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# HOW IT WORKS

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**WHAT IS THE PLACEBO EFFECT?**



**WHY ASMR SOUNDS MAKE YOU SHIVER**

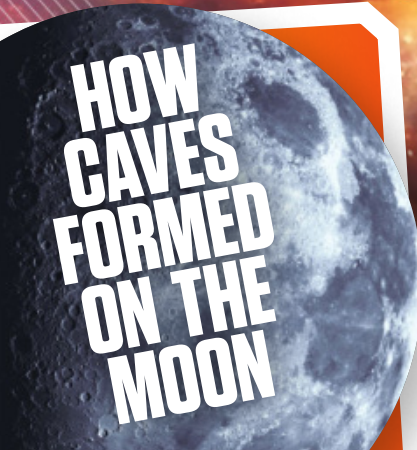


# 20 WEIRDEST SCIENCE MYSTERIES

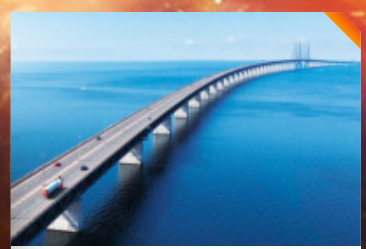
**FREAKY ANIMAL RAIN**



**UNEXPLAINED DARK MATTER**



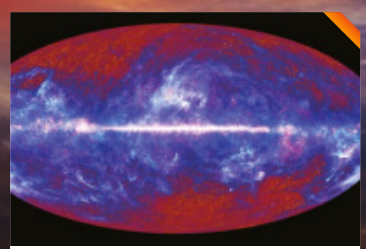
**HOW CAVES FORMED ON THE MOON**



**BUILDING THE WORLD'S LONGEST BRIDGE**



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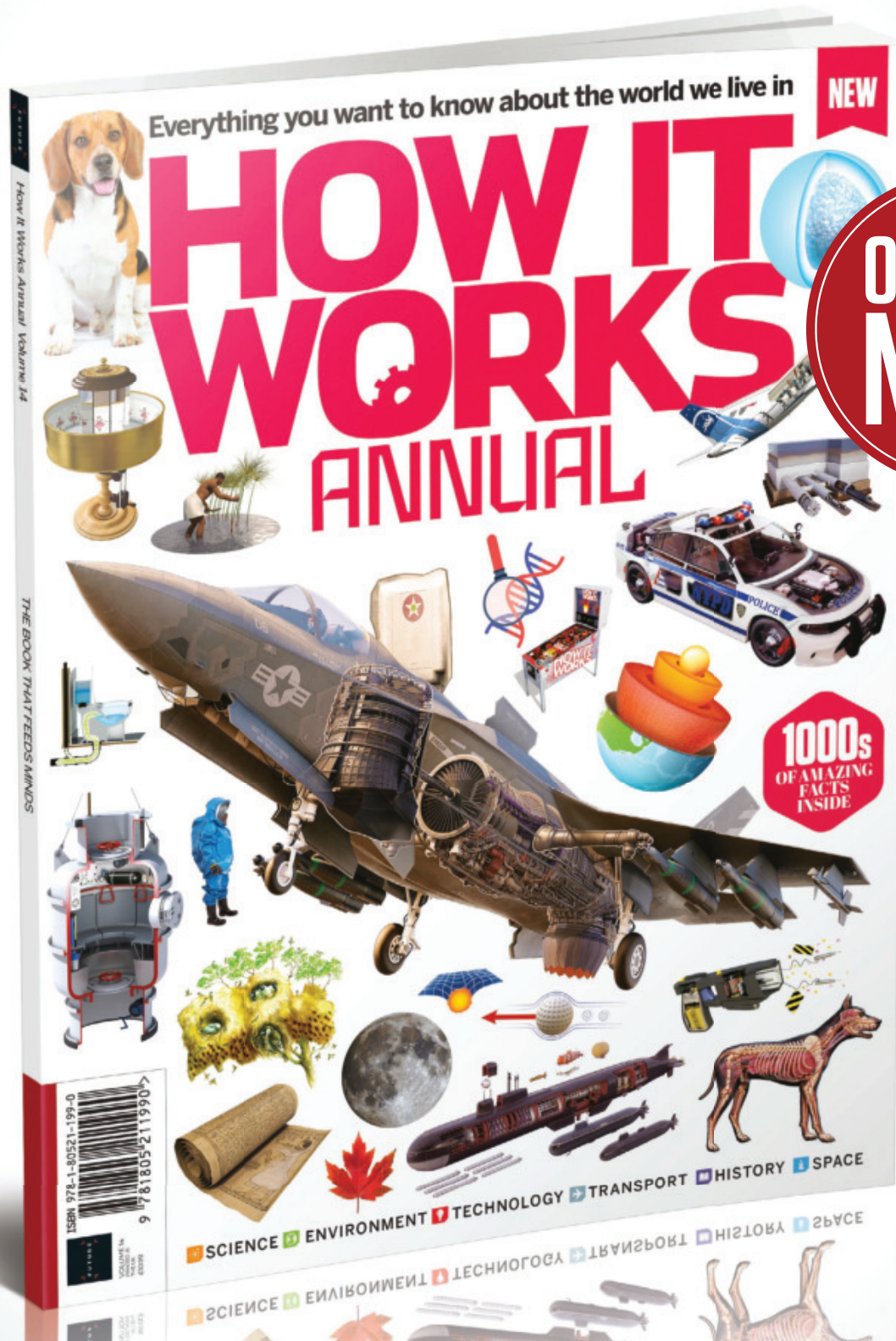


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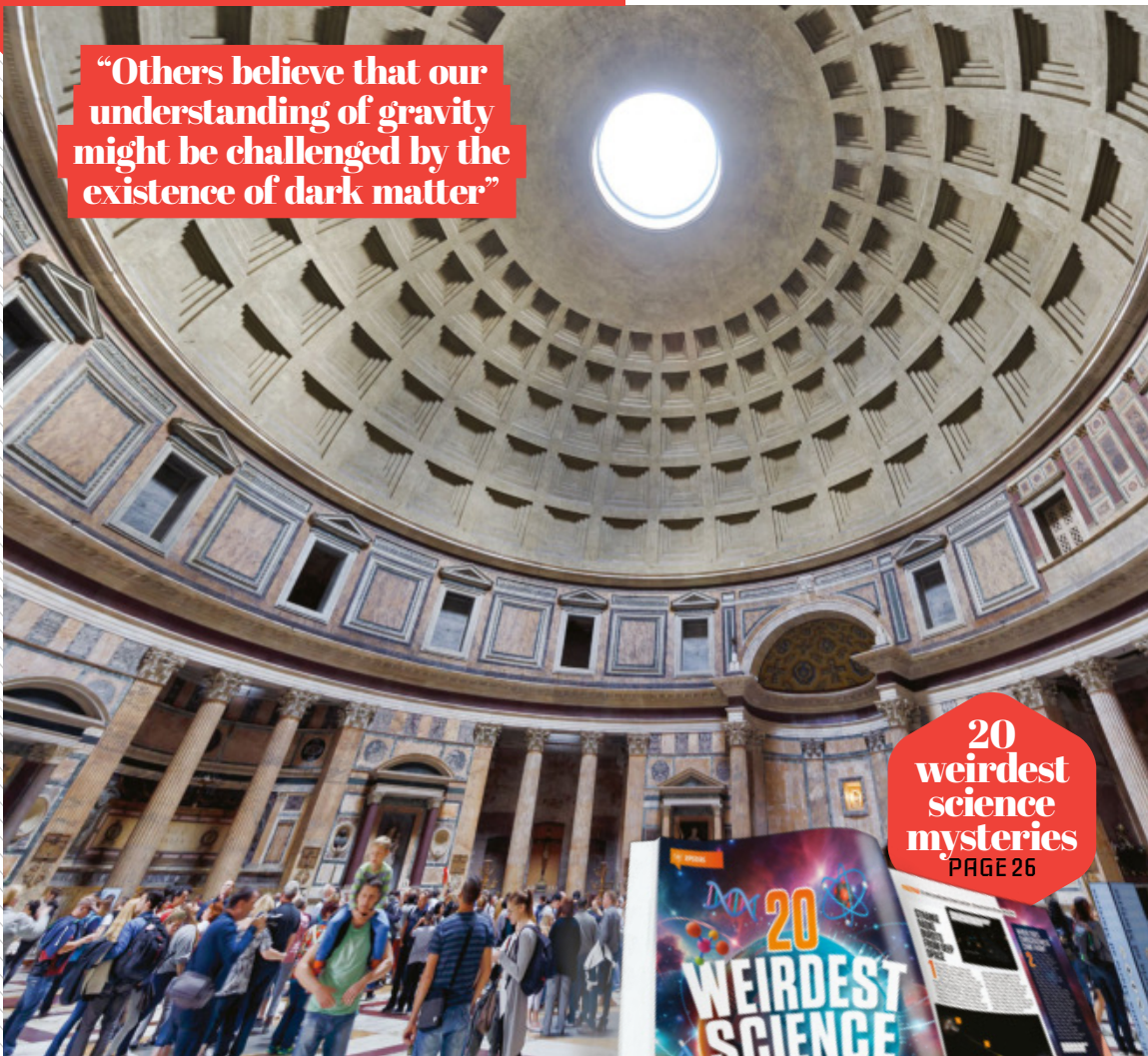
# WELCOME

Issue 195

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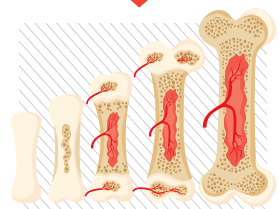
**“Others believe that our understanding of gravity might be challenged by the existence of dark matter”**



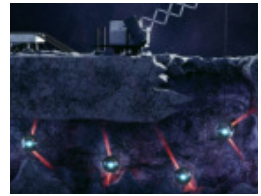
**20 weirdest science mysteries**  
PAGE 26



## HIGHLIGHTS



**38 GROWING UP**  
How your bones grow, from embryo to adult



**50 MOON DIVER**  
This robot spelunker will explore a lunar cave



**70 SEA CROSSING**  
Over the Hong Kong-Zhuhai-Macau Bridge

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GO TO PAGE 24 FOR GREAT DEALS



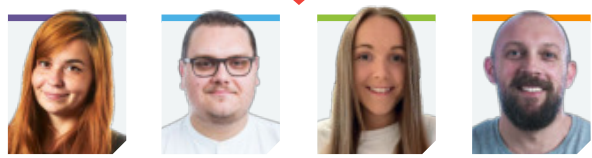
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**T**he Pantheon in Rome was built in 125 CE and is capped by the world's largest unreinforced concrete dome. Yet despite our advances in construction techniques and materials in the subsequent 1,900 years, we had no idea what made ancient Roman concrete so durable up until 2023, when scientists discovered chunks of white lime clast in a concrete sample, which allows the concrete to self-heal any cracks that form over time. It's a former science mystery that could have made it into this issue's pick of the 20 weirdest science mysteries, which includes animal rain, dark energy, the world's most mysterious book, ASMR and more. Read our cover feature on page 26 – enjoy!

