 50 and 60 people. Automating the process should help cut costs.

The ROVs will carry out these tasks using cameras and sonar, just as they would if they were

"Their tasks could include checking the integrity of subsea cabling and pipe networks"

launched from a crewed vessel. In this instance, however, the operators will remain onshore, with the vehicles being sent out and recovered autonomously.

Ocean Infinity already operates smaller robotic vessels, measuring 36 metres in length, but scaling up will allow them to do more.

"Advantages of the larger vessels include the amount of technology and robotic capability they can carry, also an increased range and their ability to operate safely in more challenging sea states," says Hook. ■

David Hambling

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Environment

Ambitious global treaty agreed to tackle plastic pollution

Adam Vaughan

A TREATY to end the plastic pollution crisis by tackling the material's entire supply chain has been agreed by 175 countries. It is the "biggest multilateral environmental deal" since the 2015 Paris climate agreement, according to Inger Andersen at the UN Environment Programme.

On 2 March, at a meeting of the UN Environment Assembly in Nairobi, Kenya, countries passed a resolution on the first

381m

Tonnes of plastic produced globally in 2015

treaty to directly deal with the 9 gigatonnes of plastic produced since the plastic age ramped up in the 1950s. Work now begins on how to implement the treaty by 2024.

Two competing ideas had been put forward for the treaty. One, led by Peru and Rwanda, encompassed all stages of plastic's life cycle, from production to consumption and disposal. The second was a far more limited deal focused on plastics in the oceans, spearheaded by Japan.

The more ambitious plan won out. Crucially, elements of the treaty are legally binding. It also acknowledges that lower-income countries will find it harder to grapple with plastic and pollution than high-income ones and so there is a need for some sort of financing model to help curb plastic use and waste.

"We now have one text. It speaks to full life cycle; it speaks to legally binding; it speaks to a financing mechanism; it speaks to understanding some countries can do it more easily than others," says Andersen.

"It has been a long, hard road, but I'm very happy."

She compared the accord to the Montreal protocol on ozone-destroying chlorofluorocarbons (CFCs) and the Minamata convention on mercury pollution, both of which led to massive reductions in emissions of these harmful chemicals. These are proof that global deals can make governments and industry work differently, she says.

In 2015, the world produced 381 million tonnes of plastic, and hundreds of thousands of tonnes are estimated to end up in the oceans every year, most of it from lower and middle-income countries that have less capacity to recycle or burn it.

Ubiquitous plastic pollution has been linked to negative impacts on marine life. There are fears that it may affect our health too, although more work is needed to establish that.

Failure to tackle the problem isn't an option, says Andersen. "The youth of today, voters, ordinary people are just

Plastic litters a beach in Bali, Indonesia



JOHANNES CHRISTO/REUTERS/ALAMY

disgusted when they go to the coast and see this stuff," she says.

"The best way to tackle plastic pollution is to prevent it in the first place," says Steve Fletcher at the University of Portsmouth, UK. "By covering the whole supply chain, a global agreement to tackle plastic pollution can support upstream solutions such as reducing or replacing plastic in products."

Exactly what measures should be enacted under this treaty, and what teeth the deal might have, will now need to be worked out. In a statement, Marco Lambertini at conservation group WWF International said the treaty must have "clear and strong global standards and targets".

Andersen hopes the treaty will take effect within three years. She says one example of how legally binding limits might be implemented is in restricting how much virgin polymer is put into economies. She adds that the plastic problem won't "turn on a dime", but "when it's done, we should not see that amount of plastic waste in our rivers and in our drains that we see today". ■

Animal behaviour

Blue wings give dragonfly stealth capabilities

Jake Buehler

WITH dazzling iridescent wings, male morpho dragonflies should be hard to miss, but their wings are simultaneously capable of both spectacle and stealth. When viewed against a bright, watery background, the insects can vanish.



SHUTTERSTOCK/IGUENTERMANAUS

Spectacular blue wings can advertise or camouflage male morpho dragonflies

Male morpho dragonflies (*Zenithoptera lanei*), native to Central and northern South America, have wings with layered structures that alter how light reflects off their surface. The males use their wings in courtship displays to attract females and deter rivals.

Rodrigo Cezário at the University of São Paulo in Brazil and his team wondered if this iridescence could also work as camouflage. The researchers collected 10 male morpho dragonflies in São Paulo state and measured the light wavelengths reflected off their wings. They combined this with models of vision in birds and flies – the dragonflies' predators and prey – as well as other male dragonflies that compete for mates (*Journal of Zoology*, doi.org/hjmq).

The team found that other dragonflies, prey insects and birds could probably spot the wings against vegetation. But the wings' brightness matched that of the surface of water, providing "counter-brightness" camouflage. This means the dragonflies would blend in with a pond, say, if they were viewed from above.

The researchers say this is the first known case of an insect using brightness matching as camouflage against the surface of water. ■

Archaeology

Clues to purpose of Stonehenge

The monument may have been a calendar – and now we know how it could have worked

Alison George

STONEHENGE has long been thought to be an ancient calendar due to its alignment with the summer and winter solstices, but exactly how the calendar system worked was a mystery.

Now, an analysis shows that it could have functioned like the solar calendar used in ancient Egypt, based on a year of 365.25 days. “It’s a perpetual calendar that recalibrates every winter solstice sunset,” says Tim Darvill at Bournemouth University, UK, who carried out the study.

The key to unlocking this calendar system came from the discovery in 2020 that most of the “sarsen” stones in the monument were quarried from the same location 25 kilometres away, and were placed at Stonehenge at around the same time.

“All except two of the sarsens at Stonehenge come from that single source, so the message to me was that they’ve got a unity to them,” says Darvill. To him, this indicated that they were intended for a common purpose. To find out what, he looked for clues in the numbers.

The sarsens were arranged in three different formations at Stonehenge in about 2500 BC, with 30 comprising the large stone circle that dominates the monument, four “station stones” sitting in a rectangular formation outside this circle and the rest constructed into five trilithons – consisting of two vertical stones with a third stone laid flat on the top – located inside the stone circle.

Stonehenge might be a 4500-year-old solar calendar

“Thirty, 5 and 4 are interesting numbers in a calendrical kind of sense,” says Darvill. “Those 30 uprights around the main sarsen ring at Stonehenge would fit very nicely as days of the month. Multiply that by 12 and you get 360. Add on another 5 from the central trilithons, you get 365.”

To adjust the calendar to match a solar year, the addition of one extra leap day every four years is needed, and Darvill thinks that the four station stones may have been used to keep track of this. In this system,

the summer and winter solstice would be framed every year by the same pair of stones (*Antiquity*, doi.org/hjn9).

This Stonehenge calendar system “makes a lot of sense”, says David Nash at the University of Brighton, UK. “I like the elegant simplicity of it.”

Other researchers aren’t so sure. “It’s certainly intriguing, but ultimately it fails to convince,” says Mike Parker Pearson at University College London. “The numbers don’t really add up: why should two uprights of a trilithon equal one upright of the sarsen circle to represent one day?”

Although a calendar with 30-day months and an extra “intercalary” month of five days might not be familiar to us today, such a system was used in ancient Egypt from around 2700 BC and other solar calendars had been developed in the eastern Mediterranean region.

The similarity between this possible Stonehenge calendar and the one used in ancient Egypt hints that the idea for the Stonehenge system might have come from afar. ■



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Physics

Laser-like beams of waves from storms pound distant coasts

IF CONDITIONS are right, the high waves produced by a tropical storm can be focused like laser beams and travel more than 1000 kilometres to hit distant coasts – though tracing such waves back to their source will be a challenge.

Normally, the waves produced by a tropical storm radiate out like those of a stone dropped in a pond, diminishing as their energy gets spread out over larger circles. But

when Rui Sun at the Scripps Institution of Oceanography in California was investigating sea conditions using a computer model of cyclone Mekunu, which formed over the Arabian Sea in May 2018, he saw a pattern he didn’t expect: circular waves turned into straight, parallel beams by an ocean current.

Mekunu made landfall on the coast of Oman on 25 May, but those beams of waves barrelled towards the west coast of India and Pakistan under the influence of the monsoon current, which moves across the Arabian Sea.

According to Sun’s model, one

day later and over 1000 kilometres from the track of the cyclone, those beams brought alternating pulses of waves that were unusually high or extra low, raised or diminished in each case by up to a metre. These waves hit all along the coast from Karachi in Pakistan to Mumbai in India. Each pulse was separated by about 100 kilometres.

Sun says this happened because the monsoon current refracted the

1000

Distance in kilometres that the beams of waves travelled

waves similar to the way glass refracts light. He presented the work at the virtual Ocean Sciences Meeting on 4 March.

Although the model’s results are clear, Sun can’t point to any examples of coastal damage that, in hindsight, must have been caused by a distant storm. This isn’t surprising, says David Woolf at Heriot-Watt University in Edinburgh, UK, because of the many uncertainties of real-life weather modelling and prediction. “Tracking down the cause in each case unambiguously would be very difficult,” he says. ■

Bas den Hond



SHUTTERSTOCK/DANILPHOTOS

Evolution

Plants may have conquered land thanks to microbe DNA

AROUND 500 million years ago, aquatic plants migrated from water to land, and they may have had genes adopted from bacteria, fungi and viruses to thank.

We already had hints that genes hopped from bacteria and fungi into early land plants in a process called horizontal gene transfer (HGT).

So Jinling Huang at East Carolina University in Greenville, North Carolina, and his team analysed the full genomes of 31 species representing the primary plant groups – mosses, ferns (pictured), seed plants and so on – and charophytes, the algae most closely related to plants. They carefully screened the data for genes acquired from other organisms and then built family trees to determine the evolutionary history and the direction of transfer.

They found that 593 families of genes in these plants originated in a mix of fungi, bacteria and viruses.

Many of the genes had roles key to living on land. For instance, the *LEA2* gene family is involved in desiccation resistance. The *pectin esterase* gene families have a role in the development of cell walls, which lend important structural support for upright growth in land plants. Both gene families came from bacteria. An ammonia transporter gene family important for uptake of nitrogen from soil came from fungi (*Molecular Plant*, doi.org/hjnw).

It isn't known how the HGT occurred, but the reproductive structures of mosses and aquatic algae are exposed, so could have close interactions with microbes, says Fay-Wei Li at Cornell University in New York. **Jake Buehler**

Earth sciences

Booming sea life left geological signature

WHEN the variety of animal life exploded in the oceans more than 500 million years ago, it changed the face of the planet. Now it seems the effects of that burst of evolution reached thousands of kilometres into Earth's heart.

Andrea Giuliani at the Swiss Federal Institute of Technology in Zurich and his team studied rocks called kimberlites, which are carried to the surface from deep inside the planet. "If we look at kimberlites, we can potentially get a more pristine signal of the deep Earth than using other magmas [molten rocks that have since cooled]," says Giuliani.

They analysed 144 kimberlites and related rocks collected from 60 locations worldwide. In each kimberlite, the team looked at the mix of different types, or isotopes, of carbon. The two most common forms are carbon-12 and carbon-13,

with living organisms generally absorbing the former.

Giuliani's team found that carbon-12 levels rose in kimberlites younger than 250 million years, probably due to huge amounts of organic matter being buried in sea-floor sediments during the Cambrian explosion (*Science Advances*, doi.org/hjw2).

Some of this Cambrian material was carried deep into Earth via tectonic plate movement. Plates can get forced down in a process called subduction, ending up in Earth's mantle. It then takes a long time for this material to travel to the surface in rocks like kimberlite. "The minimum time is about 250 million years or so," says Giuliani.

Very little organic matter is thought to have been deposited 1 billion to 550 million years ago, making the Cambrian explosion the only plausible source of the organic carbon, according to Giuliani. **Michael Marshall**

Health

Profile of blood fats flags disease risks

LEVELS of 184 fat molecules in the blood can help predict the risk of developing type 2 diabetes and cardiovascular disease.

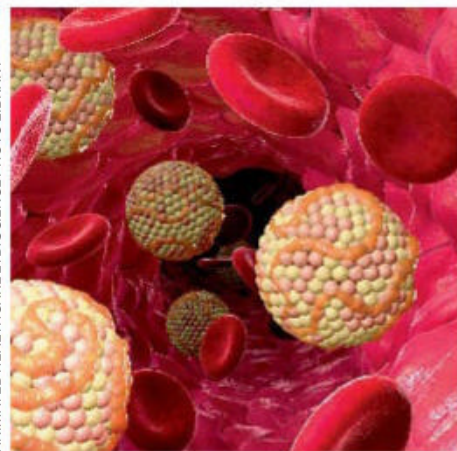
Doctors currently assess the chance of getting these conditions by measuring body mass index, blood pressure and levels of cholesterol (pictured) and sugar in the blood.

For the new method, Chris Lauber at German biotech firm

Lipotype GmbH and his team analysed data on around 4000 people who took part in a previous study from 1991 to 2015 in Sweden. Their blood was analysed in a mass spectrometer to measure levels of 184 fats. The team used data from two-thirds of these people to train computer models to make links between cardiovascular disease or type 2 diabetes and the fat levels at the start of the original study.

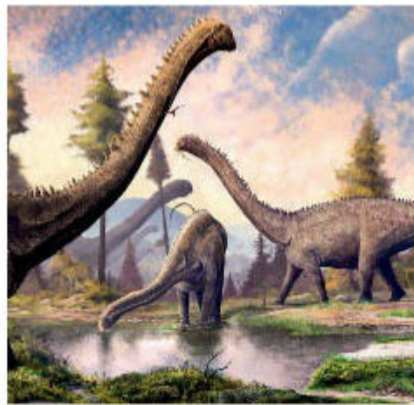
Then they used the models to predict disease risk from fat levels in the remaining third. They found the 10 per cent of people predicted to be at highest risk of type 2 diabetes had a 168 per cent higher rate of the disease, compared with the average in the study group.

Meanwhile, the 10 per cent of people predicted to be at highest risk of cardiovascular disease had an 84 per cent higher rate of this illness compared with the average rate across all the participants. The method proved better than use of genetic risk factors (*PLoS Biology*, doi.org/hjpn). **Carissa Wong**



ANIMATED HEALTHCARE LTD/SCIENCE PHOTO LIBRARY

Really brief



Huge dinosaurs had an unusual gait

Long-necked dinosaurs had a walking gait different from any living animal. Computer models and data from dinosaur footprints suggest they moved the front left foot followed by the rear right foot, and vice versa. This is unlike large modern animals such as elephants (*Current Biology*, doi.org/hjns).

Nanobots can clean polluted water

Magnetic nanobots can remove pollutants from water, and could one day be used at treatment plants. The nanobots disperse in cold water, but clump together at 25°C, trapping pollutants such as arsenic. They are then removed with a magnet (*Nature Communications*, doi.org/hjnj).

Wild boar deaths led to oak boom

The Białowieża primeval forest in Poland saw twice the typical number of acorns grow into oak trees following a 2015 outbreak of a virus that killed 90 per cent of the resident wild boar population. The animals normally eat acorns in large numbers (*Proceedings of the Royal Society B*, doi.org/hjnt).