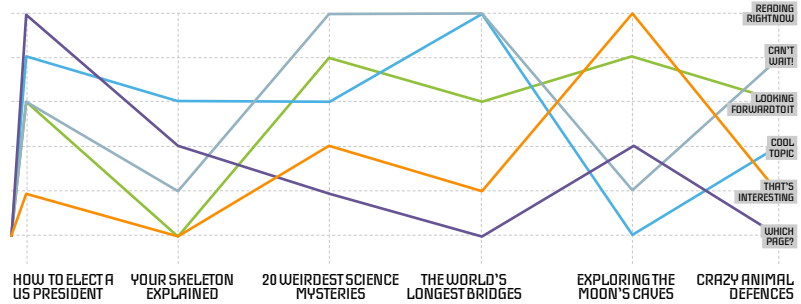


**Ben Biggs**  
EDITOR

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# INSIDE

Issue 195

## SPECIAL

### 26 20 weirdest science mysteries

From dark matter to deep-sea crabs, science still can't fully explain these strange quirks of nature

## SCIENCE

### 34 Your skeleton explained

It gives you shape and encases vital organs, but this living structure is much more than a coat hanger for your body

### 40 What is morning sickness?

Why some pregnancies have symptoms of nausea and vomiting

## HISTORY

### 42 How to elect a US president

The campaigns, votes and elections that put someone in America's most powerful office

## SPACE

### 48 Exploring the Moon's caves

Earth's rocky neighbour is home to a network of unexplored caves, and scientists are keen to take a peek inside

### 52 The life cycle of a star

They're formed from swirling clouds of gas and dust and often end their lives with an epic explosion. The life of a star is far from dull

### 56 What is the cosmic microwave background?

It's the oldest thing in the universe that astronomers can still observe today

## ENVIRONMENT

### 58 Crazy animal defences

From mesmerising distractions to bizarre biological weapons, here are the wild ways that some species fight and deter predators

### 64 What is acid rain?

Some clouds can harbour water that kills trees and melts statues

## TECHNOLOGY

### 66 The world's longest bridges

Discover the incredible feats of engineering closing some of the biggest land gaps

### 72 The power of water

We're hooked on fossil fuels. But hydroelectric power is becoming an increasingly important replacement for coal and oil

### 76 Future farming robots

Robots are transforming farming thanks to artificial intelligence, GPS and advanced technology

## TRANSPORT

### 80 On board the 'flying bum'

The HAV Airlander is exciting, ambitious and one of the world's biggest aircraft, but will it ever get off the ground?

## REGULARS

### 06 Global eye

Science and tech news from around the world

### 22 Wish list

Funky kitchen gadgets

### 84 Braindump

Your questions answered

### 90 Book reviews

### 92 Brain gym

Give your brain a workout with our puzzle pages

### 94 How to...

Make a bouncy egg

### 96 Letters

Have your say

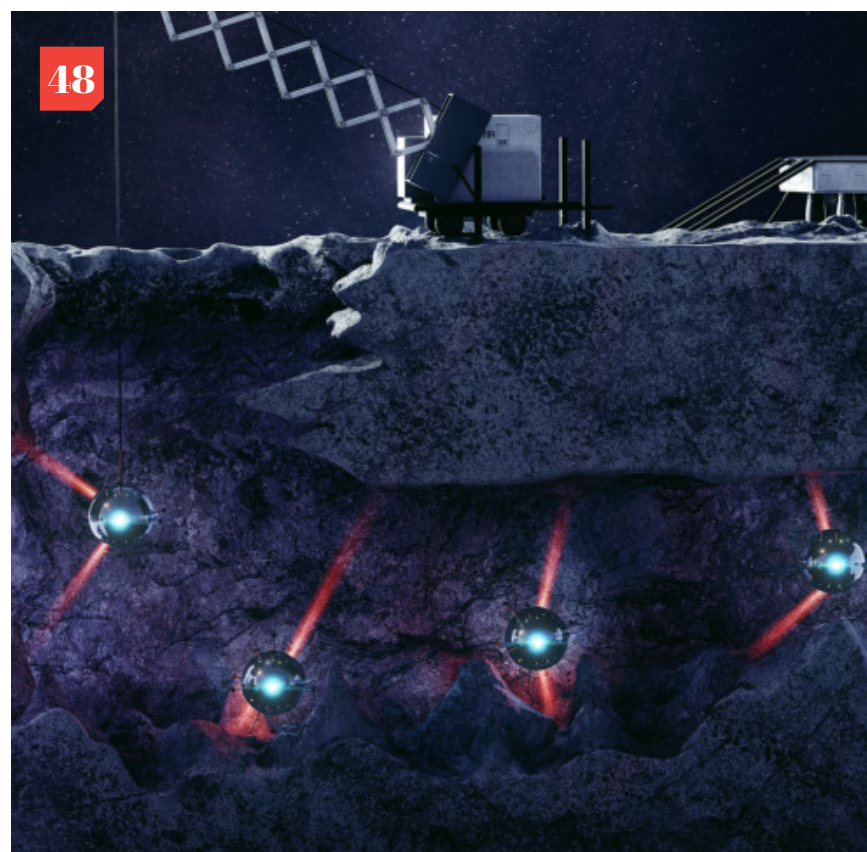
### 98 Fast facts



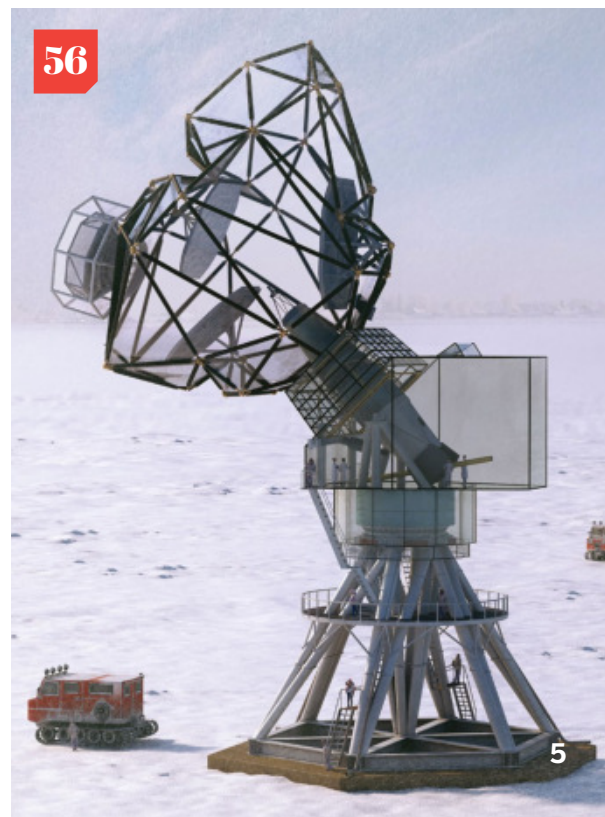
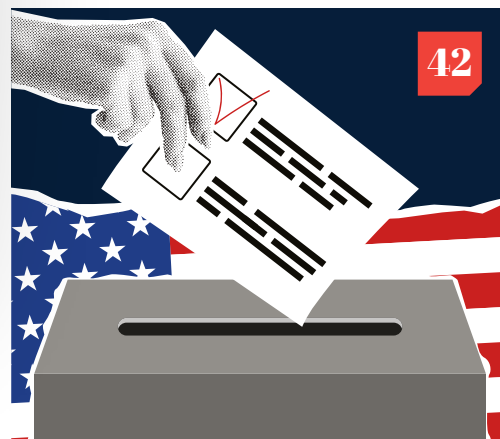
80



34



48



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## Ant assassins

Wearing their kills as a cape, *Acanthaspis petax* are ferocious hunters that puncture their preys' bodies and lap up the fluids within. Once they're done with their meal – typically ants – the bugs build a backpack of empty carcasses. Although scientists remain unsure about why these assassin bugs carry their food, some suggest that it's a form of camouflage to avoid predators.





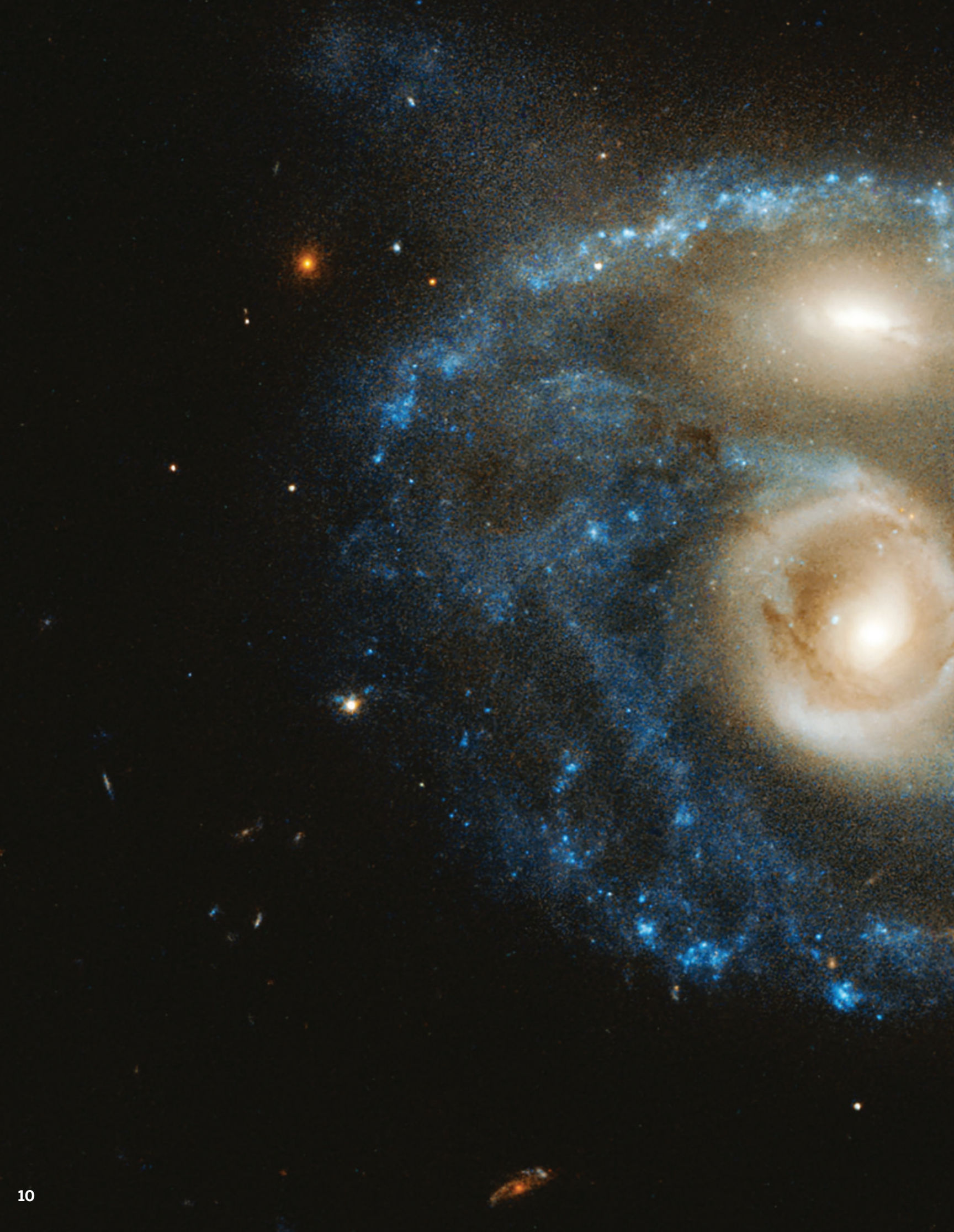


## Castle on the hill

For more than 850 years, Burg Eltz has stood on top of a 70-metre rock in Western Germany. This fog-draped castle is made up of eight towers that peak at 35 metres tall, and the bastion is surrounded by over 300 hectares of the Eltz Forest.

Although Burg Eltz is home to many turrets, the medieval castle has never endured any conflict, unlike so many others across Europe.



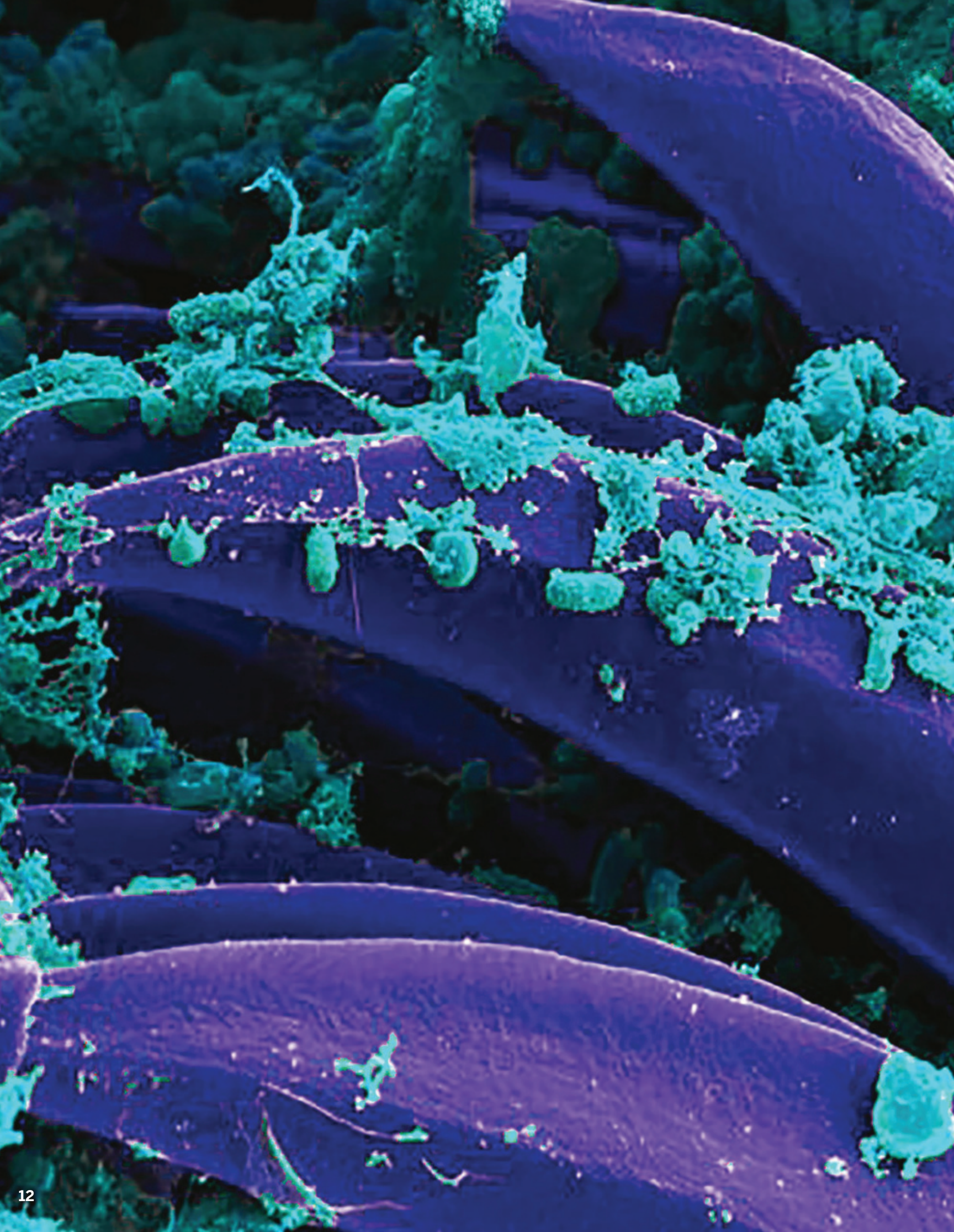




## Galactic watcher

Looming among the stars is a ghostly galactic disc of cosmic dust and gas called Arp-Madore 2026-424. The system's two starry eye sockets are formed by two galaxies heading for a collision, both of which are surrounded by young blue stars. Scientists estimate that the galaxies, which are around 704 million light years from Earth, will merge in 1 to 2 billion years.





A scanning electron micrograph (SEM) showing a rat flea (Xenopsylla cheopis) in a dark, textured environment. The flea's body is covered with numerous small, bright blue, rod-shaped bacteria, identified as Yersinia pestis. The bacteria are clustered in some areas and more sparsely distributed in others. The flea's legs and body segments are visible, showing fine details of its anatomy.

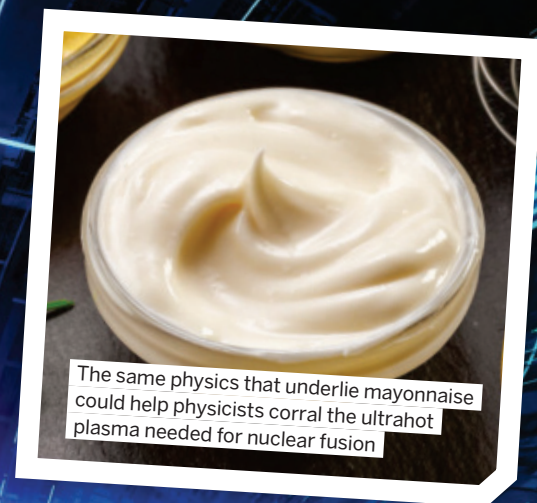
## Battling bubonic plague

Sweeping across the world in the 1300s, the bubonic plague, or 'black death', claimed the lives of 30 to 50 per cent of the global population. The disease is caused by a bacterium called *Yersinia pestis* (blue). In this scanning electron micrograph image, *Yersinia pestis* has been imaged clinging to the spines of a rat flea.



# GLOBAL EYE

Showcasing the incredible world we live in



The same physics that underlie mayonnaise could help physicists corral the ultrahot plasma needed for nuclear fusion

PHYSICS

## Physicists solve a nuclear fusion mystery with mayonnaise

WORDS TIA GHOSE

**N**uclear fusion technology could get a breakthrough from an unexpected place: mayonnaise. In a new study, scientists plopped the creamy condiment into a churning machine and set it whirling to see what conditions made it flow. “We use mayonnaise because it behaves like a solid, but when subjected to a pressure gradient, it starts to flow,” said Arindam Banerjee, a mechanical engineer at Lehigh University in Pennsylvania. This process could help explain the physics that occur at ultrahigh temperatures and pressures inside nuclear fusion reactors without having to create those extreme conditions.

Nuclear fusion forges helium from hydrogen at the hearts of stars. In theory, it could be the source of nearly limitless clean energy on Earth – if the reaction could produce more energy than it requires to run. That’s a tall order. Star-powered fusion occurs at 15 million degrees Celsius. And a star’s massive gravity forces hydrogen atoms

together, overcoming their natural repulsion. On Earth, however, we don’t have those crushing pressures, so human-made fusion reactors must run ten times hotter than the Sun.

To reach these mind-melting temperatures, scientists use multiple approaches, including one called inertial confinement. In this process, physicists freeze pea-sized pellets of gas, typically a mix of heavy isotopes, or versions, of hydrogen, into metal capsules. Then they blast the pellets with lasers, which heats the gas to 222 million degrees Celsius in a flash, and ideally turns it into a plasma where fusion can occur. Unfortunately, the hydrogen gas wants to expand, causing the molten metal to explode before hydrogen has time to fuse. This explosion occurs when the metal capsule enters an unstable phase and starts to flow.

Banerjee’s team realised that molten metal behaves a lot like mayonnaise at lower temperatures: it can be elastic, meaning it bounces back when you push on it, plastic,

meaning it doesn’t bounce back, or flowing. “If you put a stress on mayonnaise, it will start to deform, but if you remove the stress it goes back to its original shape,” he said. “So there’s an elastic phase followed by a stable plastic phase. The next phase is when it starts flowing, and that’s where the instability kicks in.”

In the new study, the researchers placed mayonnaise in a machine that accelerated the egg-and-oil emulsion until it started to flow. Then, they characterised the conditions at which the condiment transitioned between plastic, elastic and unstable states. “We found the conditions under which the elastic recovery was possible and how it could be maximised to delay or completely suppress the instability,” Banerjee said. The study also found which conditions allowed for more energy yield. Of course, mayonnaise and ultrahot metal capsules are different in many way, so it remains to be seen whether the team’s findings can be translated to a pellet of plasma many times hotter than the Sun.



Compounds produced by bacteria that live in the sea could help in the fight against antibiotic resistance

PLANET EARTH

# Deep-sea Arctic microbes may harbour next-generation antibiotics

WORDS EMILY COOKE

**T**he frigid waters of the Arctic may harbour the secret to a totally new type of antibiotic. Scientists have discovered that substances made by Arctic Ocean microbes called actinobacteria can stop harmful bacteria from growing and prevent them from causing disease. Around 70 per cent of existing antibiotics were discovered in actinobacteria, most of which live in soil on land. However, bacteria are becoming increasingly resistant to existing antibiotics, meaning that new drugs are urgently needed.

Researchers looked to sea-dwelling actinobacteria for new antibiotics. The sea-dwelling microbes are thought to produce a more chemically diverse array of compounds than their land-dwelling counterparts make. This is because of the selective pressure created by the extreme fluctuations in pressure, temperature, salt concentration and light level that occur in marine environments. Scientists analysed hundreds of unknown compounds that had been extracted from actinobacteria living inside invertebrates. The samples were collected during an expedition to the Arctic Ocean in 2020. Specifically, they tested how the compounds affected a pathogenic type of *Escherichia coli* called enteropathogenic *E. coli* (EPEC). These bacteria infect intestinal cells and cause severe diarrhoea, particularly in children.

Next, scientists looked at whether compounds produced by four species of actinobacteria could stop EPEC bacteria from infecting lab-grown cells. They found that two

compounds had particularly strong antibacterial properties: one from a strain of actinobacteria from the *Rhodococcus* genus and another from a strain belonging to the *Kocuria* genus. The team found that the compounds stopped EPEC bacteria from attaching to the cell surface and injecting substances that allow the microbes to hijack their molecular machinery and cause disease. However, while the *Kocuria* bacteria produced compounds that slowed the growth of EPEC bacteria, the compound from *Rhodococcus* bacteria didn't. If the bacteria are alive, but harmless to a host, there is less selection pressure for them to develop resistance to the compound. As such, the *Rhodococcus* compound could be a more promising candidate for a new antibiotic.

A lot more work must be done before either of these compounds could be brought to market. "We have so far only done in-vitro studies, so we are still very far from knowing if the compounds have any actual significance in terms of clinical use," said Päivi Tammela, a professor of pharmaceutical biology at the University of Helsinki in Finland. For instance, a big hurdle to overcome is figuring out how to produce larger amounts of these compounds that would allow scientists to study their structures and biological activity in more detail. Nonetheless, the team has high hopes for the future of this research, with Tammela stating that it is absolutely possible that many more of these compounds are waiting to be discovered in the depths.

Did you know?

An *E. coli* population can double every 20 minutes

TECHNOLOGY

# XB-1 PROTOTYPE ACES ITS SECOND TEST FLIGHT

WORDS ANDREW JONES

Colorado-based company Boom Supersonic's XB-1 supersonic demonstrator aircraft flew for the second time ever on 26 August 2024. The flight took place from California's Mojave Air and Space Port and lasted about 15 minutes. It saw the XB-1 reach an altitude of 3,170 metres and a speed of 277 miles per hour. The flight demonstrated landing gear being retracted and extended for the first time, and a new digital stability-augmentation system was tested to improve handling.