Space exploration

Mars rover may be near ancient ocean

CHINA'S Zhurong Mars rover landed at Utopia Planitia – a large plain in the northern lowlands of Mars – back in May 2021. Now, initial data collected by the vehicle suggests that the site has been subject to long periods of weathering in the past by wind, and maybe even water.

During Zhurong's first 60 sols, or Martian days, on the planet, it traversed 450.9 metres of flat land littered with small rocks. At the

same time, the rover collected data to study the geological structure and surface composition of Mars.

Liang Ding at the Harbin Institute of Technology in China and his colleagues analysed this initial data, which included soil and dust samples and images.

They found many of the rocks around the landing site were covered with etchings and grooves on one side, which indicates intense wind erosion from sand. Some of the rocks also have a flaky texture, which typically arises from interactions with water, say the researchers.

The rover also encountered several megaripples on the surface, wind-sculpted features made up of loose sediment that span several metres (*Nature Geoscience*, DOI: 10.1038/s41561-022-00905-6).

Overall, the initial findings suggest that the location has the potential to provide more insight into the history of Mars's surface.

“What's really exciting is that many scientists think that Utopia Planitia may have once hosted an ancient liquid water ocean, billions of years ago,” says Joel Davis at the Natural History Museum in London. **Chen Ly**

Technology



Desert solar panels adapted to extract water from the air

A TRIAL has shown a solar panel add-on can harvest water from desert air by exploiting day-night warming and cooling of the panels. The system slightly increases the electricity-generating efficiency of the panels by keeping them cooler.

Peng Wang, who is at King Abdullah University of Science and Technology in Saudi Arabia, and his team developed an approach that uses a layer of hydrogel under each photovoltaic panel and encased in a metal box. At night, the box is open to allow the desert air to flow through it where the hydrogel absorbs water vapour.

During the day, the box is closed.

The sun warms the solar panel, and thus the hydrogel under it, making the water evaporate from the gel. The humidity in the closed box gets so high that water condenses on the metal and can be drained.

During a three-month test, a small prototype system (illustrated) produced 0.6 litres of water per square metre of solar panel per day.

The team also found electricity generation increased – by nearly 2 per cent – because the transfer of heat to the hydrogel and water-harvesting box cools the panels, which makes them more efficient (*Cell Reports Physical Science*, doi.org/hjn6). **Michael Le Page**

Palaeontology

Giant duck-billed dino took a tumble

A FOUR-LEGGED duck-billed dinosaur that lived 68 million years ago in what is now eastern Russia probably broke its wrist after falling from an upright position during mating or while reaching for leaves.

Filippo Bertozzo at the Royal Belgian Institute of Natural Sciences and his team used a form of X-ray imaging to analyse a lower foreleg bone – the ulna – that was uncovered in Blagoveshchensk in south-east Russia.

Through inspection of the curvature of the bone and shape of the elbow, the team confirmed that it belonged to a herbivorous hadrosaur (*Amurosaurus riabinini*). The animal was a subadult and around 5 metres long and 2 metres high.

By analysing a digital reconstruction of the bone, and comparing its structure with ulnas of uninjured *A. riabinini* from the same fossil site, the team revealed that the dinosaur probably fell from an upright position. This caused a diagonal fracture at the end of the ulna. Based on the extent of healing in the bone, the injured animal probably limped around for at least four months before its death (*Historical Biology*, doi.org/hjpv). **CW**

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Wildly wrong

Victorian ideals have perpetuated a myth of the passive female of the species. Promiscuity is a winning maternal strategy, says **Lucy Cooke**

I ONCE stole a lion's girlfriend. At the time, I was in the Masai Mara in Kenya experimenting with audio playback as a means of deciphering lion communication.

This involved blasting a recording of a male lion's roar into another's territory and waiting for a response. Three lions – one female and two males – raced over to our Land Rover to investigate. The males quickly got bored when they failed to find anything that resembled a rival. The female, however, pinned the vehicle to the spot, legs akimbo, for over 2 hours. She was in oestrus and, in addition to mating with her consorts, she also wanted to mate with us. Not that this was anything special for the lioness: fertile females are known to mate 100 times with multiple males in a matter of days.

I was shocked and quietly thrilled to discover her licentious nature. At university, I was taught that males, with their endless supply of sperm, are wired for promiscuity, whereas females, with their limited number of eggs, must be choosy and chaste. Didn't the lioness understand this "universal law"?

My research since has exposed how sexist bias has been baked into evolutionary biology and warped our understanding of the female animal. We should remember that great scientists, even geniuses like Charles Darwin, are also people of their time. Darwin's second great theoretical masterpiece – *The Descent of Man*,



his book containing his theory of sexual selection – cast females in the role of the Victorian housewife: coy, submissive and invariant.

This theory of passivity was given an empirical lifeline in the 1940s by a British geneticist called Angus Bateman, whose legendary fruit fly mating experiment "proved" that females have little to gain from multiple mating, whereas males do. Bateman's paradigm seared these deterministic sexual archetypes into evolutionary lore and crowned males as the dominant drivers of change.

The main trouble with this neat binomial classification is

that it is wrong. Just ask the lioness. Her flagrant promiscuity is now understood to be a means of confusing paternity and protecting her offspring against the threat of infanticide by incoming males. This strategic sexuality was first discovered in langur monkeys by the primatologist Sarah Blaffer Hrdy in the 1970s, and has now been documented in dozens of species.

Hrdy leads a growing army of scientists keen to look beyond such misogynistic myopia and recognise the female of the species as just as promiscuous, aggressive, competitive and varied as the male. But what is shocking is how

stubborn the stain of Victorian sexism is proving to be, and how far it has spread.

When Patricia Gowaty began doing DNA paternity tests on songbird eggs in 1984, she discovered that each nest frequently contained multiple fathers, despite the apparent monogamy of their parents.

Members of the male ornithological establishment responded by insisting the females had been "raped". But radio trackers subsequently revealed females actively seeking sex with neighbouring cocks. Since then, a polyandry revolution has revealed that multiple mating is the norm for females, from lions to lizards. The reason is quite obvious: don't put all your eggs in one basket – greater genetic diversity means healthier offspring.

Gowaty, like me, has never tried to hide her politics. She believes in equal representation of both sexes. But, as Darwin's Victorian values show us, science is always political. A feminist perspective is urgently needed to topple centuries of androcentrism and rebrand female sexual agency, in lionesses or songbirds, from unexpected to a winning maternal strategy. ■



Lucy Cooke's new book is *Bitch: A revolutionary guide to sex, evolution & the female animal* @mslucycooke

#brainbooster

To err is fruitful Making deliberate mistakes is a surprising but effective way to improve your performance in many unexpected areas of life, writes **David Robson**



David Robson is the author of *The Expectation Effect: How your mindset can transform your life*. You can follow him on Twitter @d_a_robson

A man of genius makes no mistakes,” James Joyce wrote 100 years ago. “His errors are volitional and portals to discovery.”

Most people with good sense would accept that we can and should learn from accidental failures. It would be impossible to progress in anything, after all, without taking the odd misstep, and by understanding how we tripped up, we can avoid stumbling in the future.

Few would advocate making intentional mistakes, however. Yet a pair of fascinating new studies have shown that this may be the best way to learn new information. Consciously blundering, even when you know better, can promote deeper understanding and better recall, so you are better able to apply your knowledge later on. The phenomenon is known as the derring effect – derived from “deliberate erring” – and when applied astutely, it may bring benefits in many unexpected areas of life.

The discovery joins a small but growing body of literature on the ways that enforced failure can be a fast track to later success. In the late 2000s, for example, a group of researchers in the US asked participants to learn a series of facts from Oliver Sacks’s book *An Anthropologist on Mars*. Some of the participants were given a full 10 minutes to read the text; others had to spend the first couple of minutes taking a “pretest” on the knowledge to be learned, before they read the text.

As you would expect, their answers on the pretest were mostly wrong. But the initial errors had somehow primed the participants to remember the correct answers during their subsequent study, boosting their recall on the final test by about

a third, compared with those who hadn’t taken the pretest.

Sarah Shi Hui Wong and Stephen Wee Hun Lim at the National University of Singapore have now taken this idea one step further, by asking people to make deliberate errors when they already know the right answer. In one experiment, participants were tasked with learning concepts from a popular textbook on neuroscience. For some terms, they simply copied out the correct definition; for others, they were asked to first insert an error in their description of the term (such as giving the opposite

“This memory boost is far superior to other learning strategies that have previously proven to be effective”

meaning) before correcting the mistake.

Intuitively, you would expect the insertion of the errors to have added unwanted confusion – the last thing you want right before an exam. Yet the exact opposite was true: the participants who made deliberate errors learned about twice as much as the people who simply copied out the correct definitions.

Subsequent experiments revealed that this memory boost was far superior to that of other learning strategies that have previously proven to be effective. Making up a mistake generated stronger memories than finding a concrete example to accompany each definition, for example. Wong and Lim have also shown that deliberately erring improves knowledge transfer, so that we can apply what we have learned in new and novel situations.

Given these promising results, I couldn’t help wondering whether the derring effect could be applied across other disciplines, so I asked Wong for her thoughts. As a pianist and violinist, she is particularly interested to see if it could help music tuition. Not only might the insertion of deliberate errors help a student remember the right sequences, she suspects that such a playful approach could fuel their creativity for improvisation and composition, if the student looks for ways to resolve and develop those wrong notes into something more attractive. “It is empowering to discover that by intentionally embracing our errors and wisely placing ourselves in the way of being wrong, we can in fact overcome weaknesses and rise stronger,” she says.

It is easy to imagine how the derring effect could be useful for many other challenges too. If you enjoy cooking, for example, you may religiously follow a recipe without even questioning the reasons for the instructions. But why not try to break away from those habits and deliberately do the “wrong” thing for a change, and see where your deliberate erring takes you? If you are painting, meanwhile, you could relax one of the constraints that you usually put on your work and see what you produce.

At worst, you will have refreshed and deepened your knowledge of the rules you normally apply, so that you can be even more effective next time. At best, you may just find that you have discovered something completely new and unexpected, through a flash of inspiration that you would have missed with perfectionism. Either way, your apparent missteps will have moved you a little closer to true mastery. ■

David’s week

What I’m reading

The Conformist by Alberto Moravia, a suspenseful psychological drama about a fascist spy in Mussolini’s Italy.

What I’m watching

Most of my TV consumption is now dominated by the news cycle, I’m afraid.

What I’m working on

A feature exploring “expectation effects” – the influence of mindsets on our intimate relationships.

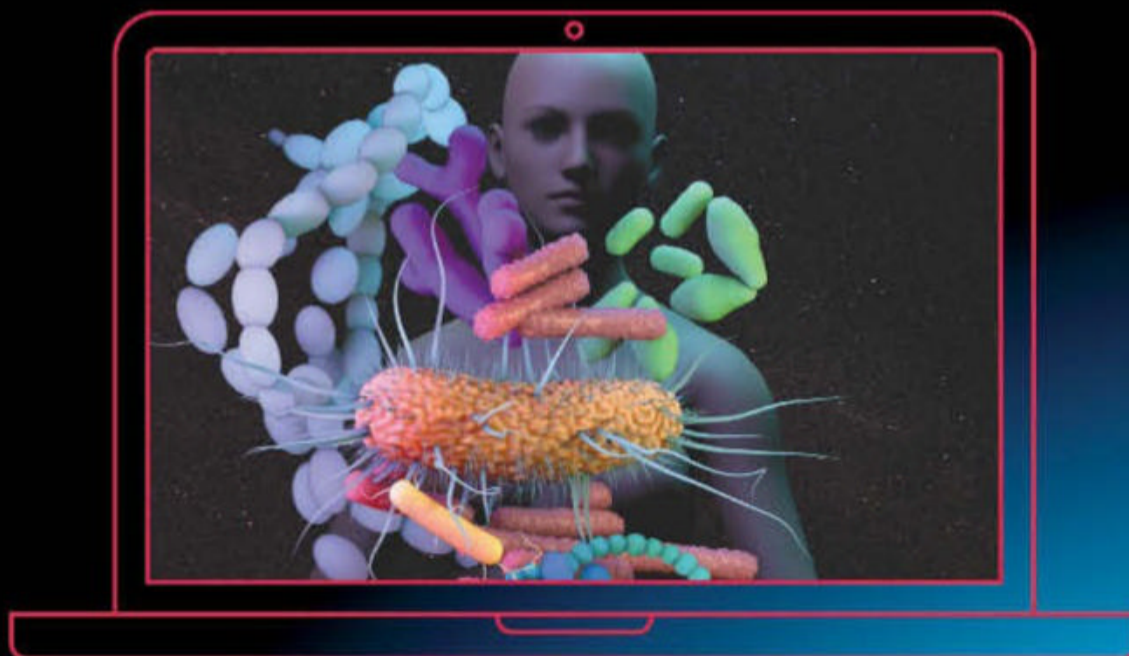
Up next week: Chanda Prescod-Weinstein

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Botany 101



Illustrator **Leonhart Fuchs**

THESE delicately detailed representations of medicinal plants are the work of Leonhart Fuchs, a 16th-century German physician and botanist commonly considered one of the founding figures of modern botany.

The images are taken from the book *Leonhart Fuchs: The New Herbal* by historian Werner Dressendörfer and published by Taschen. It is based on Fuchs's original catalogue of about 500 herbal plants and their properties.

Fuchs's work, *De Historia Stirpium*, released in 1543, was based on previous botanical knowledge and his own research. It is widely recognised for the accuracy and high quality of Fuchs's illustrations, a selection of which are shown here.

On the far left is garden balsam (*Impatiens balsamina*), a native of Asia historically used to treat skin ailments, such as burns (with the flowers) and warts (the leaves).

The remaining four images show (clockwise from top left): a variety of *Cucurbita pepo*, a group of vegetables high in antioxidants and other beneficial molecules. Other varieties are cultivated to produce crops including pumpkins and courgettes.

Next is a pasque flower (*Pulsatilla vulgaris*), which contains the medically active compound anemonin. Bottom right is mandrake (*Mandragora*), once used in Europe as a laxative, ointment and alleged aphrodisiac, among other applications.

Finally, there is *Arum maculatum*, also known as lords-and-ladies. The tubers of this have been used to create homeopathic tinctures to, supposedly, treat sore throats. Remember though, some of the plants listed can be toxic. ■

Gege Li



Editor's pick

We paved over paradise, now turn it over to trees

19 February, p 20

From Victoria Hiley, London, UK

The frequent discussions about converting land to forests in order to sequester carbon are missing something if they merely focus on using animal pasture to do so.

In the UK, large chunks of land sitting unproductively under concrete could be used for new woodlands: car parks, both public and private, and the wide spaces devoted to stationary cars in town centre streets. These huge areas are subsidised by all of us for the benefit of individual private car owners. It is undeniable that they cause flooding, habitat loss and carbon emissions, as well as creating grim, depressing urban environments and leading to the release of lifespan-reducing pollutants.

Extensive research dating back to the 1970s in countries like the Netherlands indicates that when people are given safe, pleasant alternatives to driving, they choose them. Doing so in the UK would cut demand for these spaces overall. It would also improve public health due to the cleaner air, the additional light exercise and the immense psychological benefits that living and working in an area filled with trees, rather than the current concrete hellscape, would provide.

Sitting up and taking notice of bad posture

19 February, p 42

From Chris Daniel,

Glan Conwy, Conwy, UK

Alison George makes some good points about the long-term effects of poor posture on the body. As she says, one problem is our increasingly sedentary lifestyle, slouched on settees or hunched over our computers.

But many of the problems are caused by poor furniture design. Sitting on a conventional chair results in the pelvis rocking

backwards, flattening the lumbar curvature of the spine and causing the trunk to collapse into an unhealthy C-shape. Correcting this takes muscular effort that can't be maintained without fatigue. Chairs can be improved by adding a sacral support to the backrest or designing them with forward-sloping or saddle-type seating, all of which help the pelvis to remain in a neutral or forward-tilted position, making it easier to sit with an upright posture.

Tilting the chair back slightly to reduce the effect of gravity on the trunk can also help. However, for most people, if it comes to a choice between comfort and good posture, comfort usually wins.

From David Hulme, Stockport, Greater Manchester, UK

I firmly believe that anxiety and stress lead to the inability to relax that can result in muscle and joint pain, not so-called bad posture. I have been an archer for 50 years, and the only shoulder and neck pain I experienced usually came from lack of practice, over-practice or bad technique and faulty shooting posture – always occurring the day after shooting, and easing off within 24 hours.

The only time I developed really debilitating neck and shoulder pain wasn't because of this, but in the aftermath of organising a county championship. It was a really stressful three-day period.

From Peter Sutton, Guildford, Surrey, UK

As someone who has suffered with chronic pain and repetitive strain in my 30s and 40s, I read "Are you sitting comfortably?" with great interest. However, can I question the usefulness of the main trial quoted in the article? This was done with 17 to 22-year-olds.

Surely such a young, fit and flexible population isn't the right one to use for studies on chronic pain and posture?

Vaccine success mustn't sideline smear tests

12 February, p 23

From Varun Goel, Cardiff, UK

As a sixth-form student, I was struck by your report that routine cervical swabs can also identify ovarian cancer and potentially also individuals at risk of developing this serious disease.

Due to the early success of the human papillomavirus (HPV) vaccine, there has been a fall in the incidence of cervical cancer. However, it is imperative that the long-term value of cervical screening is reinforced through education in the younger population in order to harness the wider benefits for current and future generations.

Perhaps some of that mining waste has a use

12 February, p 38

From Will Kemp, Wagait Beach, Northern Territory, Australia

I was interested to see mining waste included in the "lost" category in your chart of total resources entering the global economy. The 7.4 gigatonne figure presumably consists mostly of waste rock, or "overburden", excavated to allow access to the target ore. This isn't really lost in the sense that domestic rubbish is, as it has been moved from one place to another, leaving a hole and making a hill nearby.

Including mine waste in the "lost" category suggests an interesting question: could it be used rather than dumped? Due to the remote locations of many

mines, it might often cost more to move it than it is worth.

But "red mud" residue from bauxite (aluminium ore) mining does have a potential use. Because of its high pH, it could be used to neutralise acid drainage from the waste rock dumps of other mines.

Science has a broader imagination problem

26 February, p 25

From Trevor Jones,

Sheringham, Norfolk, UK

Regarding Hannah Cloke's look at the problems of communicating some vital science, I would say "failure of imagination" remains an issue more generally in Western science.

Philosopher Henri Bergson and psychiatrist Iain McGilchrist recognised two profoundly different ways of knowing: the method of analysis and the way of intuition. The first is about differentiation, classification, modus operandi, of getting things systematised, and gives rise to the sciences and society. The second is about integration, holism, empathy, of trying to get to the essence of something, and gives rise to the arts and culture.

Schools, universities and other institutions should embrace these two perspectives, not letting logic subjugate imagination, creating a bias against creation and the birth of new ideas.

On the global issue of rising waters

26 February, p 44

From Eric Kvaalen,

Les Essarts-le-Roi, France

Claims by climate scientists that a 5-metre rise in sea level by 2150 would be "an unimaginable disaster" seem an exaggeration. *The Day After Tomorrow* managed to imagine something far worse. And I don't see why sea level rise should cause a "massive refugee crisis" either. We are talking about a process that takes generations, giving time to prepare. ■



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Signal Boost

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



The 20-year-long Whim Bog experiment in the Scottish Borders studies how peatlands respond to nitrogen pollution

Help preserve long-term studies that address environmental change

The Ecological Continuity Trust (ECT) is a unique ecological charity committed to using evidence from long-term experiments to benefit the environment, science and society.

The ECT works to preserve and maintain long-term ecological experiments so future generations have the resources needed to sustainably manage ecosystems in the face of environmental change.

Long-term experiments (LTEs) are experiments that have been running outdoors in real-world settings for many years. The UK hosts the world's longest-running ecological field experiment, the Park Grass experiment in Hertfordshire which has been in progress for 165 years. Several others have been running for 40 years and more. These are true

experiments, manipulating environmental variables in a fully controlled and replicated manner. They are important because they are the only way to detect slow-acting impacts on the environment. Short-term trends can be misleading, and sometimes the reverse of the true "bigger picture" story. LTEs also enable us to identify mechanisms of environmental change and measure the consequences. The evidence they provide can then be placed at the heart of policymaking to ensure the best environmentally sustainable outcomes, which can then benefit society.

ECT maintains a national register of almost 40 currently-active LTEs across the UK. We support these experiments by providing small grants and other services to ensure their

continuity. We also maintain a network of key stakeholders that advocate for LTEs and the science they produce, and we communicate findings to policymakers and the wider public. Our vision now is to enhance our network of LTEs with long-term monitoring studies to help add scale and context.

Want to help?

ECT is a unique charity with limited resources. Donate to the ECT today, and help ensure that the nation's LTE resource continues to produce valuable evidence and data that can be used for ecological action. In turn this can help society address environmental change. Donate by going to: www.ecologicalcontinuitytrust.org/donate

Birds of a feather

It may seem as if we have little in common, but humans are more like avians than you think, says **Simon Ings**



Book

The Parrot in the Mirror: How evolving to be like birds made us human

Antone Martinho-Truswell
Oxford University Press

EVOLUTION has created a living world of jaw-dropping diversity. It has also generated what seem like astonishing coincidences. The pangolins of Africa and armadillos of South America, for instance, look like close cousins. In fact, each is more closely related to humans than to each other. Their similarity arises because they independently evolved near-identical strategies to cope with the same kind of environmental challenges.

This is just one example of what is known as convergent evolution, but there are many others, and not all of them are so easy to spot. Take humans and birds: few readers will be immediately won over by Sydney-based zoologist Antone Martinho-Truswell's claims that we are "like a strangely featherless bird", and that we have more in common with birds than with our mammalian cousins.

By the time I finished *The Parrot in the Mirror*, though, I found that idea both compelling and reasonable. Martinho-Truswell explores the traits shared by humans and birds, from our unusual longevity to our advanced social skills, from our parenting styles to our intelligence and even the use of language. These, he argues, are all examples of convergent evolution.

Briefly, his argument goes like this: once birds could fly, they could elude almost all predators. Since they were now less likely to be eaten in any given year, they could live longer and produce more offspring. With longevity

came the opportunity and the need to develop increased intelligence. It is an advantage for long-living animals to be smart because it helps them to survive long enough to raise their young to adulthood. What's more, because longer development requires a bigger egg and a bigger yolk sac, and because an egg can only get so big if its mother is to fly, most birds hatch out very immature, helpless young. Chicks require enormous amounts of care, often provided by pair-bonded parents, and sometimes supplemented by a larger community. This favours the evolution of complex social behaviour and communication.

Martinho-Truswell argues that the human evolutionary story is a warped mirror image of this. Our story begins, not with flight, but with communal behaviour among

primates, which promoted the evolution of intelligence and social behaviour. This reduced the likelihood of predation, and longevity followed, boosting intelligence to the point where big-brained human young have to be born immature and helpless

“Humans and birds evolved intelligence in response to similar challenges. But how do we compare abilities?”

so as not to endanger their mothers' lives during childbirth.

So, the argument goes, humans and birds evolved measurable intelligence in response to similar challenges. But how do we compare our abilities?

In this regard, Martinho-

Truswell does well to strike a balance between precision and imagination. On the one hand, a duckling's ability to identify its mother shortly after the moment of its birth puts it well ahead of chimpanzees, parrots, pigeons, crows and even human children. But this one hardwired ability doesn't necessarily make the duckling more intelligent.

On the other hand, it would be a dull observer indeed that didn't see quite staggering evidence of advanced cognition in Irene Pepperberg's 30-year study of language use in Alex, an African grey parrot. The bird not only answered questions, he asked them, too. And he got annoyed if people gave him silly answers.

Containing the complexities of convergent evolution in a straightforward narrative isn't easy. Evolutionary causes and effects don't follow each other in neat, storybook fashion, and there is always the temptation, reading this book, to take Martinho-Truswell's acts of narrative shorthand at face value and suppose that humans, 50 million years behind parrots in the evolution of intelligence, somehow became more human by actually mimicking their distant avian cousins.

Clearly that isn't the case. But perhaps it is better to be slightly misled by a gripping story than to be bludgeoned by a dull one. Martinho-Truswell has written a superb introduction to a surprisingly complex field of study. Having read it, you won't look at yourself in the mirror in quite the same way. ■

Simon Ings is a writer based in London



VEERA/SHUTTERSTOCK

Size and colour aside, we are a lot like our feathered friends

Total recall

An emotional tale of a man's reprieve from dementia explores what we forget and why, finds **Jon O'Brien**



TV
The Last Days of Ptolemy Grey
Walter Mosley
Apple TV+

"I GOT to set things right," says Ptolemy Grey, Samuel L. Jackson's latest screen incarnation. He talks into a tape recorder while loading a bullet intended for the man banging on his apartment door. "That motherfucker got to pay for what he's done." *The Last Days of Ptolemy Grey's* opening scene could have been lifted from a belated *Pulp Fiction* spin-off, revisiting Jackson's foul-mouthed, fast-food-obsessed, gun-toting hitman Jules Winnfield nearly three decades on.

Then the action flashes back to just two months earlier. Now we see Ptolemy as a dishevelled, confused 93-year-old living on tinned sausages and beans in a cockroach-infested flat. Regular visits from his kindly great-nephew Reggie (Omar Benson Miller) are his only respite.

This six-part drama, adapted by Walter Mosley from his 2010 novel of the same name, begins by painting a heartbreakingly convincing picture of a man with dementia. His mundane daily routines are interspersed with visions of his beloved late wife and often horrifying flashbacks from his childhood in the Deep South.

The story takes a turn for the fantastical when Ptolemy discovers he is eligible for a new drug trial that will restore his memories in crystal-clear detail. The catch is that it is a temporary fix and will worsen his condition in the long run.

Despite this obvious drawback, Ptolemy jumps at the chance to sign up, having discovered that what he thought was a birthday party was actually Reggie's funeral. He needs his mind back to find out who is



HOPPERSTONE/APPLE TV+

Ptolemy Grey (Samuel L. Jackson) has advanced dementia, but a new drug changes everything

responsible for Reggie's death.

It is an intriguing set-up, but one that Mosley fails to capitalise on. Ptolemy's amateur sleuthing isn't engaging, and the culprit is eventually revealed so casually that it barely registers. A gripping whodunnit this isn't, perhaps surprisingly considering that Mosley built his reputation on his novels about the hard-boiled detective Easy Rawlins.

The series works much better as a meditation on memories, consciousness and the passing of time. Ptolemy enjoys learning how things like hip-hop and the internet have progressed during his cognitive decline.

But as he tells Dr. Rubin (Walton Goggins), who is running the drug trial, some things are forgotten for a reason. Remembering elements of his traumatic childhood under racial segregation solves a few mysteries, but also increases his night terrors. And as Ptolemy gets closer to the truth about his great-nephew, he finds it harder to control the reactions that would have stayed buried with his memories.

Jackson, giving his first on-screen lead performance in TV's new golden age, appears to relish flexing his acting muscles a little harder than he has of late. Through some impressive ageing and de-ageing make-up, he gets to portray Ptolemy across a half-century of his life, giving his character's shifts between degeneration and regeneration an emotional resonance that has been lacking in some of his recent big-screen work.

Fresh from her BAFTA-nominated role in *Judas and the Black Messiah*, Dominique Fishback also impresses as teenage orphan Robyn, the only other member of Ptolemy's circle who sees him as a person rather than an inconvenience. Their touching, platonic relationship is far more engaging than any of the several romantic subplots.

But even this strong central pairing isn't quite enough to compensate for an unfocused and underwhelming narrative. Ironically, for a drama about the power of memory, *The Last Days of Ptolemy Grey* is unlikely to leave a lasting impression. ■

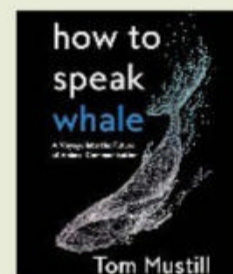
Jon O'Brien is a writer based in Merseyside, UK

Don't miss



Visit

True Crime meets research at this *New Scientist* event featuring writer Val McDermid, psychologist Mark Freestone and forensic investigator Niamh Nic Daeid. At London's Conway Hall from 6.30pm on 16 March.



Read

How to Speak Whale

is a question that has intrigued humans for centuries. Now that AI is helping us decode animal languages, conversations with whales may be possible, says naturalist Tom Mustill. But what will they have to say?