The test marks another step towards achieving supersonic flight, expected later in the year. "XB-1 had a fantastic second flight this morning. Initial results indicate we've successfully resolved the findings from flight one and are excited to continue flight testing on the path to supersonic flight," said Blake Scholl, founder and CEO of Boom Supersonic. "I'm proud of the team. Today's flight is another step towards the return of supersonic passenger travel."

The XB-1 test plane had its first flight in March 2024. The company now intends to ramp up its flight rate and plans around ten tests before reaching for supersonic speeds. XB-1 is part of the design and development process for Boom's flagship project, Overture, a planned supersonic airliner. Boom Supersonic aims to revolutionise air travel by making it much faster and more efficient.



Boom Supersonic's XB-1 prototype conducts its second-ever test flight on 26 August 2024

## Did you know?

Albatrosses can dive to depths of three metres

A pair of wandering albatrosses in a nest on South Georgia Island, Antarctica



## ANIMALS

# Albatross-eating mice sentenced to death by 'bombing'

WORDS PATRICK PESTER

**I**nvasive mice are eating albatrosses alive on a remote island in the Indian Ocean, so conservationists have come up with an explosive solution: 'bombing' the mice. Mice have been wreaking havoc on Marion Island, between South Africa and Antarctica, for decades. Humans accidentally introduced the mice in the 19th century, and the rodents have since developed a taste for wandering albatrosses and other threatened seabirds.

The Mouse-Free Marion Project, a collaboration between the South African government and BirdLife South Africa, is trying to raise around £22 million (\$29 million) to drop 600 tonnes of rodenticide-laced pellets onto the island in 2027. The project plans to send a squad of helicopters to drop the pellets. By striking in winter when the mice are most hungry, conservationists hope to eradicate the entire mouse population of up to a million individuals. "We have to get rid of every last mouse," Mark Anderson, CEO of BirdLife South Africa, said. "If there was a male and female remaining, they could breed and eventually get back to where we are now."

House mice first arrived on Marion Island via sealing ships. They began their reign of terror by decimating the island's invertebrates and feasting on seabird eggs. By 2003, the mice were eating seabird chicks alive, and now the mice have figured out they can take on adults,

too. Researchers discovered the carcasses of eight adult wandering albatrosses in April 2023. The birds had deep wounds indicative of mice attacks and likely died of infection or starvation. Further reports of fatalities show that mouse attacks are escalating. "Mice just climb onto them and slowly eat them until they succumb," Anderson said. "We're losing hundreds of thousands of seabirds every year."

Albatrosses are defenceless against mice because they didn't evolve alongside terrestrial predators. They spend most of their lives at sea, and nesting sites like Marion Island are so isolated that mice and other non-marine mammals couldn't reach them until humans came along. Because the birds evolved to live in an environment where they didn't encounter terrestrial predators, they don't possess any defence mechanisms.

An attempt to control Marion Island's mice population with cats had dire consequences. Researchers took five cats to the island in 1948, but their offspring went feral and hunted seabirds as well as mice. The feral cats bred and spread across the island until they were killing an estimated 455,000 birds a year in the 1970s. Researchers successfully eradicated the cats in 1991. The rodenticide at the heart of the new eradication strategy, in contrast, should only kill mice because it doesn't affect Marion Island's native invertebrates and the seabirds usually feed at sea.

## SPACE

# NASA'S SOLAR SAIL SPREADS ITS WINGS IN SPACE

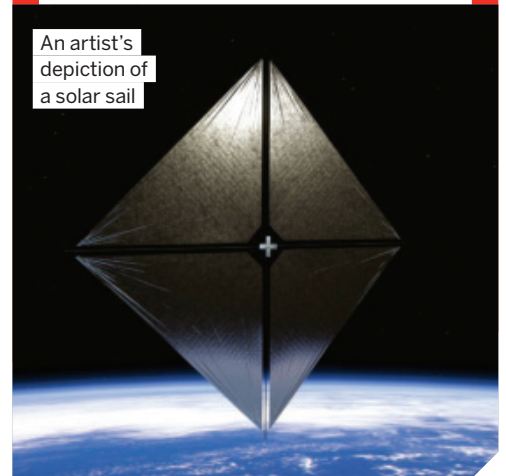
WORDS MEREDITH GAROFALO

Over four months after launching to space, a solar-sailing spacecraft has spread its wings above our planet. NASA's Advanced Composite Solar Sail System (ACS3) caught a ride to space on 24 April on Rocket Lab's Electron vehicle, and at the end of August NASA shared that the technology reached full deployment. On 29 August the team obtained data indicating the test of the sail-hoisting boom system was a success.

It only takes a slight amount of sunlight to guide solar sails through space. Though photons don't have mass, they can force momentum when they hit an object, and that's what a solar sail takes advantage of. The Advanced Composite Solar Sail System spacecraft will be put to the test over the next few weeks as the team observes the sail's manoeuvring ability in space. By adjusting the orbit of the spacecraft, researchers will be able to learn more about how to design and operate future solar sail-equipped missions.

The location of the spacecraft in its orbit is roughly two times the altitude of the International Space Station. If you were looking at the sail from above, it would look like a square that measures nearly half the size of a tennis court, at approximately 80 square metres.

An artist's depiction of a solar sail



# A new reactor could triple yields of a valuable chemical

WORDS VICTORIA ATKINSON



Ammonia is one of the most valuable chemicals, but producing it is incredibly energy-intensive

**“Nitrate is converted into ammonia gas and hydroxyl ions”**

**A** new reactor could turn wastewater into drinking water while also generating one of the world’s most sought-after chemicals. The new reactor produces ammonia gas from water contaminated with nitrate ions. Ammonia ( $\text{NH}_3$ ) is an extremely important industrial chemical. It is one of the key components in fertilisers and also vital in chemical manufacturing processes. Over 163 million tonnes are produced annually, mostly by the 100-year-old Haber-Bosch process – a high temperature, high pressure reaction between hydrogen and nitrogen. This one chemical reaction alone uses approximately two per cent of the world’s energy. Nitrate, on the other hand, pollutes rivers and streams when excess runoff from fertilised farmland enters local waterways. Nitrates devastate aquatic ecosystems, and at higher levels in drinking water can pose health risks. To be safe to drink, water must be thoroughly treated to remove nitrates.

Existing commercial treatments use bacteria to convert nitrate ions directly to nitrogen, but this procedure is expensive, and also produces nitrous oxide, which is far more potent as a greenhouse gas than carbon

dioxide. To avoid this climate impact, scientists are working on ways to convert nitrate into ammonia using electricity, but early systems have struggled with unwanted side reactions. In these devices, there is a positive and negative end, with a difference in charge between the two. Chemical reactions occur at both. Water is split into oxygen gas and hydrogen ions at the negative end of the reactor, while a second reaction converts nitrates to ammonia and hydroxyl ions ( $\text{OH}^-$ ) at the positive end.

Unfortunately, hydrogen ions produced on one side tend to diffuse to the other, where they chemically react to form hydrogen. Because even highly polluted water still has tiny concentrations of nitrate, this hydrogen reaction winds up dominating and prevents the main nitrate-to-ammonia reaction from occurring efficiently. Scientists have tried to get around this by putting additives into the mix, but this is impractical for real-world applications in water treatment. Researchers got around this problem in part by adding an intermediate chamber, creating a three-chamber reactor.

In the first chamber, nitrate is converted into ammonia gas and hydroxyl ions. These

combine with sodium ions already present in the water to form sodium hydroxide. As the cleaned water leaves the first chamber and is pumped into the middle chamber with this sodium hydroxide, the newly formed ammonia gas is bubbled out. In the third chamber, hydrogen ions produced by the splitting of water diffuse across the cell into the middle chamber. Here, hydrogen and hydroxyl ions from the sodium hydroxide combine to form water. The leftover sodium ions then move back from the middle chamber into the first to repeat the cycle.

Crucially, no hydrogen ions reach the other side of the reactor to interfere with the nitrate reaction. In a ten-day test run, over 90 per cent of the electric current in the research team’s cell was able to power ammonia production, compared with around 20 per cent for former systems. The design is still experimental, and they still need to work out several issues before the technology can be rolled out commercially.

## HEALTH

### THE WORLD'S OLDEST PERSON DIES AGED 117 YEARS OLD

WORDS JENNIFER NALEWICKI

Maria Brnyas Morera, the oldest person in the world, has died. She was 117 years old. The supercentenarian, who was born in San Francisco on 4 March 1907, died “peacefully in her sleep” in Olot, Spain, her family announced on her X account on 20 August. She passed on 19 August. Morera had been a resident at the Residència Santa Maria del Tura nursing home for the last 20 years. Recently, Morera told her family she was beginning to feel weak and knew that her time was coming to a close: “One day I will leave here. I will not try coffee again, nor eat yoghurt, nor pet my dog. I will also leave my memories, my reflections and I will cease to exist in this body. One day I don’t know, but it’s very close, this long journey will be over.”

In 2023, the *Guinness Book of World Records* officially announced that Morera was the world’s oldest person. She received the title upon the death of Lucile Racon, also known as Sister André, who was 118 years old when she died on 17 January 2023. Because of her longevity, Morera captured the attention of the medical community. Researchers who studied her genetic and lifestyle habits determined that she not only had low levels of fat and sugar in her blood, but also that her cells aged more slowly than the average person’s.



Maria Brnyas Morera celebrated her 117th birthday earlier this year



Some of the silver coins discovered in the Black Forest region of Germany

## ARCHAEOLOGY

### Massive medieval coin hoard worth ‘about 150 sheep’ discovered

WORDS KRISTEL TJANDRA

**A**rchaeologists in Germany have unearthed over 1,500 medieval silver coins after a citizen noticed what looked like ‘small metal plates’ while digging during a construction project. The discovery “is the biggest treasure since 1949 in the region of Freiburg,” said Andreas Haasis-Berner, an archaeologist at the State Office for Monument Preservation in Stuttgart. The find, which was made in May while workers laid pipe near a pool in the municipality of Glottertal, bears clues to what the mining and minting trades looked like in the area 650 years ago.

Back in 1949, archaeologists in Freiburg im Breisgau found about 5,000 coins from around the 1280s, but no medieval coins had been found in Glottertal, which is about six miles northeast of Freiburg. Glottertal sits in the Black Forest mountains in an area known for its picturesque valleys and dark pine forests, which are dotted with orchards and vineyards. Freiburg was founded by the House of Zähringen, a dynasty ruled by dukes from around 1120 to 1218. When the Zähringer line ended, the city was taken over by the House of Urach.

“Glottertal has been one of the most important mining areas for the dukes of Freiburg,” Haasis-Berner said, “The site where the coins were found was a main settlement area for miners.” These miners unearthed

metals such as silver. During the pipeline installation, Haasis-Berner received a call from Claus Völker, a Glottertal citizen who said he had found some coins during the construction project. “The next morning, he examined the place a second time, and now his wife found a huge amount,” said Haasis-Berner. “Some hours later, I went to the place and dug about 1,000 coins.” In the days after the initial discovery, a few experts were brought to the site with metal detectors. Despite the adverse weather conditions with rain and knee-deep mud, the team managed to retrieve 500 to 600 more coins. The coins were minted in the 14th century, and at the time “you could have bought about 150 sheep with the coins.”

After a rough cleaning, experts determined that the coins were likely minted in the 1320s and were mainly from an area that is now Germany, Switzerland and France. The find joins four similar coin hoards previously found in the greater region that date to the 1320s. “With these treasures, we can see which coins have been common,” Haasis-Berner said. Importantly, the latest discovery sheds light on Glottertal’s medieval history and economy. “The evaluation of this coin hoard will enable us to make statements about the circulation of coins in Freiburg im Breisgau, the minting activity, the silver trade but also the mining in Glottertal.”

# The hottest ocean temperature in 400 years threatens the Great Barrier Reef

WORDS KRISTEL TJANDRA

**T**he Great Barrier Reef is facing the hottest sea surface temperatures in four centuries. The rapid warming is causing massive coral bleaching that threatens the marine ecosystem and biodiversity. “The world is losing one of its icons,” said Benjamin Henley, a palaeoclimatologist at the University of Melbourne in Australia. “We will sadly see the demise of one of Earth’s most spectacular natural wonders.”

The Great Barrier Reef, off the coast of Queensland, is home to the world’s largest collection of coral reefs, stretching for more than 1,400 miles and covering an area greater than 134,000 square miles. In a recent study, scientists revealed that the sea surface temperature in the first three months of 2024 is the warmest ever recorded in 400 years, reaching 0.19 degrees Celsius above the previous record high. This unprecedented high temperature is the key driver of coral bleaching, the scientists said. Coral bleaching occurs when environmental stress, such as heat and pollution, causes a coral to expel the colourful algae, its primary food source, that live inside it. When the algae leave, the coral

loses its vibrant colours and turns white. Bleached corals are more susceptible to disease and death.

Scientists reconstructed sea surface temperatures from 1618 to 2024 using temperature records from several locations on the eastern part of the reef. The temperature records came from ship and satellite data as well as coral cores, which are drilled from coral skeletons and contain light and dark bands denoting the years. It’s “a bit like tree rings that we can count,” said Helen McGregor, a palaeoclimatologist at the University of Wollongong in Australia.

By measuring the strontium and calcium ratios in coral cores, the scientists could infer the water temperature at the time of the corals’ growth – the higher the temperature, the lower the strontium-to-calcium ratio. Similarly, the scientists also measured levels of one isotope of oxygen left behind in the coral. The higher the oxygen-18 content, the cooler the water temperature.

The scientists focused on the period between January to March, which marks

the Australian summer. They found that in the area they studied, sea surface temperatures between 2016 and 2024 were 0.77 degrees Celsius higher than they were between 1970 and 1990, and were nearly 1.7 degrees Celsius higher than the coolest summer in the four-century dataset. The new study shows the danger climate change poses to the Great Barrier Reef, McGregor said. In a 25 June decision, UNESCO’s World Heritage Committee declined to change the reef’s status from ‘under serious threat’ to the more urgent category, ‘in danger’, in part because conservationists have done a good job protecting the reef.

But McGregor said the new study clearly shows the problems with the UNESCO decision. “The science is pointing very clearly to the reef being in danger,” she said. While the findings highlight how urgently emissions need to be reduced, “there is a glimmer of hope,” Henley said. If the sea surface temperature can be kept from increasing further, there is a possibility of restoring the ecosystem.

## Did you know?

Coral reefs date back 240 million years



Mass coral bleaching has been happening to the Great Barrier Reef for decades

# Real-time brain stimulation slashes Parkinson's symptoms by half in trials

WORDS CHRISTOPH SCHWAIGER

**B**rain stimulation that rapidly adjusts in real-time can dramatically reduce Parkinson's symptoms, an early trial suggests. The device in question uses implanted electrodes that automatically respond to brain signals associated with slow movement or spasms seen in Parkinson's patients. The device then gives more or less electrical stimulation as needed. By comparison, traditional brain stimulation delivers constant electrical stimulation, and patients must have the degree of stimulation adjusted by a doctor.

The new adaptive deep brain stimulation (aDBS) system "cuts the duration of their motor symptoms in half and increases their quality of life," said Dr Carina Oehr, a cognitive neuroscientist at the University of California, San Francisco. Parkinson's disease is a neurodegenerative disease in which specific brain cells that make dopamine malfunction and steadily die off. These cells play a critical role in movement. Most Parkinson's patients take levodopa, a drug that elevates dopamine levels in the brain. But as the disease progresses, levodopa often stops being enough to manage the symptoms. At that point, many patients complement the drug with constant deep brain stimulation (cDBS), in which surgeons implant electrodes that alter the signals underpinning Parkinson's symptoms. While the treatment is safe and works because stimulation is constant, it can both under or over-compensate for a person's symptoms.

To see if there could be a better approach, Oehr and her colleagues implanted a device that could switch between providing continuous or aDBS in four men with Parkinson's. The researchers asked each patient which symptom bothered them most. Three said bradykinesia, or

slow movement, while the last said spasms. Then they zeroed in on the brain signal related to the problem symptom. After continuously recording from two brain regions, the team trained algorithms to predict the course of a patient's symptoms and respond to them. The aDBS device reacted to a brain signal that marked when a patient's dopamine levels rose right after they took their medication, and fell as the effects of the drugs wore off.

After the training period, the patients left the clinic and went about their daily lives. The device then delivered either cDBS or aDBS, switching back and forth over time. In theory, patients didn't know which type of stimulation was active at any given time. "But after a while, they could really tell the days when they were on aDBS just because their motor symptoms were controlled so well," Oehr said. The patients rated which stimulation they preferred through a phone app, reporting aDBS to be superior. Oehr said there are likely many patients for whom cDBS alone will suffice because their symptoms don't change throughout the day. Those whose

symptoms fluctuate would be most likely to benefit from the new system, she suggested. While the researchers focused on just one type of symptom at a time for this study, Oehr hopes future algorithms can respond to additional symptoms.

The study is noteworthy because it looked at a new type of brain signal as a trigger for activating the device, which could open the door to a wider range of applications than has previously been considered. According to Dr Martijn Beudel, a neurology specialist at Amsterdam University Medical Center, the new research has "significantly advanced" the therapy's potential in treating Parkinson's disease.

A new device reacts to rising and falling levels of Parkinson's medication to help alleviate the symptoms of parkinson's disease



In just one minute, the new charger can power up smartphones from nothing to 25 per cent

## TECHNOLOGY

# The world's fastest charger fully powers smartphones in five minutes

WORDS KEUMARS AFIFI-SABET

**S**cientists have revealed the fastest battery-charging technology in the world for smartphones, which can fully charge a smartphone in less than five minutes. The 320-watt fast-charging technology, dubbed '320W SuperSonic Charge', was developed by Chinese consumer electronics company Realme and beats out previous chargers. Smartphone maker Redmi had previously unveiled a 300-watt technology to charge up a device in four minutes and 55 seconds in 2023, but no manufacturer has since been able to go beyond this, until now. Realme representatives demonstrated the new technology at the Realme 828 Fan Festival event in Shenzhen, China, on 14 August. The record-breaking fast-charging capability can power up a smartphone's battery to 26 per cent in one minute and to 50 per cent in less than two minutes. It takes four minutes and 30 seconds to fully charge a smartphone.

Unlike conventional charging, in which power is transferred to a single battery cell or to multiple cells in sequence, fast-charging technology simultaneously charges multiple battery cells in a single battery. In a demonstration, Realme representatives rapidly charged a folded battery design with a 4,420 milliampere-hour capacity that stacked four cells on top of each other. This design provides a ten per cent higher capacity than conventional designs. The scientists miniaturised each battery cell into layered structures to pack more charging capacity into

a smaller space before folding four battery cells to mimic the shape of satellite panels.

The company also created a power adapter known as a 'Pocket Cannon' that has a power density of 3.3 watts per cubic centimetre. Other devices, including iPhones with a USB-C port, will receive power from the adapter, but not at the same rate. By comparison, a 240-watt charger the same company revealed last year was enabled with an adapter with a 2.34 watts per cubic centimetre power density. This previous technology could charge up the Realme GT Neo 5 smartphone in less than ten minutes. The new adapter can be used with many fast-charging standards, company representatives said, including UFCS, PD and SuperVOOC, and has two USB-C ports so users can charge up two devices at the same time. The maximum charging rates are up to 150 watts for Realme smartphones and 65 watts for compatible laptops.

Realme also unveiled the 'AirGap' voltage transformer, which ensures that high voltages are isolated from smartphone batteries during any electrical faults like circuit breakdowns. This is to prevent damage to the smartphone. The transformer relies on something called 'contact-free electromagnetic conversion'. The tiny transformer reduces the voltage to 20 volts to protect battery life and helps the fast-charger maintain a 93 per cent power efficiency while charging.

## SPACE

# THE TRIANGULUM GALAXY SHINES IN A NEW HUBBLE IMAGE

WORDS SAMANTHA MATHEWSON

A nearby galaxy is shining with star formation in a new image from the Hubble Space Telescope. The spiral galaxy Messier 33, also known as the Triangulum Galaxy, is the third-largest member of the Local Group of galaxies after the Andromeda Galaxy and our own Milky Way. Measuring only 60,000 light years across, Messier 33 is about half the size of the Milky Way. Located nearly 3 million light years from Earth, the Triangulum Galaxy is regarded as a 'hotbed of starbirth', forming stars at a rate ten times higher than the neighbouring Andromeda Galaxy. "Interestingly, Messier 33's neat, organised spiral arms indicate little interaction with other galaxies, so its rapid starbirth is not fuelled by galactic collision, as in many other galaxies," NASA officials said.

Instead, new stars are born from ample amounts of dust and gas within the galaxy. Collisions between massive ionised hydrogen clouds known as H II regions create high-mass stars, which can be seen in the new Hubble image. The large reddish clouds in the Hubble photo represent the pockets of ionised hydrogen, which along with the dark streams of gas fuel the galaxy's rapid star formation.

### Did you know?

The Hubble Space Telescope orbits Earth at 17,000 miles per hour



Hubble image of the Triangulum Galaxy, the third-largest galaxy in our Local Group of galaxies

# WISH LIST

The latest **KITCHEN GADGETS**

## TOTAL CONTROL SOUP MAKER

£129.99 (APPROX. \$170)

MORPHYRICHARDS.CO.UK

Making soup may never be easier than when using this soup maker by Morphy Richards. From crunchy vegetables to velvet-smooth broths, there are nine individual settings to create a wealth of soups, broths and sauces. Simply put your ingredients into the 1.6-litre container, choose a cooking setting and let the soup maker chop, blend and cook them into a delicious meal. The soup maker's smart response technology will also automatically adjust cooking times based on the quantity of your ingredients.



## CUISINART VERTICAL WAFFLE MAKER

\$59.95 (APPROX. £46)

CUISINART.COM

A Belgian waffle is a thing of culinary beauty, and with this Cuisinart creation, making them at home is foolproof. By simply adding batter into the spout of the vertical waffle maker to the fill line, you can create perfect waffles that don't overflow. To suit everyone's waffle preference, there are five different browning levels to choose from, and when the waffle is ready the maker sounds an audible alert. The vertical design of

the waffle maker also makes it easy to store and minimises the room it takes up on your countertop.



## SHROOLY

€399 (APPROX. £337 / \$440) EU.SHROOLY.COM

There are so many weird and wonderful edible mushrooms to enjoy, and Shrooly lets you cultivate your own fungi crop at home. This countertop fungi farm uses a pre-spored brick to grow luscious mushrooms in just seven days. Simply load in the mushroom brick, fill up the water tank and activate it through the companion app. Over the next seven days, Shrooly will humidify and provide the right amount of light for growth. Some fungi species can be harvested more than once, and the soil within the brick can be composted or used as plant soil.