Visit

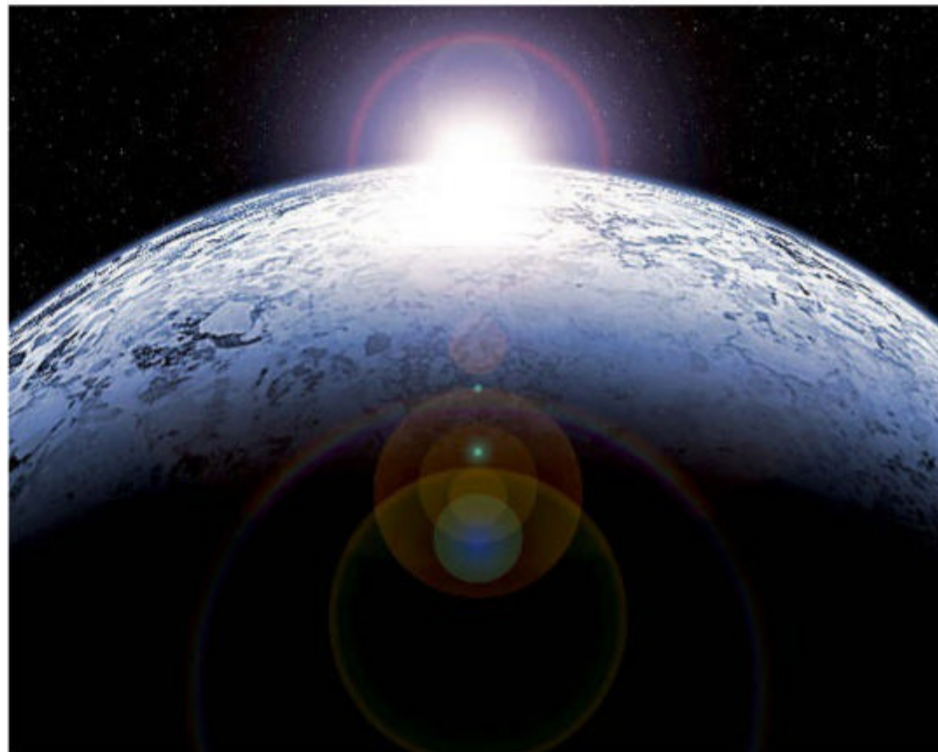
Into the Abyss go ocean explorers Don Walsh, Victor Vescovo and Patrick Lahey, who will share their submarine adventures and vision of the future of oceanic exploration at London's Royal Institution on 14 March at 7pm.

The sci-fi column

Prisoners of geography Three new science-fiction books grapple with the strangeness of uncharted terrain and ponder whether people make maps to guide the way or to hide the truth, finds **Sally Adee**



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



SHUTTERSTOCK/VIKAS31

Pluto is inhospitable to humans in more ways than one in *Plutoshine*

Pluto into a habitable water world for humans. This requires some suspension of disbelief given that the ambient temperature is -240°C , methanol and nitrogen freeze solid and it isn't easy to pick out the sun in the murky "daytime" sky.

It is undeniably science fiction, but there is a heavy emphasis on science. From astrophysics to cosmochemistry, there is a lot to learn, including about the various isotopes of hydrogen.

Science lessons aside, *Plutoshine* is worth the admission fee for the fantastical depictions of Pluto alone, with its jewelled ice slopes in a rainbow of different colours of frozen elements. And also for the point at which it transpires that mapping technology missed what is hiding under all that ice.

What drives us to map such wild, uncharted terrain at all is the central question of *Sweep of Stars*, Maurice Broaddus's beautiful new Afrofuturist vision. In Broaddus's world, space exploration is driven not by the whims of billionaires, but by people who have been pushed to create empires where others fear to tread. The Muungano Empire is the diaspora of Black people on Earth who fled to escape their oppressors. The elders must chart their expansion while keeping their peoples' histories alive. Not easy, when they are pursued by their enemies, who spout the eerily-familiar motto: "Earth first". Broaddus's characters are as captivating as those in *Game of Thrones*, and the story is as big as Isaac Asimov's *Foundation* series.

All three books provide a timely reminder not only to look more closely at maps, but to question who created them and why. ■



Books

The Cartographers
Peng Shepherd
Orion Books (17 March)

Plutoshine
Lucy Kissick
Gollancz (17 March)

Sweep of Stars
Maurice Broaddus
Tor Books (29 March)

Sally also recommends...

Book
Until the Last of Me
Sylvain Neuvel

Michael Joseph
Book two of the Take Them to the Stars series, about an ancient matrilineal society whose goal is to get humanity into space. Catch up by reading the previous book, *A History of What Comes Next*, which takes place in an alternative version of the 1960s space race.

MAPS can seem such dry, factual objects: blueprints of reality that are useful to get from A to B, but instantly forgettable when you get there. Three new science-fiction books, released this month, challenge this view, showing that maps are more than the objective depictions we take them to be.

In *The Cartographers*, Peng Shepherd's latest work of magical realist speculative fiction, the characters have a habit of asking "what makes a map?". The answer, it becomes clear, is its purpose. From political maps to resource maps and road maps, the main purpose of cartography is to create a shared version of reality: one that suits the map-maker's ideals.

Shepherd's protagonist, a young cartographer named Nell, finds this out to her cost when she inherits a mysterious map after the death of her estranged father. The power of maps to make visible what the map-makers want you to see, and to hide what they would rather you didn't, is revealed when Nell discovers a shady cartel that has killed a lot of people to keep this particular map secret.

First and foremost, *The Cartographers* is a love letter to maps and the secrets they hide. It is also a Luddite's cri du coeur against Google and other tech giants, whose maps are stripped of cultural and historical perspective.

As speculative fiction, it works well, but the book also drifts into vignettes about dramas between

"If maps shape our expectations of reality, what happens when reality contradicts those expectations?"

student cartographers in an academic hothouse that recall scenes from Donna Tartt's *The Secret History*. The book ultimately sags under the weight of so many competing ambitions, but overall, the plot is strong enough to carry you through to the end.

If maps shape our expectations of reality, what happens when reality contradicts those expectations? Lucy Kissick explores this in *Plutoshine*, which follows the quest to terraform

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New Scientist feature editor
and author of *The Art of
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Leah Crane

New Scientist space and
physics reporter

Joshua Howgego

New Scientist feature editor

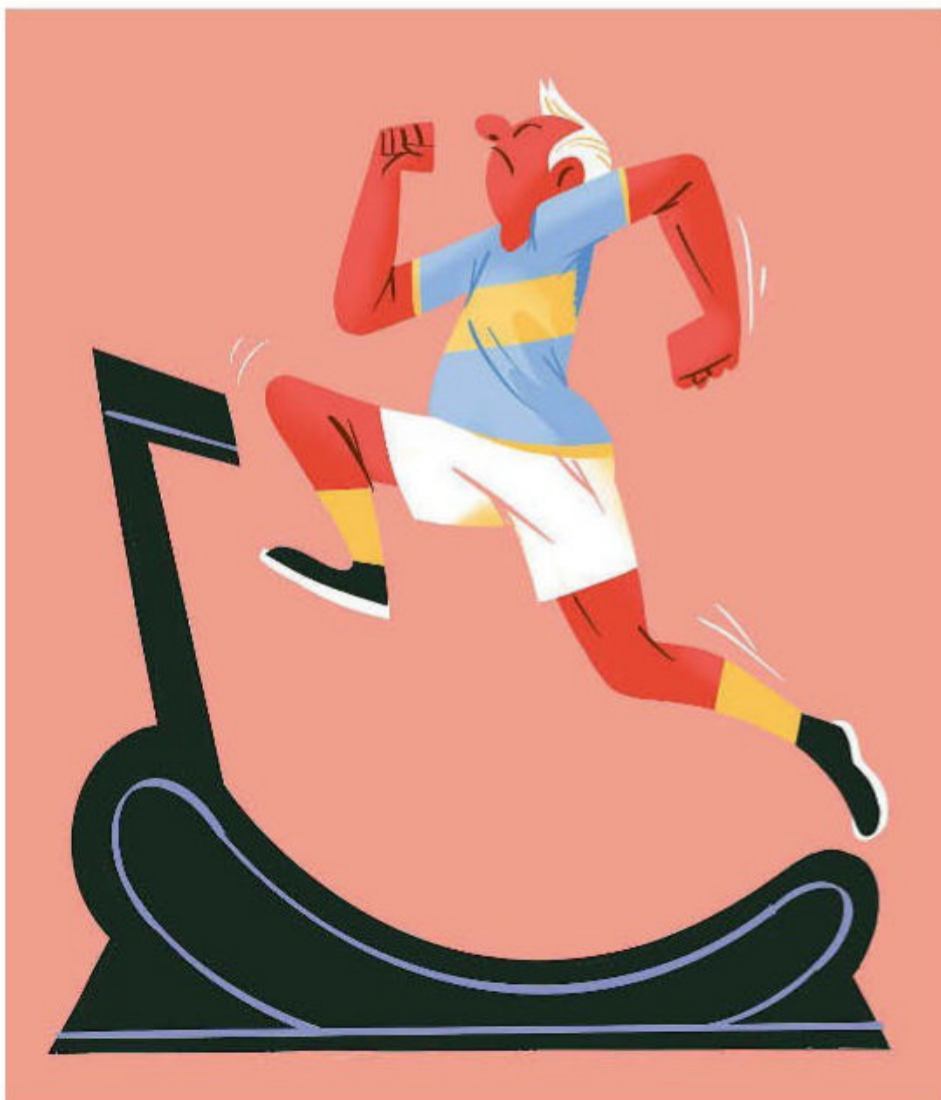
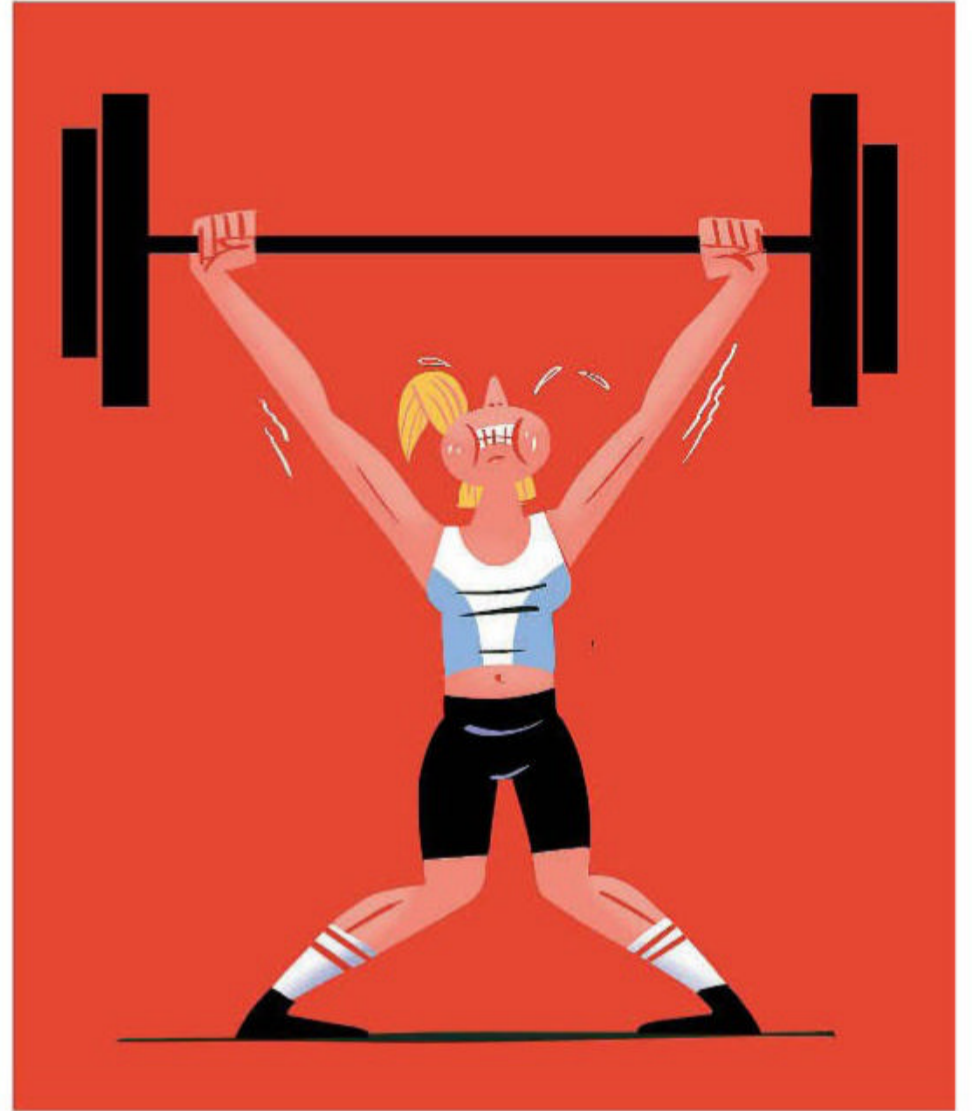
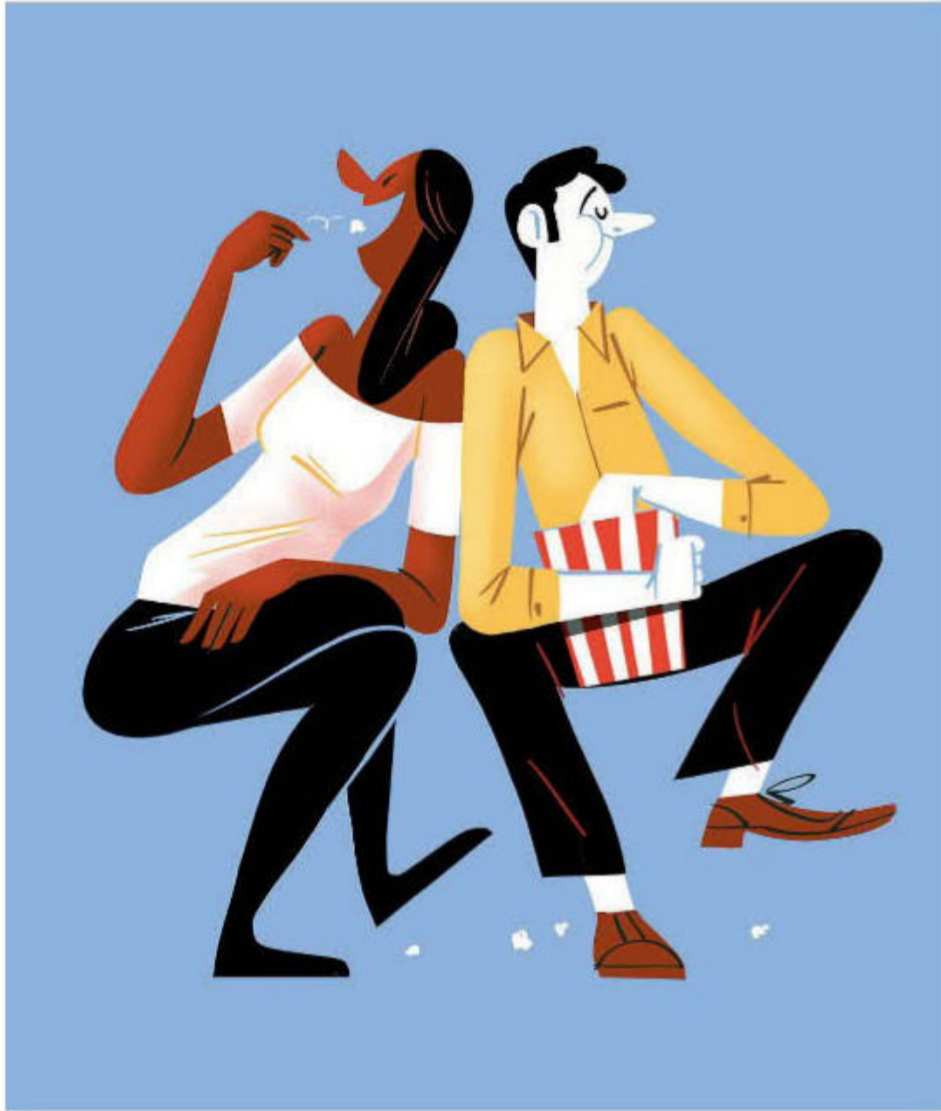
Richard Webb

Host, *New Scientist*
executive editor

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Features Cover story



ANTONIO SORTINO

Battle of the mid-life bulge

It is a myth that extra belly fat in middle age is due to a slowing metabolism. So what does cause the dreaded spread and what can we do about it, asks **Sara Novak**

FEW of life's milestones are as unappealing and unceremonious as arrival in middle age. Our skin becomes noticeably looser, grey hairs more numerous and, of course, our clothes typically start to feel a bit tighter – especially around the waist.