## R2530 BREADMAKER

£179.99 (APPROX. \$235.10)

PANASONIC.COM

From sourdough to brioche buns, this fully automatic breadmaker by Panasonic lets you create a whole host of different breads at the touch of a button. There are 30 bread mix programs for you to get inspired by, which include specific gluten-free programs so that everyone can enjoy making bread. There are also a few handy features, including an automatic raisin and nut dispenser for textured breads and a timer to delay baking. Surprisingly, bread and cakes aren't the only foods that this machine can create, thanks to its jam, compote and pizza dough programs.



## BOSCH SERIES 4 STAND MIXER

£429.99 (APPROX. \$561.60) BOSCH-HOME.CO.UK

As one of the most high-tech stand mixers on the market, this Bosch creation is packed full of features to make cooking easier. It has a powerful motor with seven different speeds, comes with an integrated weighing scale for direct measurements in the bowl and an integrated timer for precise preparation times, such as for proving dough. There's also a myriad of accessories, such as whisks, paddles and grating plates to add cheese and butter

directly to the bowl. To ensure that the Bosch Series 4 doesn't hop along the countertop while mixing, a sturdy suction cup under its base holds it in place.



## CHOCOLISSE

£59 (APPROX. \$77) PETRA-ELECTRIC.COM

As the chill of autumn emerges, a cup of hot chocolate is a wonderful way to warm up. To make a smooth and rich beverage, the Petra Chocolisse hot chocolate machine heats up to 300 millilitres of milk and chocolate flakes to 65 degrees Celsius for up to five minutes. There's also the option to create 150 millilitres of frothed milk using its integrated frothing whisk. Using the touchscreen panel, you can select light foam for lattes or thick foam for cappuccinos. There's also the option to create cold froth to make iced coffees.





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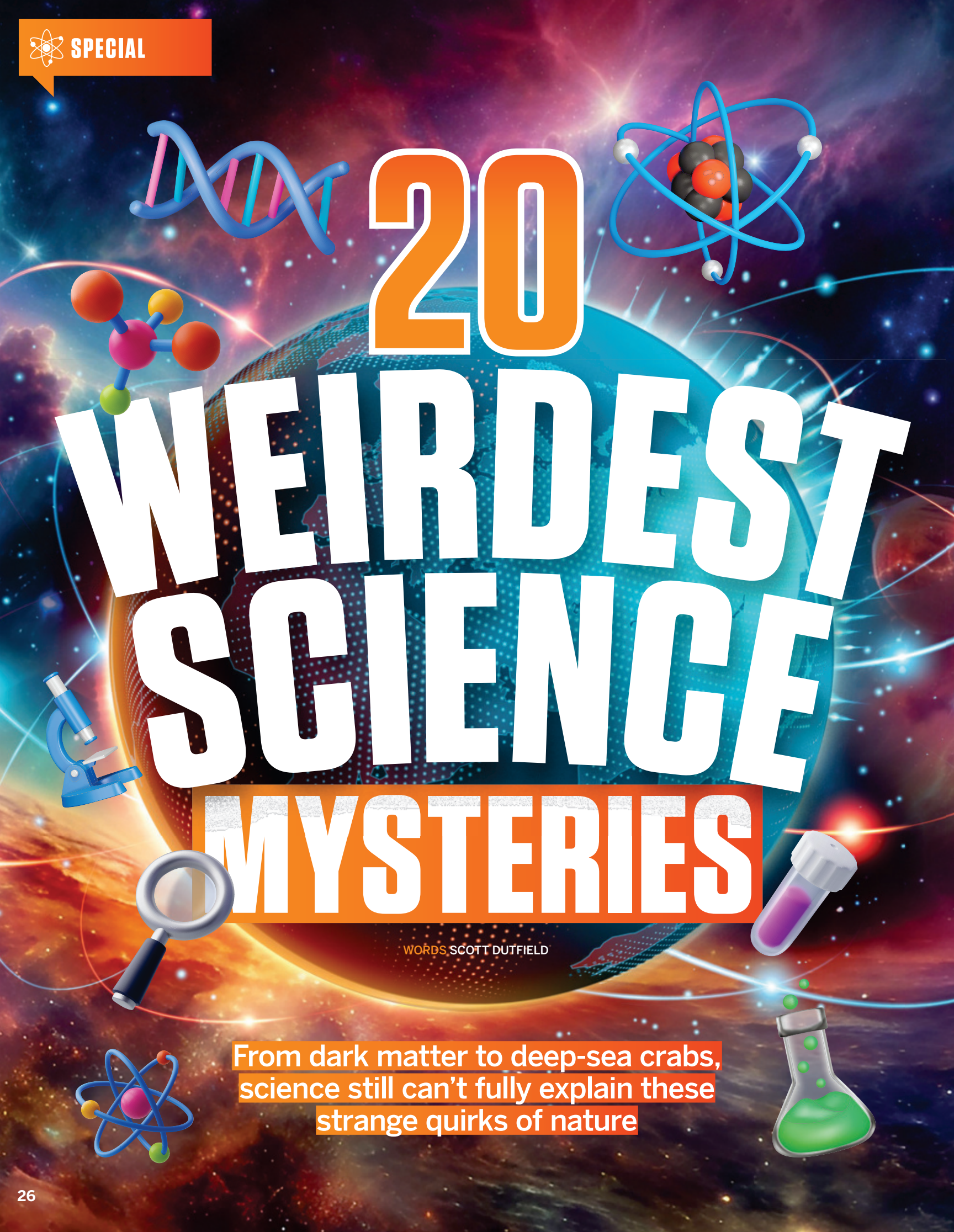
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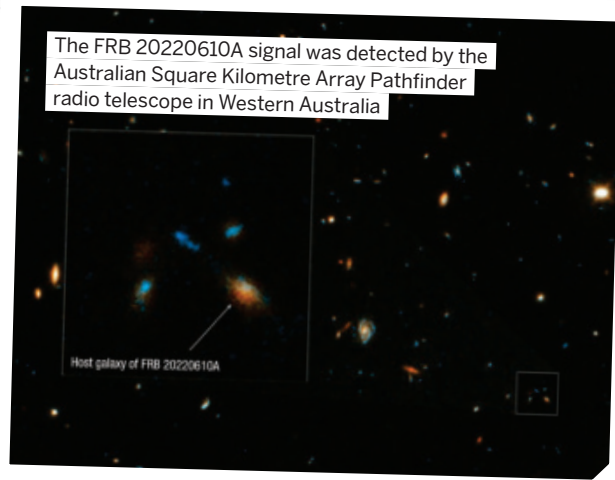
# 20 WEIRDEST SCIENCE MYSTERIES

WORDS SCOTT DUTFIELD

From dark matter to deep-sea crabs, science still can't fully explain these strange quirks of nature

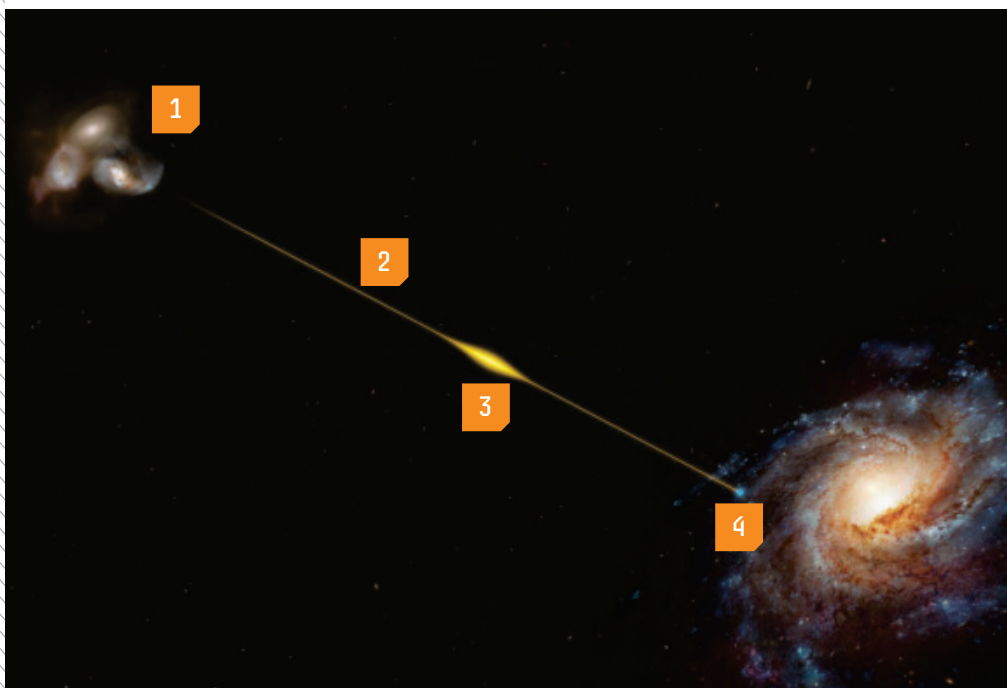
**DID YOU KNOW?** The oldest possible age for humans is unknown – the current record is 122 years and 164 days

# STRANGE RADIO BURSTS FROM DEEP SPACE



**1** Since 2007, scientists have been plagued by cosmic signals called fast radio bursts (FRBs). In just one-thousandth of a second, bursts of radio waves radiate from a source. These then travel through space and are picked up on Earth. FRB 20220610A, detected in 2022, travelled around 8 billion light years before it reached our planet. The first FRB was detected in 2001 by the Parkes Observatory in Australia, emanating from a nearby dwarf

galaxy called the Small Magellanic Cloud. However, researchers didn't discover the burst until 2007 while looking through archival data. Since then, around 1,000 have been detected, though their origins remain unknown. Many theories have emerged to answer the mystery behind the bursts, including energetic neutron stars, black holes or highly magnetised stars. Most FRB signals are also non-repeating, curbing scientists' efforts to pinpoint their sources.



## MYSTERY SIGNALS

The journey FRB 20220610A took before reaching Earth

- 1 GALACTIC SOURCE**  
Although the exact source of the FRB is unknown, scientists know that it emerged from a dwarf galaxy that's part of a compact group of galaxies.
- 2 LONG JOURNEY**  
The FRB travelled from 8 billion light years away – one light year is equal to around 5.8 trillion miles.
- 3 POWERFUL BURST**  
Within a fraction of a second, the burst emitted more energy than the Sun's total energy output for the last 30 years.
- 4 DETECTION**  
The FRB was traced back to the dwarf galaxy by the Very Large Telescope (VLT).

# WHERE DOES CONSCIOUSNESS COME FROM?

**2** We all know that who we are comes from our brains, but scientists are still scratching their heads when it comes to figuring out how this organ conjures up consciousness, which gives us the ability to be self-aware and feel things with the help of the sensory information that the brain receives from our bodies. All the information directed to the brain crosses a network of billions of neuron cells that store, recall and process it, allowing us to interact with the world around us and develop a sense of self. Within that network of neurons is a region of the brain called the cerebral cortex, which scientists believe is the 'seat of consciousness'. However, how the neurons create consciousness in the cerebral cortex remains a mystery.

Consciousness means the brain is the only organ which can question its own existence



**Did you know?**  
The human brain is 60 per cent fat



# SPONTANEOUS HUMAN COMBUSTION

**3** Spontaneous human combustion (SHC) is something that has puzzled the scientific community for the past 300 years. Over this time, around 200 accounts of humans bursting into flames have been recorded. In December 2011, a coroner ruled that a 76-year-old man in Galway, Ireland, had died as a result of SHC. Investigators found no accelerant for the fire that consumed the man, along with damage to a patch on the ceiling directly above the body and the floor below it.