The last of these is known as middle-aged spread, the commonly accepted idea that we start to pack on the pounds around the abdomen as we get older. This excess weight is said to be easy to put on and harder to shift than when we were younger, the thinking being that our once-perky metabolism gets sluggish with age. We can no longer get away with as much, and our efforts to ditch the belly with diet or exercise become a losing battle.

So far, so miserable. But then, last July, a study of over 6000 people around the world blew the idea out of the water. It showed that metabolism stays remarkably stable as we age, at least until our 60s. "The amount of calories you burn per day from age 20 to 60 remains about the same," says Herman Pontzer at Duke University in North Carolina. "We've shown that you have much less control over metabolism than we thought." The idea that your metabolism is just as active as you approach your 60s as it was in your 20s should be welcome news for anyone nearing middle age – usually defined as the period from 45 to 65 years of age – and facing the dreaded spread. But it leaves a burning question: if metabolism isn't to blame, then what is? And what can be done?

Middle-aged spread is more than just folklore. Studies consistently show an insidious uptick in body weight at this time of life, with most of us putting on the best part of a kilogram each year. For instance, one estimate of weight gain in people in the US

put that figure at between 0.5 and 1 kg per year between the ages of 21 and 55. A different study showed that women gain on average 0.7 kg per year between the ages of 40 and 60, regardless of their initial body size, race or ethnicity.

This is contributing to a major problem, of course. Over 300,000 people in the US die prematurely each year as a result of obesity-related diseases. That the weight gain is concentrated around the abdomen is particularly bad news. Increased abdominal fat is strongly correlated with high amounts of visceral fat, which surrounds the body's internal organs. This dangerous variety of fat

“Metabolism doesn't diminish – or increase – with age”

is made of particularly active cells that produce hormone-altering signals that disrupt the body's sensitivity to insulin. Visceral fat also pumps proteins called cytokines into the body, affecting the immune system and causing inflammation. All of this means that too much visceral fat greatly increases your risk of chronic conditions, such as type 2 diabetes, cardiovascular disease and cancer as well as heart attacks. Those with just 10 centimetres of extra belly fat, as measured by their waist circumference, have been shown to be at an 11 per cent higher risk of early death, and this

increased exponentially as waistlines grew.

All of this makes it imperative that we take middle-aged weight gain seriously and understand the causes in order to tackle it head-on. But one thing now seems clear: metabolism isn't to blame. According to Pontzer, metabolism doesn't change from age 20 to age 60 because the body is always working to keep itself within a narrow calorific range. His previous work has also shown that our bodies seem to adapt to exercise, burning similar amounts of calories whether we live very active lifestyles or not. It turns out that our bodies are well-oiled machines, perfectly honed for survival and designed to self-regulate the number of calories we burn every day. Metabolism doesn't diminish with age, but it doesn't increase either.

While metabolism remains a constant, middle age is a time when other things change, offering clues as to the cause of the weight gain. The most obvious shift is in hormones.

Women tend to have more subcutaneous adipose tissue, or general body fat, than men and it is usually distributed more evenly over the body, whereas men are more naturally prone to have visceral fat. During the female menopause, the amount of oestradiol, the main oestrogen steroid hormone, decreases at the same time that visceral fat increases. While this is often termed a "fat reshuffle", it is an inaccurate description, says endocrinologist Eve Bloomgarden at Northwestern University's Feinberg School of Medicine in Chicago. "It's not like fat that started at a woman's hips and thighs gets on the adipose bus and heads to the belly," she says.

Rather, fat becomes less pronounced in other parts of the body such as the hips and thighs at the same time as visceral fat begins ➤



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expanding. We are born with all the visceral fat cells we will ever have and genetics, along with lifestyle choices like sleep, diet and exercise, influences whether those cells expand into tiny balloons filled with cholesterol and lipids. The jury is still out as to why this switch occurs, but oestrogen probably plays an important role – it seems to inhibit the growth of visceral fat, but how remains elusive.

As well as directly influencing fat cells, a drop in oestrogen in middle age can also exacerbate other conditions that affect weight. Crucially, the drop in the hormone during the menopause, and the changes this brings, can have an impact on sleep. Hot flushes, for instance, can lead to serious insomnia. During the menopause, women are at higher risk of depression and anxiety, two conditions that also interfere with sleep, and medications for which can lead to weight gain.

You snooze, you lose

The impact of sleep problems on body weight shouldn't be underestimated, for both men and women. For a start, sleep loss affects our decision-making, and has been repeatedly shown to weaken resolve, leading to poor food choices and less exercise, both of which can result in weight gain.

This is compounded by the fact that not getting enough sleep has been associated with depleted stores of leptin, a hormone made in our fat cells that inhibits hunger and influences calorie regulation in the body. Simultaneously, a lack of sleep increases levels of ghrelin, also known as the hunger hormone. Poor sleep can interfere with other hormones that cause people to put on fat and lose muscle mass too.

On top of all this, sleep deprivation has been shown to trigger higher levels of endocannabinoids, lipids involved in signalling that turbocharge the satisfaction gained from food, a phenomenon that has been compared with the “marijuana munchies” – a term for hunger provoked by using cannabis.

As for the influence of sex hormones around middle age, men too are affected, although it isn't universal. A deficiency in testosterone, or “low-T”, occurs in upwards of 24 per cent of men over the age of 45, although estimates vary. It has a number of causes, from trauma or injury to alcohol misuse, renal failure, cancer, medication use, obesity, diabetes, obstructive sleep apnoea and plain ageing. Those who experience low-T are more likely to see a loss of muscle mass and bulk (see “Muscle vs fat”,



AKABERKALAMY

Blame your hormones?

Aside from hormone changes that happen naturally at middle age, there are some more extreme cases in which hormones can exert a strong influence on weight. Around 5 per cent of people experience hypothyroidism, which means the thyroid, a gland in the neck, is underactive. This condition can lead to weight gain. This is also true of Cushing's syndrome, a rare illness that causes the extreme overproduction of the stress hormone cortisol. This results in weight gain around your middle, but only when levels far exceed what is normal. Both conditions are easy to treat.

A lack of sleep can lead to the munchies and poor decision-making

opposite), which can lead to increases in fat accumulation around their middle. This is because low testosterone usually also means low oestrogen in men. While oestrogen is less abundant in men, it is still necessary and a drop can cause an increase in visceral fat, as it does for women.

Men generally also seem to consume more dietary fat than women, but testosterone appears to play a role in their visceral fat too. “This is an area of very active research,” says Bloomgarden. “We know that when testosterone is supplemented in men with low-T, muscle mass increases and fat accumulation decreases. But we're not sure why.” Low testosterone is easily treatable by taking testosterone supplements. But for men with normal levels of the hormone, any weight gain is unrelated, and they should refrain from trying to boost their testosterone. Taking these

supplements if you don't need them causes what doctors call a testosterone trap. The body stops making the hormone itself and coming off the supplements causes a noticeable dip in levels until natural production resumes. This can lead to depression, fat accumulation and further loss of muscle mass.

Hormones and other substances in our bodies, then, can play a part in mid-life visceral weight gain, but apart from a few exceptions (see "Blame your hormones?", opposite page), these chemical messengers don't directly cause us to gain fat, instead indirectly affecting our behaviour. "It's easier to say that it's a hormone thing because we can easily fix it, but that's not usually the case," says Bloomgarden.

Middle age brings with it another enemy of the waistline: stress. The hormone cortisol is produced when the body perceives a physical or mental threat. In those who are constantly stressed, the body makes too much of the stuff, which some research has shown can boost our appetite. Some people respond to stress by eating more, choosing unhealthy foods and making other lifestyle choices that lead to weight gain. And stress can cause insomnia, with all the problems that brings for weight.

Last year, David Almeida at Pennsylvania State University and his colleagues looked into the question of stress in middle age and were shocked to discover how stressed middle-aged people are compared with this age decades ago. Using a long-running survey, his team compared 1500 people in the US of all ages in the late 1990s with another group of the same size two decades later. During each day of the survey, participants were asked how many stressful events they had encountered as well as the positive or negative emotions associated with their experiences. While stress remained largely the same in the younger and older age groups as it had in the 1990s, those in middle age in the more recent cohort experienced a 50 per cent rise in daily negative emotions and two to three more daily stress factors.

Almeida isn't completely sure what is causing stress to skyrocket in this group, but has a few suggestions. Mid-lifers, he says, are often having to contend with taking care of children and parents at the same time. And because so many of us can access work from home, there is less separation between work and home life than in previous generations. "We're just being pulled in too many directions, which is having an impact on our overall health," say Almeida.

The causes of middle-age spread are clearly

Muscle vs fat

Metabolism stays fairly stable until 60 (see main article). Then what? First, muscle begins to fade. Lean muscle mass makes up half of the total body weight in young adults, but drops to a quarter by age 75. And because muscle burns more energy than fat, this transition causes metabolism to become sluggish. With a slower metabolism, fat starts to accumulate. Muscle loss is due to a host of age-related changes, but the main factors are a decrease in the body's ability to turn over and repair muscle tissue at the same time as we are decreasing physical exertion. This double blow is hard to counter and is one of the reasons why muscle-building weight training is recommended for older people.

Exercise like resistance training becomes more important as we age



MARIDAV/SHUTTERSTOCK

a complex interplay between biology, behaviour and environment. So if we aren't focusing on outrunning a slow metabolism, what should we be doing to stay trim? The place to start, says Bloomgarden, is one of the most overlooked and important aspects of weight loss. "I always tell my patients if you're not getting at least seven to eight hours of sleep per night, don't bother dieting," she says. "That's not a place where you can make healthy life choices."

Getting enough sleep starts with a good routine – simple things like going to bed at a regular time and avoiding using screens emitting blue light in the bedroom. For those who experience insomnia, it is better to try cognitive behavioural therapy, which has been shown to help target the underlying issue, rather than simply taking a sleeping pill.

Diet is second to sleep in staving off the spread. "The one thing we do know is that it's calories going in that are causing the weight gain, not calories going out, as we may have formerly thought," says Pontzer, though exercise is still important to health, he adds. During middle age, food consumption tends to be more inconsistent and unstable, leading to unhealthy dietary decisions. According to the American Psychological Association, 38 per cent of adults admit to having overeaten or eaten unhealthily because of stress in the past month. Bloomgarden suggests choosing fresh produce over processed foods, which can be packed with sugar, and taking note of calories in alcohol and other beverages.

Even if its impact on metabolism is limited, exercise is still important for weight maintenance and is the next step after sleep and diet. It has been shown to help lower the production of stress hormones, which in turn makes it easier to sleep and avoid stress eating. Exercise also helps to maintain muscle mass, which keeps us mobile as we age and improves metabolic health. So it might not be the weight-loss wonder we previously thought, but exercise is the ultimate health stabiliser.

The good news in all of this is that we aren't fighting a hardwired metabolic slowdown as we age, but that even in middle age, metabolism is on our side, meaning tackling the bulge is often within our control. At a time when stress is apparently the mortal enemy, this, at least, is one less thing to fret about. ■



Sara Novak is a freelance writer based in South Carolina

Evolution's urban hothouse

City life is increasingly driving the evolution of many species. What can we expect to emerge, asks **Rob Dunn**



BIORN GROTTING/LAMY

TO THE naturalist in me, the world is full of sorrows: extinctions, the deaths of ancient forests, fires and floods. But the evolutionary biologist in me is more sanguine. The process of evolution continues unabated. If anything, humans have caused it to speed up.

Look closely enough and you can see a new world evolving around us. Witness it in the London Underground, where, beside the rumbling trains, a new species of mosquito is in the midst of an evolutionary flowering. And it is far from alone.

For centuries, evolutionary processes were thought to happen at a glacial pace compared with the speed of daily experience. However, over the past decades we have come to realise that evolution can in fact occur very quickly, even within days, as the virus that causes covid-19 has demonstrated. As I argue in my book, *A Natural History of the Future*, this evolution is occurring disproportionately fast in our cities.

These urban landscapes might seem a far cry from the Galapagos Islands and the other wild places where the rules of evolution were first uncovered, but no amount of environmental tinkering or destruction by humans can rewrite the rules of nature. And by considering the laws of evolution, we can make predictions about the kinds of new species that will emerge via the radical biological change taking place, mostly unnoticed, right under our noses.

We might have anticipated this rapid urban evolution a long time ago thanks to one of the most robust and influential models of the natural world: the theory of island biogeography. This was devised by the mathematical ecologist Robert MacArthur and the big-thinking ant biologist E.O. Wilson to explain the dynamics of life on islands. Their 1967 book on this concept outlined how the closer an island is to a mainland, the more species will colonise it, and the bigger it is, the more species will be able to survive without going extinct.

Deep in this book was another less-noted idea: that the rate of evolution of new species should also be greater on bigger islands. This applies not only to true islands, but also to island-like habitats. A cornfield is an island relative to the sea of surrounding forest.

Pigeons, as well as crows, jays and owls, are thriving in the urban jungle

So is a lake. For face mites, your body is like an island. So is a city, and as the world's population grows, we are creating more of these vast islands of urbanisation. In these habitats, just like on oceanic islands, the rate of origin of new species should be highest in those that are big, or growing in area. We should be able to look at cities and see evolution in action. Recently, scientists have.

One of the ways that species evolve in cities is through isolation. Some members of a species become separated from their counterparts in other habitats and then diverge. This process has been the driver of the evolution of new species since our ancestors first formed large settlements, relying on stored foods in the early cities and proto-cities. Species such as house sparrows, house mice, granary weevils, grain moths and many others are the result of groups of animals that became isolated from their rural counterparts and diverged.

This process continues apace. New York's brown rats now have longer noses and smaller upper molar tooth rows than those from the 1890s, the latter possibly due to a softer, higher-quality diet. In the UK, urban living is changing fox populations (see "Fox and the city", page 44). And populations that become isolated in a particular city can evolve differently from those found in other cities.

When creatures that live alongside us, such as carpet beetles and certain spiders, arrived in a specific spot they were unlikely to move back. Once isolated, they began to evolve independently of the populations elsewhere, due to chance changes between generations, or natural selection thanks to the unique features of a particular place. The house mice, carpet beetles and rats in cities around the world are nearly all now evolving along divergent trajectories.