However, the existence of SHC has been furiously debated, with many scientists laying blame on undetected flame sources being the true culprit. This scepticism has been further



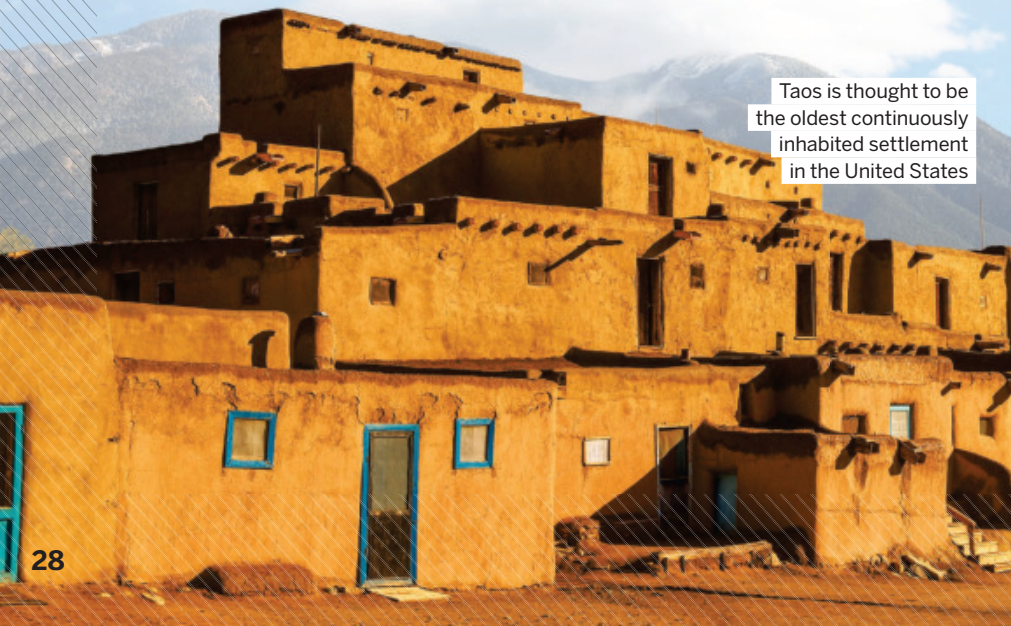
Dr John Irving Bentley is thought to have died from SHC aged 92 in 1966 – only his leg remained

supported by a theory called the wick effect, where clothes act as a candle wick and body fat acts as the fuel. British biologist Brian Ford has suggested that the buildup of flammable acetone in the body may offer some explanation as to how the human body might stay alight. Nevertheless, scientists haven't been able to categorically prove whether SHC is a real phenomenon, and if it is, how it can be explained.

# THERE'S A CONSTANT HUM IN NEW MEXICO

**5** There's a hum that has rippled through the town of Taos in New Mexico since the early 1990s. Only around two per cent of Taos' residents can hear the hum, which many describe as a low-rumbling engine, while others have compared it to a bee hive or the whir of a fan. Researchers have attempted to locate the sound and have been unable to account for the source of the hum.

However, there have been plenty of suggestions as to why people may experience the sound, including geological formations creating acoustic resonance, electromagnetic fields or that the hum is a form of tinnitus or 'spontaneous otoacoustic emission' in the hearers. Taos is not alone. There are several unexplained 'hums' around the world, including in Auckland, New Zealand, and Darmstadt, Germany.



Taos is thought to be the oldest continuously inhabited settlement in the United States

# WHAT IS DARK MATTER?

**4** Over 27 per cent of the known universe is made up of a mysterious substance called 'dark matter'. Unlike visible matter, also known as baryonic matter, dark matter emits no light or energy and is completely undetectable by conventional sensors. The only way that scientists know of its existence is because of the gravitational effect it has on visible matter. It was first inferred in the 1930s while Swiss astronomer Fritz Zwicky was studying the movement of galaxies in the Coma Cluster. However, the existence of dark matter wasn't confirmed until the 1970s by American astronomer Vera Rubin. What scientists don't know is what particles make up dark matter. Some researchers have speculated that weakly interacting massive particles (WIMPs), which are currently

hypothetical, are the building blocks of dark matter. Others believe that our understanding of gravity might be challenged by the existence of dark matter and that it exists as a web throughout the universe and affecting visible matter.

## Did you know?

Dark matter outweighs visible matter by around six to one



Though scientists don't know what it's made of, they are sure that dark matter has mass

**DID YOU KNOW?** Scientists have only explored around five per cent of the world's oceans

## BREEDING GROUNDS OF AN ELUSIVE EEL

**6** The ancient Egyptians believed that eels sprung up from the Sun-warmed waters of the Nile, and during the 4th century BCE, Aristotle thought they erupted from mud. However, it wasn't until 2022 that scientists finally tracked down where the mysterious European eel goes to mate. Every year, European eels journey from continental rivers to their breeding grounds in the Sargasso Sea in the North Atlantic. How they find their way there and what they do once they arrive, however, has not been documented and remains a mystery.

Scientists do know the mechanisms of how eels reproduce, though laboratory studies proved difficult as the eels have no obvious reproductive organs: it turns out that reproduction

for eels is their final affair. When they are ready to mate, their stomachs dissolve and reproductive organs develop in their place. Females release eggs into the water, and the males fertilise them. Shortly after, the adults die, meaning their journey to the Sargasso Sea is a one-way trip.



## AN EEL'S LIFE CYCLE

The many phases of this fish's journey across the sea

### 6 YELLOW EEL

As immature adults, elver eels grow into yellow eels. This life stage lasts for many years while they spend time in rivers.

### 5 ELVER EEL

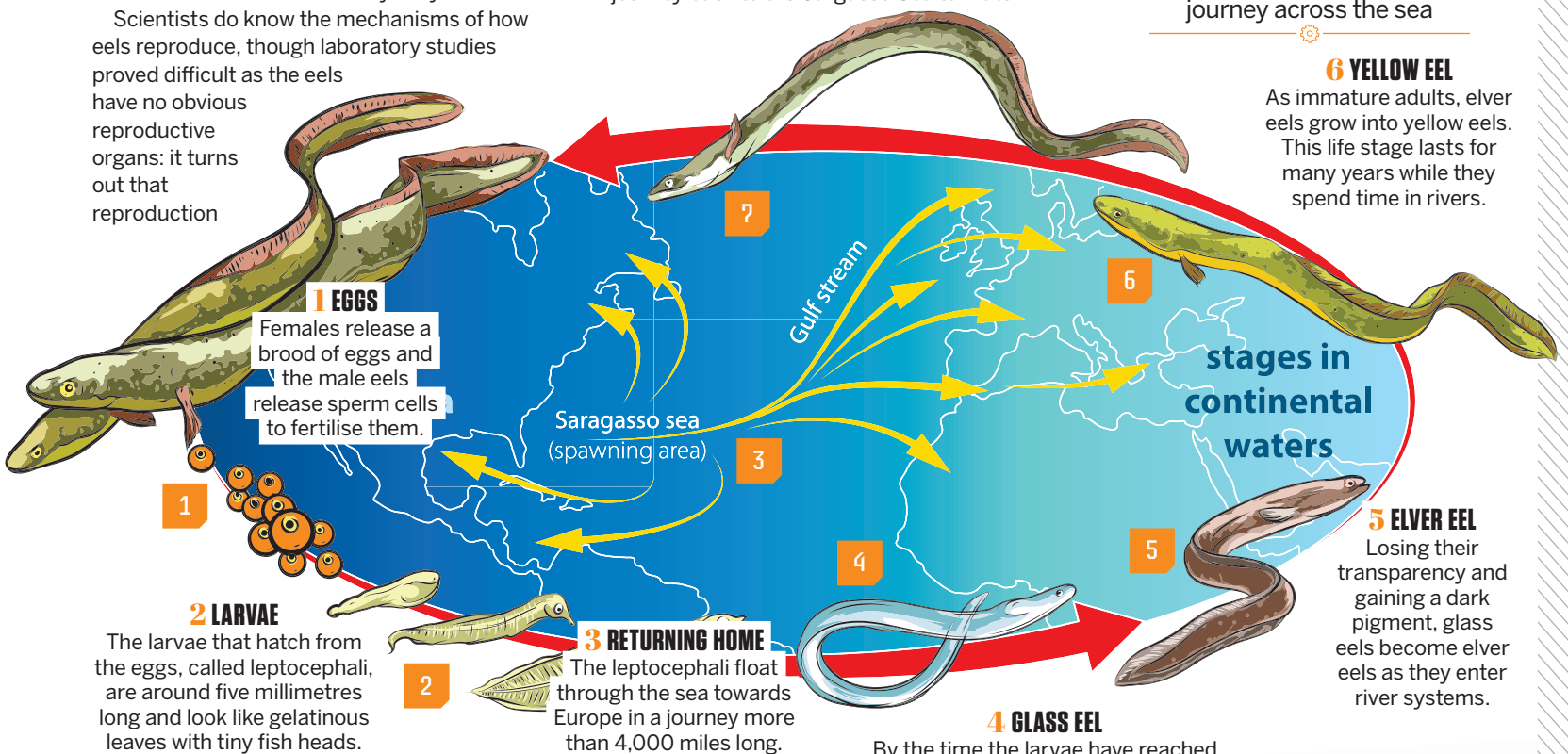
Losing their transparency and gaining a dark pigment, glass eels become elver eels as they enter river systems.

### 4 GLASS EEL

By the time the larvae have reached the continental shelf of Europe, they have grown into slender transparent eels called glass eels.

### 7 SILVER EEL

When the eels reach maturity they grow into silver eels, which can reach up to 70 centimetres long. They will then make the journey back to the Sargasso Sea to mate.



## DECIPHERING AN ANCIENT CODEX

**7** Often touted as the 'world's most mysterious book', the Voynich manuscript is a 15th-century codex that researchers are still trying to understand. Thought to have been written in Central Europe, its author and the language within it remain largely unknown. Between the 240 pages of the codex are some 38,000 words and a myriad of illustrations that fall into six categories: botany, astronomy, anatomy, geography and recipes. Among the illustrations are 113 unidentified seemingly prehistoric or alien plant species.

A Polish antiquarian bookseller named Wilfrid Voynich acquired the manuscript in

1912, but knowledge of its ownership over the centuries contains many gaps. Researchers have established that the manuscript was purchased by the Holy Roman Emperor Rudolph II some time between 1576 and 1612. In 1969, the Voynich manuscript was donated to the Beinecke Rare Book and Manuscript Library at Yale University, where it remains. The origin of the manuscript, its true author and its contents remain mostly a mystery. In April 2024, researchers made some headway in deciphering its contents and proposed that a section of the manuscript was dedicated to female reproductive health and medicine.





Why do so many crustaceans end up looking like crabs?

**Did you know?**  
Crabs first evolved around 200 million years ago

# ANIMALS KEEP TURNING INTO CRABS

**8** If you've ever been told that everything will look like a crab in the end, then you've heard something that isn't that far from the truth. While humans probably aren't destined for life under the sea in the near future, transformation into a crab, called *carcinisation*, has happened many times to various species over millions of years. Among the 52,000 species of crustaceans that traverse the world's waterways, 7,600 are known as 'true crabs', but 10,000 belong to a group called 'false crabs'. Animals in the false crab infraorder Anomura, which includes king crabs and coconut crabs, look remarkably like their true crab cousins. The groups share qualities like a rounded, flat body and an abdomen hidden on their underside with hidden tails tucked underneath. The similarities in their evolution are an example of convergent evolution, where animals develop similar characteristics that are beneficial to their environment. However, when it comes to crabs, scientists still aren't sure what natural driving force is moving so many species to the crabby side.