Uptown rats

This is even occurring within cities. Jason Munshi-South at Fordham University in New York and his colleagues have shown such divergence in brown rats. Their 2017 genetic analysis of rats in New York revealed two distinct clusters that differ genetically, but also probably in other ways that have yet to be discerned. Uptown Manhattan rats seem to avoid sex with the rats from downtown, separated by a geographic barrier, midtown, a mainly commercial district that lacks the household

"RADICAL BIOLOGICAL CHANGE IS TAKING PLACE RIGHT UNDER OUR NOSES"



trash and backyards that rats thrive on.

Meanwhile, Elizabeth Carlen, now at Washington University in St Louis, Missouri, has found that pigeons in different cities in the US are also diverging from each other genetically. It is likely that the lice that live on the birds are diverging more so than their hosts, and the louse-dependent bacteria species even more than the lice, because species with shorter generation times evolve at a faster pace.

It isn't just blind chance that governs which of these species is likely to diversify and eventually give rise to new species. There are rules at play. Charles Darwin noted that populations will tend to diverge if their "tendency to modification" isn't "checked by intercrossing" with species from other regions. He was right. What's more, such intercrossing – what we now call gene flow – is more likely for species that readily disperse, whether on the wing, by catching a ride (be it on a bird, inside a louse or with humans on a plane, train, boat or automobile) or even by running, than for those that don't.

On oceanic islands, the dispersal ability of a species is the key determinant of whether it is likely to diversify, and evolve into new species. On the Galapagos Islands, the finches, which tend to fly only short distances, have remained genetically isolated from mainland kin and so diverged from their ancestors, with each finch species or subspecies now possessing unique attributes, behaviours and, especially, beaks. So too the mockingbirds.

But the blue-footed booby, and other seabirds with a proclivity for long-distance ➤

Fox and the city

flight, haven't. Their greater dispersal ability means genetic mixing with other populations is still at work, constraining the diversification of specific populations.

On remote islands, biological features of organisms determine their ability to move. In cities, human behaviour is a big factor in who moves and who doesn't. Tighter control of ship hygiene (and hence the ability of rodents to catch a ride), for instance, is probably responsible for the modern divergence of rat lineages among and within cities. Conversely, research on which I collaborate has shown that at least one kind of face mite, a lineage of *Demodex folliculorum*, appears to have sufficient movement on us as we ride cars, planes and boats, to maintain gene flow from Mexico to Australia to New York and beyond, so avoiding localised divergence.

It is in the context of the concepts of island area and gene flow that the story of the London underground mosquito has begun to be pieced together. The presence of these subterranean insects came to light during the second world war, when thousands of people took shelter in underground stations during bombing raids, and they would come to be called *Culex pipiens* f. *molestus*, a form of the species *Culex pipiens*, the common house mosquito.

The above-ground *C. pipiens* mosquitoes are seasonal, active in the warmer months, require a meal of blood before they can lay eggs and tend to feed on birds. In contrast, the subterranean form is active year round, the females tend to feed on mammals and can lay eggs without first ingesting blood.

Could this be an example of speciation in response to city living? A clue comes from the fact mosquitoes that look very much like the *molestus* form are found in the subways, sewers and even flooded basements of cities as far flung as Paris, Minsk in Belarus, Mailuu-suu in Kyrgyzstan, Tokyo and New York.

Recent genetic studies indicate that the *molestus* form probably began its divergence from *C. pipiens* in the ancient cities of the Fertile Crescent, a region of the Middle East. It was here that many urban species originally found their footing. Then, as they dispersed northwards, *molestus* mosquitoes persisted even in regions with cold winters by taking advantage of the heat trapped below cities.

Other studies by Dana Price and Dina Fonseca at Rutgers University in New Jersey suggest that as the *molestus* mosquito

Over the past century, foxes have taken up residence in many UK cities. Thanks to the abundance of food waste from humans, the home ranges of these animals can be tiny, just 0.4 square kilometres compared with 30 sq km for their rural cousins.

But that isn't all; the bones of urban foxes are evolving relative to those of their bucolic brethren. A 2020 study by Kevin Parsons at the University of Glasgow, UK, and his colleagues found that city foxes have shorter, wider snouts than ones that live in the countryside, and the part of their skull that encases their brain is smaller.

These anatomical changes match those seen during domestication – in dogs, for example – leading the researchers to conclude that urban foxes may be self-domesticating in our midst.

City foxes appear to be self-domesticating in response to urban living



colonised the underworld it evolved new versions of genes associated with odour recognition, digestion and immunity, all of which seem to have enabled it to thrive in subterranean sewers rich with organic wastes.

Meanwhile, this mosquito continues to evolve and genetic studies indicate that various *molestus* populations have begun to diverge genetically from each other. For instance, when the *molestus* populations in the London Underground were studied in detail, Victoria Line *molestus* were genetically distinct from those in the Bakerloo Line.

We could be heading for a future in which each line of the Underground has its own mosquito species. However, this divergence isn't seen in the above-ground *C. pipiens* mosquitoes, which more readily disperse.

Future paths

What can fast-evolving city rats and mosquitoes tell us about future urban evolution and the kind of new species we can expect to see? Although the precise consequences of evolution can be idiosyncratic – it would be hard to have predicted the existence of Komodo dragons or fungus-farming ants, for instance – the broad strokes of evolutionary change are predictable, reflecting nature's general rules.

Mammals tend to evolve bigger bodies in cold climates; we should expect the same for urban species, with fat-bodied rats in the far north and mouse-like rats around the equator. This is likely to already be occurring, unnoticed. On islands, species often lose the ability to fly and disperse (for example, flightless cormorants in the Galapagos); it is better to stay near home than to fly off in search of land that might not exist. The same has already begun to occur in cities. The seeds of hawkbeard plants growing in beds around trees in the city of Montpellier, France, produce smaller wings for their seeds than their rural relatives. Granary weevils have entirely lost their wings and blackbirds in some cities have ceased migrating.

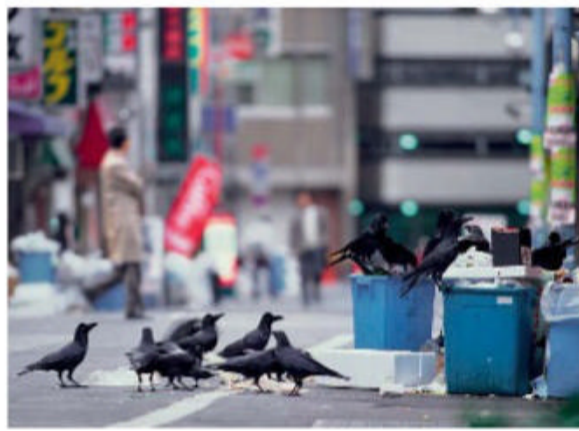
On islands, species also often evolve the ability to reproduce without mating. This is because species often arrive alone, and under these conditions, it is beneficial to be able to produce offspring without a mate. So the subset of arrivals with the genes to reproduce without a mate are more likely to thrive.



ORJANELLINGVAG/ALAMY



IMAGEBROKER/HEINZ KRIMMER/ALAMY



NATURE PRODUCTION/NATUREPL.COM

In cities, this has also happened for some Surinam roaches, American cockroaches and crazy ants – so called because of the jerky, unpredictable way they move.

Species also evolve traits that reflect available foods. Populations of urban house sparrows in Arizona have larger, stronger bills to deal with the tougher seeds found in the city, which in turn affects their songs. But more often, the change relates to the food provided by humans. House mice and dogs have evolved the ability to produce extra amylase in their mouths to break down starch, as carbohydrates are a significant part of urban diets.

Another way to cope with the demands of city living is to use brainpower. Rooks, for example, have learned to use bin liners as a tool, working in pairs to pull a liner up from rubbish bins to get hold of the food within. Already, a disproportionate number of the species that thrive in cities are those with inventive intelligence, such as rooks, crows, owls, ravens, jays and, in the tropics, parrots – as demonstrated by Ferran Sayol, now at University College London, who investigated the brain size (a marker of intelligence) in 629 bird species in 29 cities.

Rats and mosquitoes are evolving new traits because of city life, whereas the intelligence of urban crows gives them the upper hand

“CITIES FAVOUR SPECIES WITH EVER BIGGER, MORE INVENTIVE BRAINS”

Looking to the future, we should expect cities to favour species with ever bigger, more inventive brains, but this isn't the only way to thrive in the urban world. Sayol's research also shows that species with small brains, such as pigeons and swifts, can be very successful in urban environments by having large numbers of chicks, many of which don't survive. Conditions are variable in cities. One way to deal with that variability is to be smart and make different choices under different conditions. The other way is to produce lots of babies and hope a few, by chance, survive.

But the most predictable features of urban evolution (at least in the near future) aren't terribly glamorous. They relate not to the island-like attributes of cities, but instead to the dominant selective pressures – the factors that kill. In cities, humans are the key factor, most often through the use of chemical biocides. In response, German cockroaches living in buildings in which sugary roach baits are used have evolved a disinterest in the sugar; as a result they walk away unaffected by our baits. Meanwhile, bedbugs, houseflies, German cockroaches, house mosquitoes and many other species have evolved resistance to pesticides and, so, are harder to control.

This kind of evolutionary pressure can mean serious consequences for the spread of disease. For instance, urban populations of two species of malaria-carrying mosquito appear to be diverging from rural populations, potentially because of selection due to pesticides used on the city insects. It is a kind of evolution that isn't as visible as, say, changes in the beak of a finch, yet is still a measure of the awesome power of natural selection.

Cities have set the stage for an extraordinary evolutionary experiment that is unfolding all around us. Granted, the species involved tend to be ones that eat our waste or even our bodies, and their blossoming has come at the expense of the loss of thousands of species of birds, butterflies, mammals and bees due to habitat loss. Yet each is a manifestation of natural selection's ceaseless working, a reminder that, despite our assaults on Earth, the process of living goes on. ■



Rob Dunn is professor of ecology at North Carolina State University. His latest book is *A Natural History of the Future*

Life, the universe and everything

In a career spanning more than half a century, **Martin Rees** has contributed to some of our most intriguing theories about the universe and beyond. *New Scientist* met him at his home in Cambridge, UK, to look back at his scientific life and discuss everything from black holes to billionaires

AS ASTRONOMER Royal, you have to assume Martin Rees isn't in it for the money: £100 a year is the reward for advising the UK monarch on all matters astronomical.

It is just one of many hats Rees has worn, though – including president of both the Royal Astronomical Society and the Royal Society and, since 2005, as an appointed member of the UK's House of Lords. His work as a government adviser and public face of science has come on the back of an equally distinguished career in cosmology stretching back more than half a century, encompassing seminal research on the nature of the big bang and black holes, extreme phenomena throughout the cosmos, the search for life elsewhere in the universe and, latterly, humanity's own fate within it.



DAVID STOCK

Richard Webb: When you started out in cosmology, the idea that the universe began in a big bang wasn't even accepted science. How have things changed in the past half-century?

Martin Rees: Amazingly. When I started research in the mid-1960s, the [late] astronomer Fred Hoyle was still advocating the idea of a steady state universe that had existed from everlasting to everlasting. Evidence for the big bang theory was very weak. The debate was settled in most people's minds in 1964 when cosmic microwave background radiation was found – a relic of a hot, dense, early phase of the universe.

It was a good time to be starting research. Objects such as black holes and neutron stars were being found where Einstein's general relativity was important, not just a tiny correction as it is in our solar system. At the

same time, theorists like Roger Penrose were developing new techniques to solve Einstein's equations, which was a big leap forward.

Is the big bang theory set in stone now?

As in all of science, every advance opens up new questions. We can understand the physics of the universe right back to when it was a microsecond old. That's an amazing achievement. But why is the universe expanding the way it is? Why does it contain the mixture of atoms, radiation and dark matter that it does? And why did it have the kind of irregularities that resulted in it not remaining a uniform gas, but developing clusters of galaxies?

The answer to those questions lies before the first microsecond, when the entire universe was just the size of a tennis ball. As yet, we've got no experimental foothold on the very extreme physics involved.

Can we claim any sort of understanding when 95 per cent of the universe comes in forms we can't explain – that is to say, dark matter and dark energy?

Clearly, our knowledge is incomplete. We know dark matter behaves like neutral particles in a swarm that don't collide with each other. We notice about five times as much mass in that form as within atoms, and that allows us to get a good model of how galaxies form. What it is, we don't know. But it is easy to envisage particles we haven't discovered yet and that are harder to discover. There's no reason why everything in the universe should shine.

Dark energy is telling us something we don't understand about space itself. It's saying that the vacuum itself has properties: it exerts a force that causes the universe to accelerate when you'd expect it to be decelerating through gravity's pull. I think this is one of the big challenges related to the very, very early universe. With dark matter, I think there's a reasonable hope, within the next 20 years, of making progress. With dark energy, I think it will be much longer.

Meanwhile, cosmology is increasingly embracing outlandish concepts such as the multiverse. Do you subscribe to that idea?

The multiverse comes from the theory of inflation, the best theory we have to explain why the universe is as large and uniform as it is now. It implies that it started off small enough that quantum fluctuations could have shaped

the entire universe. One idea developed out of that, mainly by the cosmologist Andrei Linde, is eternal inflation, this idea that inflation might go on, producing many big bangs and many universes.

I was once at a panel discussion with Linde. Someone asked: would you bet your goldfish, your dog or your life on the multiverse? I said I was dealing with a dog level. Linde said he had spent 25 years on this theory, so he would almost bet his life. When asked his views at a later conference, [physics Nobel laureate] Steven Weinberg said he would happily bet Martin Rees's dog and Andrei Linde's life. But I think Andrei Linde, my dog and I will all be dead before it's settled.

One idea associated with the multiverse is the anthropic principle – that certain features of the universe are just so because if they were any different, we wouldn't exist to observe them. Isn't that a bit of a cop-out?

One of the theories that would explain what happened under the extreme conditions of the big bang – string theory – suggests that empty space, the vacuum, is not simple. It's got a microstructure, so there may be many different versions of it. Many big bangs might cool down in such a way that they ended up with a space with different conditions – a different strength of gravity or nuclear forces, a different mass of the electron. Only a subset of them would have had the properties that allowed life to emerge: for example, if gravity was very strong, objects as big as us couldn't exist without being crushed, so we need gravity to be important, but very weak. It's all speculative, but what it's saying is that reality is very complicated. There are many things we can't predict: the weather a month ahead, for example, because of chaos theory. What we now regard as universal laws prevailing throughout the observable universe may, in the grander perspective of the multiverse, be just parochial bylaws applying in our cosmic patch. I don't think you can call that a failure, just as you can't blame weather forecasters for not giving an exact weather forecast.

We have just seen the launch of the James Webb Space Telescope. What answers will it give us?

There are two important fields that it's going to illuminate. One is the very early stages of galaxy formation. About a half a million years after the big bang, the universe enters a literal dark age until the first stars form and light it ➤



up again. We'd like to know whether these first stars form already in galactic structures or separately.

The second is the search for life in the universe. One of the most exciting developments in the past two decades has been the realisation that our solar system isn't that special. If there were an Earth-like planet around one of the nearest stars, the Webb telescope might be able to take a crude spectrum of its light.

We might be able to use this to show evidence of life. It is probably just about the limit of what it can do. But if I look ahead 50 years, I would hope there will be large telescopes in space that will not merely detect light from extrasolar planets, but even a blurred picture revealing their surface features. It would be great if by 2068 – 100 years after the famous 'Earthrise' picture (see right) – we could display an image of another Earth.

Is not just life, but intelligent life, out there?

My view is that any intelligent life is unlikely to be a flesh-and-blood civilisation, but some exotic and possibly malfunctioning electronic entity. The timespan of our technological civilisation is just a few thousand years, and it could be less than another 1000 before it's usurped by electronic entities. That is a very thin sliver of time, not only compared with the three and a half billion years of Darwinian evolution, but also to the billions of years that lie ahead. If there were another planet in the galaxy that had evolved like ours, it would be most unlikely we would catch it in this sliver.

Why stop at electronic organisms?

I completely agree. Since we are not the culmination of intelligence, we've got to be mindful that there could be aspects of reality of which we are unaware, which our brains couldn't grasp. And so it could be that there is complexity and intelligence out there of a kind different from anything we can envisage.

Talking of lifespans, two decades ago, you put the probability of our own extinction by 2100 at about 50 per cent.

I've since refined the arguments. I think the chance of something wiping out every human is small. On the other hand, I think the chance of some serious global setback to civilisation is quite high. This century is special: it's the first in which one species has the power to

"Any intelligent life out there is unlikely to be a flesh-and-blood civilisation, but some exotic, electronic entity"

determine the future of life on Earth. Of course, we started saying things like that when nuclear weapons were developed. But they are expensive, they need special facilities to build and we can monitor them. Now we have bio and cyber weapons and genetic modification, for example "gain of function" experiments to make a virus more virulent or transmissible. Threats that can cause a serious setback to our interconnected civilisation can be created in labs, or even in someone's bedroom.

How should we be responding to these threats?

One thing we need is more resilience. Covid-19 has shown how dependent we are on networks: suppose the internet had failed during lockdown. We shouldn't depend on supply chains where a single link disrupts manufacturing, and we should keep a lot more slack in our hospitals.

But the ability of a few disaffected people to create a global catastrophe means we're also going to have to contend with a tension between three things we want to preserve: freedom, privacy and security. We may be forced to accept more intrusive surveillance

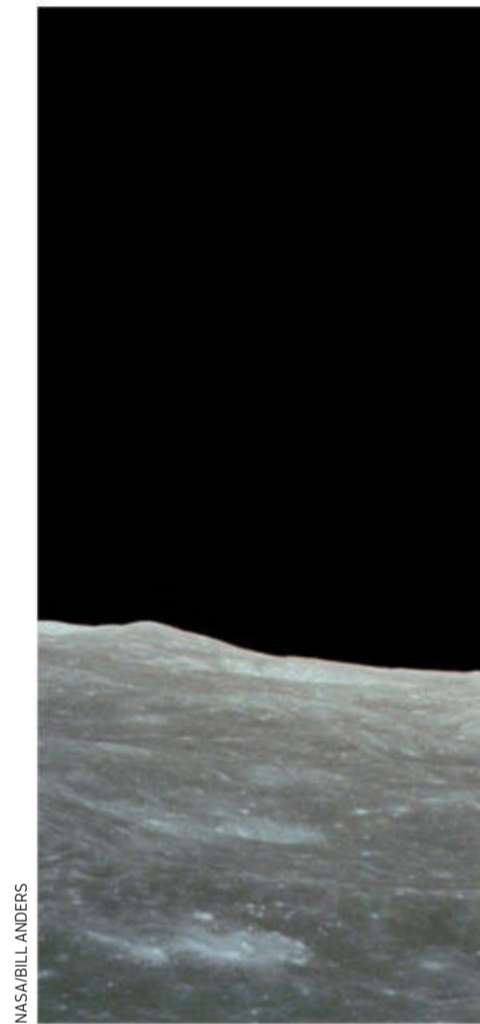
as the price we have to pay to minimise the risk of catastrophe.

Climate change and biodiversity loss represent a different form of existential threat that we are failing to tackle...

The problem is that when something sudden like covid-19 happens, politicians and the public are immediately aware that they must do something about it, whereas, with these slow-burners, we are rather like the frog in the pot of water that is being heated – not taking action until it is too late to escape.

Do you despair at our inability to think longer term?

There's a paradox that strikes me whenever I visit Ely Cathedral, an amazing building just a few miles away from where we are sitting. It was built by masons as a structure that wasn't to be finished in their lifetime, but which still inspires us 800 years later. We can't think long term like they did. I think the reason is that those masons thought their grandchildren would live similar lives to them. Now, however, the pace of technological change means we





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don't know enough about the preferences of people half a century in the future to be able to make confident plans. Although our horizons in space and time have hugely expanded, our capacity to do reliable long-term planning is less than it was in medieval times.

So meeting climate targets isn't enough to plan for future generations?

Even if a country such as the UK meets its net-zero target by 2050, that is only a small contribution. What's more important is what happens to the 4 billion people who will be in India or sub-Saharan Africa by 2050, and who are going to need more per-capita energy if they are to develop. If we can somehow enable them to leapfrog directly to clean energy, just as they've leapfrogged directly to smartphones having never had landlines, then that will be something which does more for the world than simply meeting our own targets.

When you started out as a scientist, it was the middle of the space race. Now, we're back there again. Is space the solution to our problems? I think it's a dangerous delusion to imply, as

"Earthrise" – an iconic photo taken aboard the Apollo 8 lunar mission (above). Ely Cathedral in Cambridgeshire, UK (below)



IVAN DOVIN/ALAMY

Elon Musk does, and as my late colleague Stephen Hawking did, that there could be mass migration to Mars to avoid Earth's problems. Dealing with climate change on Earth is a doddle compared to terraforming Mars to make it habitable.

Should we be sending astronauts to space at all?

If I was from the US, I wouldn't want my tax money to go to NASA's space programme for human space flight. Miniaturisation and robotics are advancing fast, so the practical case for astronauts is getting weaker all the time.

What about Elon Musk, Jeff Bezos and the other billionaires attempting it?

They can do it more cheaply and can afford to take higher risks than NASA or any Western government could impose on publicly funded civilians. If you look back to the space shuttle, it was launched 135 times and failed twice, resulting in catastrophic crashes.

Each of those was a big trauma in the US. But a less than 2 per cent failure rate is acceptable to test pilots and thrill seekers. If Messrs Bezos and Musk want to have a programme of human space flight for thrill seekers prepared to take a risk, that is great. But they shouldn't present it as tourism.

One reason why I wish them luck is that human enhancement is going to be strongly regulated on Earth. But if there are these guys in a hostile environment on Mars, they would have every incentive to adapt themselves to that environment and they'd be away from the regulators. So if there is to be a post-human species, then it could evolve fastest from the progeny of these bold pioneers.

Which achievements are you most proud of when you look back on your life as a scientist?

I wouldn't claim any great individual achievements, but I think I've been very lucky to have contributed to exciting debates that have led to a growth in the understanding of the cosmos, galaxies and stars.

I think when the history of science in this half-century is written, then the expansion in our understanding of the cosmos will be one of the exciting chapters. ■



Richard Webb is executive editor at *New Scientist*



EPSRC Centre for Doctoral Training in Enhancing Human Interactions and Collaborations with Data and Intelligence Driven Systems – Call for Applications for 4-year Funded Research Studentships.

The global pandemic has taught us many things and perhaps the greatest insight of all is the preciousness of every human life. While some see technologies like AI and data-driven systems as ones that will overtake, outpace, or outsmart humans, at our Centre we focus on the most important technology of all: people. We are now looking for PhD researchers who are committed to changing the world via world-class research that focuses on amplifying human capabilities through the use of data driven and intelligence enabled systems. The programme spans 4-years and includes an integrated Masters.

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Candidates should have an aptitude and ability in computational thinking and methods including the ability to write software or enthusiasm to learn how to do so. While such aptitude might be evidenced by a degree in Computer Science or Engineering, we are building a community that aspires to have a high degree of diversity of perspective. So, if you have a background in Arts and Humanities; Social Sciences; Management for instance, please be encouraged to apply.

For future AI and big data technologies to serve society and the economy effectively, they have to be created and critiqued by a diverse and wide set of perspectives as possible: we welcome applications from anyone who feels they can help in the Centre's mission.

This year, we have 12 fully funded places (fees plus stipend set at the UKRI rate). Places are also available for those in receipt of four-year external funding.

Applications should be made via our website (www.swansea.ac.uk/Science/epsrc-centre-for-doctoral-training) by March 25th, 2022. To discuss your application, please contact Professor Matt Jones (Director-Enhance-CDT@swansea.ac.uk)



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Almost the last word

If energy can't be created, where does it come from? **p54**

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Twisteddoodles for *New Scientist*

Picturing the lighter side of life **p56**

Citizen science

Gaming against cancer

If you enjoy competitive puzzles, here is one you can play on your phone that will also help fight cancer, says **Loyal Liverpool**



Loyal Liverpool is a science journalist based in Berlin. She believes everyone can be a scientist, including you. @layallivs

What you need

A smartphone with the GENIGMA app installed
A knack for puzzles

CONTRIBUTING to cancer research is now as simple as playing a game on your smartphone.

Each cell in your body contains about 2 metres of DNA, folded up and tightly packed. The precise structure matters, because in cancer, unwanted changes in the arrangement of DNA can interfere with the functioning of genes.

Marc Martí-Renom at the Centre for Genomic Regulation in Barcelona, Spain, and his colleagues want to create a 3D map of the DNA inside cancer cell lines – cancer cells adapted to being grown in the laboratory – to better understand what cancer DNA rearrangements look like and how they disrupt gene function. By downloading the GENIGMA app on your smartphone and playing the game, you can help the team achieve this goal.

The game is like a puzzle, with each piece representing a real DNA fragment, identified through analysis of a breast cancer cell line by the GENIGMA team. By playing with the order of the pieces, you can help the team uncover possible rearrangements associated with cancer – and score points in the process.

Martí-Renom and his team have already solved one aspect of the puzzle: their research in the laboratory has identified fragments of DNA that interact with each other a lot. This suggests they are in close proximity to one another in the cancer cell line. But they need your help to work out the precise order that the fragments are in. Your score in



XAVIRAMIRO.CRG/CNAG

the game weighs the total number of interactions between all the different fragments. The higher your score is, the closer you are to identifying the true configuration of DNA fragments.

I am very competitive, so I love the fact that the game pits you against other players to achieve a record score. This competitive aspect helps the GENIGMA researchers too, because they benefit from the wisdom of the crowd: once at least 40 players have achieved a top score on the same challenge, that particular game is considered solved, and the scientists can use the information to map the corresponding region of DNA.

Martí-Renom and his team have also developed algorithms to try to solve the same DNA puzzles, but

currently these aren't able to scour the entire genome because this would require a prohibitive amount of computer power, he says. "We think that the citizens – the intelligence of the group – will give us more interesting results," says Martí-Renom.

Happily, more than 30,000 people across 130 countries have played the GENIGMA game so far and the team has already solved the puzzle for an entire chromosome in the breast cancer cell line. If you install the GENIGMA app, you can also share your progress with other players on social media using the hashtag #GenigmaChallenge. ■

Citizen science appears every four weeks

Next week

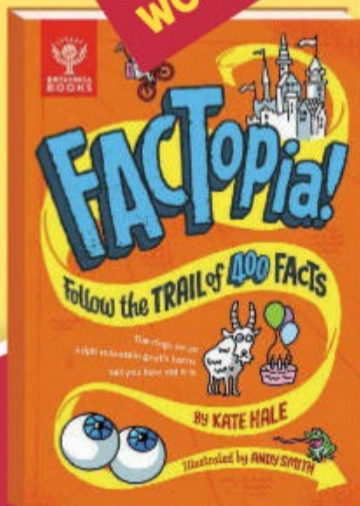
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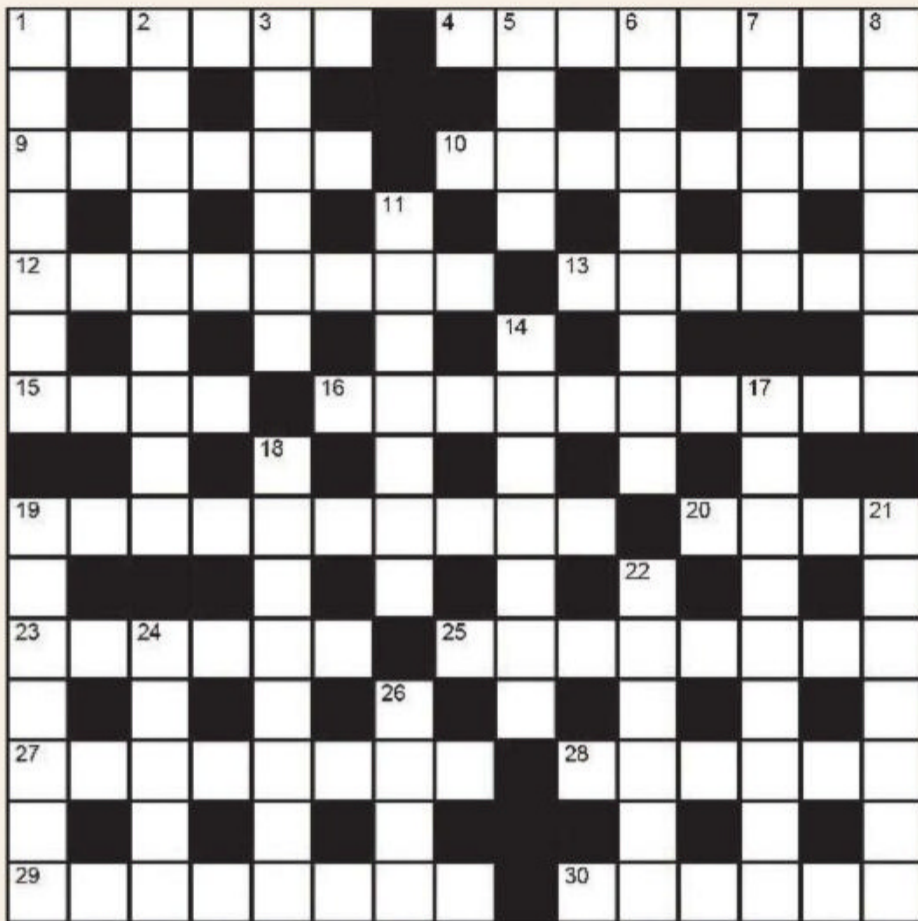
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Gravity is the familiar force that keeps our feet firmly on the ground - and explains the orbits of the planets in the solar system and the whole structure of our universe, too. That much we know, but there's much about gravity that remains a mystery. In this talk, Professor Claudia de Rham will explore how much we actually know about this most fundamental of phenomena - and how much more is left to uncover.

For more information and to book your place visit:
newscientist.com/gravityevent

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Quick crossword #103 Set by Richard Smyth



Scribble zone

Answers and the next cryptic crossword next week

ACROSS

- 1 Globule of gas within a liquid (6)
- 4 Measure of information in a sample or pixel (3,5)
- 9 Muscular convulsion (6)
- 10 ___ sequence numbering, used in routing protocols (8)
- 12 Extinct jellyfish-like organism (8)
- 13 Voice box (6)
- 15 Back of the neck (4)
- 16 Deficit of CO₂ in the blood (10)
- 19 Life-sustaining biochemical processes (10)
- 20 A (4)
- 23 Small, acrobatic songbird (6)
- 25 Extinct subspecies of prairie chicken (5,3)
- 27 Radioactive sea monster first seen on film in 1954 (8)
- 28 60 seconds (6)
- 29 Loss or lack of feeling (8)
- 30 Substance that induces vomiting (6)

DOWN

- 1 Highly viscous form of petroleum (7)
- 2 Unseeing or unseen region (5,4)
- 3 Swarming grasshopper (6)
- 5 Fe (4)
- 6 Term for a knock-on electron (5,3)
- 7/17 First female engineer to work in NASA's mission control (5,9)
- 8 Deficit of O₂ in the body (7)
- 11 Two-wheeled human-powered vehicle (7)
- 14 27 Across, for example (7)
- 17 See 7 Down
- 18 Volcanic glass (8)
- 19 Agent that alters genetic material (7)
- 21 Concerning breathlessness (7)
- 22 Chamber of the heart (6)
- 24 Modulator-demodulator (5)
- 26 + (4)

Quick quiz #142

- 1 What is the fragmented rock, dust and other material ejected in volcanic eruptions called?
- 2 Which Soviet biochemist was a leading proponent of the "primordial soup" theory of the origin of life?
- 3 What name is given to the region of space that our galaxy and others are being pulled towards?
- 4 In what year did Marie and Pierre Curie discover radium and polonium?
- 5 The hardened wing casings of beetles are more formally known as what?

Answers on page 55

Puzzle

set by Rob Eastaway
#158 League of nations

The TV sporting highlight of my childhood was always the Five Nations rugby championship, which involved a series of matches between England, Scotland, Wales, Ireland and France.

Every fortnight, on Saturday afternoon, there would be two matches, with the fifth country having the day off.

The fixture list had an elegant symmetry to it. Each country played every other country once, with two matches at home and two away, and each country alternated between playing at home and away.

I recall that in one year, the fixtures on the opening Saturday were Ireland vs England and France vs Wales, and that, on the third Saturday on which matches were played, Wales competed at home.

If those memories are correct, what were the final two matches of the competition?

Solution next week



Our crosswords are now solvable online
newscientist.com/crosswords

Original spark

If energy cannot be created or destroyed, where does it come from?

Herman D'Hondt

Sydney, New South Wales, Australia

It may sound incredible, but many scientists believe that the total energy of the universe is zero. Hence, no energy needed to be “created” when the universe came into existence.

While it seems obvious that there is a huge amount of energy in the particles and radiation that pervade the universe, this energy may be balanced by negative energy caused by the gravitational attraction between the particles. As Stephen Hawking explained, when you pull two objects apart, you need to expend energy to overcome the gravity that pulls them together. As it takes positive energy to separate them, gravity must be negative energy.

If that theory is correct, then there was never any need

“The total energy of the universe may be zero, hence no energy needed to be created when it came into existence”

to create energy or matter – they cancel each other out. That implies that the big bang could have started as a simple statistical fluctuation.

It also means that it may be possible to create our own big bang: just squeeze some vacuum in the right direction and bingo, a new universe, no energy required.

Mike Follows

Sutton Coldfield, West Midlands, UK

Energy can be transferred between different stores. Energy and matter are equivalent, so nuclear energy, for example, starts off as matter. When an inventory is taken of all the



REBECCA COLE/LAMY

This week's new questions

Aitch issue Why do Hs get dropped in some languages? Greek mythology is full of names starting with an H, yet the H sound is dropped in modern Greek, and also in Italian, French and Cockney English. *Katka Kessler, Letchworth, Hertfordshire, UK*

Great gusto Why, or how, do winds gust? *David Lockyer, Bedhampton, Hampshire, UK*

matter and energy in the universe, it adds up to zero, which seems counter-intuitive to say the least.

The zero-energy universe hypothesis is the simplest explanation of this, as outlined in 1973 by Edward Tryon, who was the first to suggest that our universe is the result of a quantum fluctuation.

According to Albert Einstein, mass and energy are equivalent and, according to Tryon, the positive energy associated with mass is counterbalanced by gravitational potential energy, which is negative. Also, according to quantum field theory, particles routinely pop into and out of existence. Tryon suggested that the same could happen for a universe.

Keith Ross

Villembits, France

The amount of energy/matter in the universe is constant and derives from the mysterious big bang. Over time, this becomes more and more spread out and less and less useful, even though the actual amount doesn't change.

Take the sun as an example. Its nuclear fusion reactions turn matter (think of it as concentrated energy) into visible sunlight and other forms of energy. The sunlight hits a green leaf on Earth and the solar energy is now transferred into a chemical energy store as oxygen is separated from carbon dioxide and water, leaving carbohydrate in the leaf.

We eat the leaf and breathe in the oxygen. The respiration reaction in our muscle cells

Why has the “H” sound been dropped in several languages?

allows the energy to be used to move our arm as we hammer in a nail. The arm, nail, hammer and the air absorb the sound, get hot and radiate infrared heat to outer space.

So the energy concentrated in the original hydrogen atoms in the sun is now scattered into the universe. Low-grade and almost useless, but still the same amount we started with.

Face up to it

On a cold night, why does our body require clothing or bedding yet our face remains warm without covering?

Mike Tipton

Extreme Environments Laboratory, University of Portsmouth, UK

Firstly, don't forget that your head does have some insulation: it often has hair (though mine doesn't) and about half of it is lying on a pillow and so is insulated by it.

Secondly, the air temperature near your head won't be as cold as the rest of the room because the microclimate immediately around your head will be warmed by heat lost from your head, heat escaping from under the covers and by your exhaled breath, which is warmed in the lungs to about 33°C.

Then there is physiology. Your sensation of “thermal comfort” is primarily driven by skin temperature (actually by cold receptors just under the surface of the skin). This, in turn, depends, in large part, on blood flow to the skin. In a cool environment, regions such as the hands and feet reduce their blood flow, or vasoconstrict, to very low levels. In contrast, the blood flow to the head doesn't decrease by anywhere near as much, so, as the temperature of the rest of the skin falls, that of the head remains higher. This is why you can lose plenty of heat via your head in the cold and should wear a hat.



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Tom Gauld
for *New Scientist*



There are also differences in the impact of different body regions on the overall sensation of cold and thermal comfort. The temperature of the hands and feet dominate your overall perception of how cold you are. This is why many people can't fall asleep until their feet warm up in bed. We know, too, that in a cooling environment, the temperature of the lower back and chest determines the loss of thermal comfort, and during mild exposure to cold, local warming of the chest and abdomen, rather than the face, produces a strong sensation of comfort.

Finally, remember that the face is adapted to being exposed to the elements. So, it is a good idea to keep the extremities and torso warm in bed, then you can leave the head above the covers. The tip of your nose may get cold, but it won't stop you sleeping, and it is good to breathe fresh air!

Pamela Ross

Findochty, Moray, UK

I was totally mystified by this question, but maybe I

“There are differences in the impact of different body regions on the overall sensation of cold and thermal comfort”

have a different metabolism.

I realised some years ago that one reason I struggled to sleep was that my head was cold, so I took a leaf out of the book of our ancestors and knitted myself a “nightcap”. After all, babies lose a lot of heat through their heads, so we put bonnets on them to keep them warm. Over the years, I have found the best thing is not to wear it on my head, but draped over it, particularly my forehead. This keeps my head and face cosy and facilitates sleeping. I even knitted a special one to take with me when I go away from home.

@Si7hlord via Twitter

I have an extensive beard covering most of my face and keeping it warm. It also makes a fine scarf to stop the chill getting to my chest.

Red rainbow

My friend spotted a strange red-only “rainbow” just after sunrise. There was no rain, so what caused this? (continued)

Natalie Roberts

Watford, Hertfordshire, UK

As a member of the Cloud Appreciation Society, I would like to point out that it is something of a misconception that rain is required to form a rainbow.

They also form in water spray such as from waterfalls or even that produced by hosepipes and pressure washers. You can get bows in fog or other low clouds, although the small, regular size of the water particles usually renders such fog or cloudbows pure white.

High in the sky (or low in exceptionally cold conditions, where tiny crystals form as “diamond dust”), ice crystals in the frigid atmosphere produce a wide range of rainbow forms, typically much brighter than water bows, such as sun dogs or circumzenithal arcs. ■

Answers

Quick quiz #142 Answers

- 1 Tephra
- 2 Alexander Oparin
- 3 The Great Attractor
- 4 1898
- 5 Elytra

Cryptic Crossword #78 Answers

ACROSS 1 Arrow, 4 Hanover, 8 Spandex, 9 Boson, 10 Nets, 11 Antelope, 13 Castor, 15 Massif, 18 Snottite, 19 Flea, 22 Zero g, 23 Readmit, 24 Dynasty, 25 Prowl

DOWN 1 Arsenic, 2 Roast, 3 Wade, 4 Hexane, 5 Nobleman, 6 Viscous, 7 Rinse, 12 Voltages, 14 Sporan, 16 Fractal, 17 Sturdy, 18 Sized, 20 Limbo, 21 Camp

#157 Weather or not Solution

Eileen has a better chance of winning than Ike. Call a rainy day R and a no-rain day N. Eileen chooses NRR and Ike RRN. In the first three days, they each have an equal (1/8th) chance of being right.

But if the sequence RRN first crops up after day three, then NRR must have occurred a day earlier unless it rained on every previous day.

So for Ike to win, the sequence has to be RRN or RRRN or RRRRN... etc, for which the probability is $1/8 + 1/16 + 1/32...$, which adds to $1/4$.

The chance of Eileen winning is therefore $3/4$, three times as likely as Ike. This is a variation on the classic game of Penney Ante (or Penney's Game).

Slobber dogs

Feedback can think of few more unnerving fates than coming round from one of our regular fainting fits at the dentist's in a pool not just of our own drool, but canine saliva too.

Yet, "Dental patients at a practice in Green Bay, Wisconsin, can cuddle with a cockapoo named Charlie. In Cornelius, North Carolina, Whalen Dentistry advertises that a goldendoodle named Beamer will 'make any appointment a little less... RUFF!'", we read on Kaiser Health News.

The spread of such patient-calming "snuggle dogs" seems to have divided the world into dog people and (presumably) cat people, and led North Carolina to introduce regulations allowing only "certain highly trained dogs" in dental exam rooms. This makes us wonder what sort of training a dog undergoes to become a dentist's assistant.

Still, we see that a pilot study from researchers at the Autonomous University of Nuevo León in Mexico in 2019 recorded lower blood pressure spikes among a small sample of anxious dental patients when a dog (English shepherd, schnauzer, border collie or Labrador retriever) was placed on a clean towel over their legs, so there is some solid science behind it.

That is more than can be said for fish. Proving there really is research for every occasion, we encounter a 2021 paper from researchers at the University of Zurich in Switzerland detailing a clinical trial looking at the effect of fish in a dental waiting room on patient stress levels. None, as it turns out. Still, slapping with a wet fish could be a good way to revive those who do pass out. And has no one really thought to try out dental cats?

Enter the Dollyverse

We can't tell you how excited we are that next week at SXSW Dolly Parton is launching an audience-centric Web3 experience to be livestreamed on the blockchain. That is mainly because about the only words we understand in that

Twisteddoodles for New Scientist



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sentence are "Dolly Parton".

Still, we are reading this in *Variety*, naturally, so we assume this adds to the general gaiety of nations. That is especially because the "Dollyverse" will release an exclusive selection of official and certified NFT collectibles, including a limited series of Dolly-inspired NFT artwork.

Ah yes, NFT art! This is a subject we have shown our age about before (1 May 2021). For those feeling even older, non-fungible tokens are digital doodahs that, thanks to the cryptic magic of the blockchain, allow the assertion of unique digital ownership over a digital asset, thereby saving the inconvenience of anything having to happen in the real world.

As far as we can make out, Dolly Parton at least remains a physical asset – as she might be the first to say – in this virtual farrago.

Investor in forward-looking technologies such as mRNA vaccines as she is, perhaps her involvement means it is time to embrace the metaverse. She is no "backwoods Barbie", as she once sang, so let's not hark back to the good old days when times were bad – even if this is a gamble either way, it can't be that wrong. Etc, etc.

Spook on spook

In an interview with *The Telegraph's Planet Normal* podcast, Richard Dearlove, the former head of the UK's not-so-secret intelligence service, MI6, adds his voice to those original thinkers advocating that the only rational way to wean ourselves off Russian gas in the light of the Ukraine crisis is to forget net-zero targets and install a fracking well in every living room. Even if the nuclear balloon doesn't go up, we

might as well cook ourselves slowly.

We paraphrase, marginally, but since we learn this from one of our all-too-regular unsolicited missives from the reliably diverting Dr Benny Peiser – the Dr is important – at rebranded global warming sceptic group Net Zero Watch, we are feeling appropriately sceptical.

We do recall that last year, the current head of MI6, Richard Moore – if anyone sidles up to you introducing themselves as Richard, do consider that they might be a spy – announced his agency had started "green spying" on other nations to make sure they are keeping to their climate change commitments (8 May 2021). At this rate, the UK could soon be spying on itself. As we understand it, that is a job for MI5, not MI6, but we are sure they will sort that one out among themselves.

People in megahouses

Staying on energy policy, Henry Webber wonders when it became the done thing to quote the output of power stations, solar farms and the like not in megawatts or gigawatts, but in thousands or millions of houses. Do we have a conversion factor, he asks?

Several, it turns out. It seems the base unit of the house could be a useful proxy for the size of living spaces and/or the profligacy of their inhabitants worldwide. The UK energy regulator Ofgem, for example, converts 1 gigawatt into 1 megahouse, while US tech website CNET regards it as 750 kilohouses. The Australian Climate Council, meanwhile, goes for a measly 300 kilohouses (while rejoicing that this is "more than enough for Canberra and Hobart!").

Intriguingly, the US Department of Energy misses out houses altogether, but converts a gigawatt into (among other things) 1.3 megahorses. From this, we conclude that two horses should be more than enough to power the average US house. As with most things at the moment, we are unsure where this leaves us. ■



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