## COMMON SIGNS OF CARCINISATION

Meet the crustaceans that have mimicked the evolution of their crabby cousins

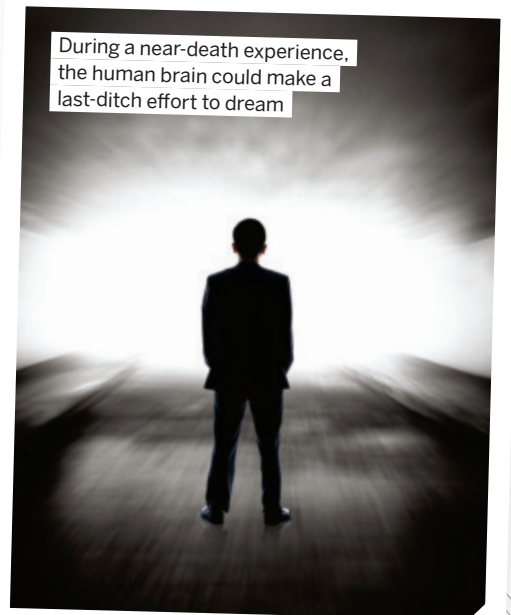
- 1 FLAT BODY**  
The carapaces of crabs are flattened and wide, often with raised edges on the dorsal carapace.
- 2 FUSED THORACIC STERNUM**  
The underside of a crab is made up of fused segments, called sternites, into a single plate called the thoracic sternum.
- 3 HIDDEN TAIL**  
The abdomen, or pleon, is hidden underneath from the dorsal view, under the body.
- 4 LOSING THE ENDS**  
Carcinisation causes crustaceans to lose the final fanned out segments of the tail, called uropods.

## NEAR-DEATH EXPERIENCES

**9** Around 10 to 20 per cent of people who have been close to death but have survived to report their experiences say they caught a glimpse of their loved ones who have passed, or witnessed a bright-white light. While many think the light source is a beacon from the 'other side', scientists aren't quite as convinced.

In 2023, researchers at the University of Wisconsin-Madison made some headway into discovering the source of this bright-white light. Scientists monitored the brain activity of four terminal human patients using electroencephalograms. Their brain

activity was monitored both before and after the patients were withdrawn from ventilation support. What the researchers discovered is that two of the patients experienced high levels of gamma activity in the regions of the brain that are associated with internal visualisation while dreaming. This could explain the visions of loved ones and bright lights experienced during a near-death experience, though much more research is needed to fully understand how the brain reacts in a near-death situation. There are also no clues yet as to why some people experience these visual events, while others don't.



During a near-death experience, the human brain could make a last-ditch effort to dream

**DID YOU KNOW?** In the 1970s, unknown forces slightly deviated the trajectories of Pioneer 10 and 11

## FEELING THE ASMR TINGLE

**10** If you're the type of person who feels a spine-tingling sensation brought about by someone moving a brush over a sensitive microphone, then you might be experiencing an autonomous sensory meridian response (ASMR). Two symptoms of ASMR affect those who experience it: a tingle or sparkly sensation that travels from their heads down their spine, along with a sense of relaxation. ASMR isn't solely a response to delicate sounds – a gentle touch can also produce it. Researchers have located the region of the brain that initiates the sensation – the medial prefrontal cortex. However, an explanation as to why some people experience it and others don't remains to be found. Some scientists have

suggested that brain formation and early experiences can cause a difference, or even that differences in personality may prevent certain people from experiencing the sensation.

The term autonomous sensory meridian response was coined in 2010



## STRANGE LIGHTS IN THE SKY

**11** In the village of Hessdalen in central Norway, mysterious lights have intrigued people since the 9th century CE. Known as the Hessdalen lights, this is an atmospheric phenomenon that produces ball-like lights of different shapes and colours. These dancing lights move quickly through the sky, but can also remain in place for up to two hours, according to some reports. While some have speculated that the lights could be beacons for extraterrestrial life, scientists have proposed several earthly theories. It's been suggested that the lights may come from ionised dust that illuminates under specific conditions in the atmosphere. Other theories attribute their existence to interactions between Earth's geomagnetism and the atmosphere, charged particles from radioactive radon gas or even the piezoelectricity of nearby quartz. Nevertheless, all of these theories are yet to be proven, and the Hessdalen lights remain a mystery.

Hessdalen lights over Fjell, Norway, in the late hours of twilight



The simple act of taking medicine, whatever its effectiveness, can help improve some conditions

## THE PLACEBO EFFECT

**12** When trialling a new medical treatment, researchers commonly administer a portion of trial participants with a 'fake' version of the treatment, called a placebo. By using the placebo, scientists can compare the results of the trial with genuine treatments. If patients who were given the genuine treatment improved when compared to those given the placebo, it indicates that the treatment works. Along with discovering new medicines and treatments, using a placebo also brought a phenomenon called the placebo effect to light, where the act of simply taking medicine can help someone heal.

In a 2014 study of migraine attacks, researchers found that a placebo was 50 per cent as effective at treating a migraine compared to a real drug. Little is known about why taking a placebo works, but many scientists suggest that an increase in the release of neurotransmitters such as endorphins may play a role. Taking a placebo might simply act as a prompt for the brain that there's an issue in the body and it needs to act.

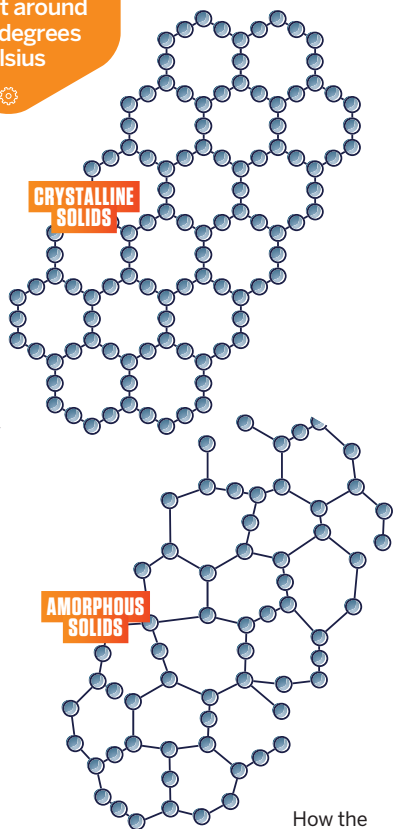


# GETTING TO GRIPS WITH THE GLASS PHASE

**13** School taught us that there are three states of matter: gas, liquid and solid. As matter shifts between these states, molecules arrange themselves into different orientations. However, glass doesn't technically fall into any of those three categories, and still leaves scientists confused today. When glass transforms from a molten liquid state to a solid, glass atoms don't fall into the uniform 'crystalline lattice' of a typical solid. Instead, the atoms in the 'glass phase', also known as an amorphous solid, remain in irregular orientations like a liquid. It's been suggested that the amorphous state of glass means that the atoms within it are still moving like liquid, albeit on an extremely slow basis, taking millions of years to see any sort of difference in the glass. As to why the molecules of glass don't form crystalline lattices like other solids, it remains a mystery.

**Did you know?**

Sand melts into glass at around 1,700 degrees Celsius



How the amorphous solid structure of glass compares to a crystalline solid



Dancing mania plagued Central Europe during the 14th and 17th centuries

# THE DANCE-TO-DEATH PLAGUE

**14** In 1518, a woman known as Frau Troffea began to dance with a rhythm that would eventually spread uncontrollably throughout the city of Strasbourg. In July, Troffea began to twist and shake through the streets. Her lively jive continued for six days straight without any respite, by which time 34 additional people had 'caught' her dance fever. By August, around 400 people had come down with the dancing disease and were compelled to bust a move. Doctors at the time blamed 'hot blood', suggesting that the dance moves were an attempt to shake the fever. Musicians were even

brought to Strasbourg to help alleviate sufferers of their affliction, with little success. Some dancers suffered exhaustion and even died from strokes and heart attacks. Over time the dancing plague wore off, without any real explanation for it in the first place. Modern scientists suspect that ergot fungus poisoning may have caused hallucinations and convulsions, or that a psychological phenomenon called mass psychogenic illness, also known as mass hysteria, may have been the culprit. The Strasbourg dancing epidemic isn't an isolated incident. Historical records show several similar dancing plagues have occurred throughout the ages.



The Mpemba effect can be easily observed by anyone at home

# WHY DOES HOT WATER FREEZE QUICKER THAN COLD WATER?

**15** Figures in philosophy and science, such as René Descartes and Aristotle, observed a strange phenomenon: that hot water freezes faster than cold water. However, the first scientific investigation into the oddity came from a Tanzanian teenager named Erasto Mpemba and physicist Denis Osborne in the 1960s. Mpemba had stumbled upon the mystery after impatiently putting boiled milk and sugar into a freezer to form ice cream during a school experiment, finding that it froze faster than the cool concoctions of the other students. When Osborne visited Mpemba's class, he asked Osborne why water at 100 degrees Celsius freezes before water at 35 degrees Celsius.

Intrigued by his question, the two went to University College in Dar es Salaam to recreate Mpemba's theory, which became known as the Mpemba effect. As to why the Mpemba effect occurs, the jury is still out. Several efforts have been made to explain it, including the theory that heating water might weaken the hydrogen bonds between water molecules so that it cools quicker, or that evaporation reduces the volume of the water and makes it quicker to chill. However, scientists are yet to come to a consensus as to why exactly hot water freezes faster than cold water.

**DID YOU KNOW?** Scientists still don't know how migrating animals precisely navigate thousands of miles to breeding sites

# RAINING ANIMALS

You've probably heard the saying, 'it's raining cats and dogs', but in some parts of the world, animals have quite literally fallen from the sky as rain. Frogs, fish and birds have all reportedly been seen as 'animal rain' over the years. Tornado-like storms over large bodies of water, called waterspouts, are commonly cited as the cause of animal rain. During the storm, animals caught in the wind are thought to be whipped up, thrown around at up to a hundred miles per hour and tossed onto land. Similarly, updraft winds are thought to have the power to lift lightweight debris high above Earth's surface before releasing it as rain. What's most mysterious about animal rain is that reports tend to identify just one type of species falling from the sky at a time, without any other debris. The weight of a species could offer some explanation. For example, during a storm any animals swept up by strong winds and carried across land would drop in weight order, with the heaviest species falling first and the lighter species landing last, some distance apart from each other.



Why does just one type of animal fall from the sky?



16



17



18



20

**16 SPIDERS IN BRAZIL**  
In 2013, a downpour of social spiders flooded the town of Santo Antônio da Platina in southern Brazil. Scientists suggested that it may have been a 'dispersal event' or sudden migration.

**17 JELLYFISH IN ENGLAND**  
In the city of Bath, England, in 1894, by-the-wind-sailor jellyfish supposedly rained down through the streets. The cause of the downpour is unknown, although a waterspout over the Bristol Channel may have carried them across land.

**18 FROGS IN HUNGARY**  
On 18 and 20 June 2010, the town of Rákóczi in Hungary experienced two frog-raining events. These froggy phenomena may have been caused by a tornado.

**19 OCTOPUSES IN CHINA**  
2018 was the year that octopuses and some other sea life landed throughout the Shandong province of China. The eight-legged rain could have come after a heavy thunderstorm that may have washed the creatures onto land.

**20 WORMS IN LOUISIANA**  
Clumps of earthworms landed on the ground of Jennings, Louisiana, in 2017 in their hundreds. The worms were alive as they fell and continued to wiggle around.



# YOUR SKELETON EXPLAINED

WORDS AILSA HARVEY

**It gives you shape, holds you together and encases vital organs, but this living structure is so much more than a coat hanger for your body**

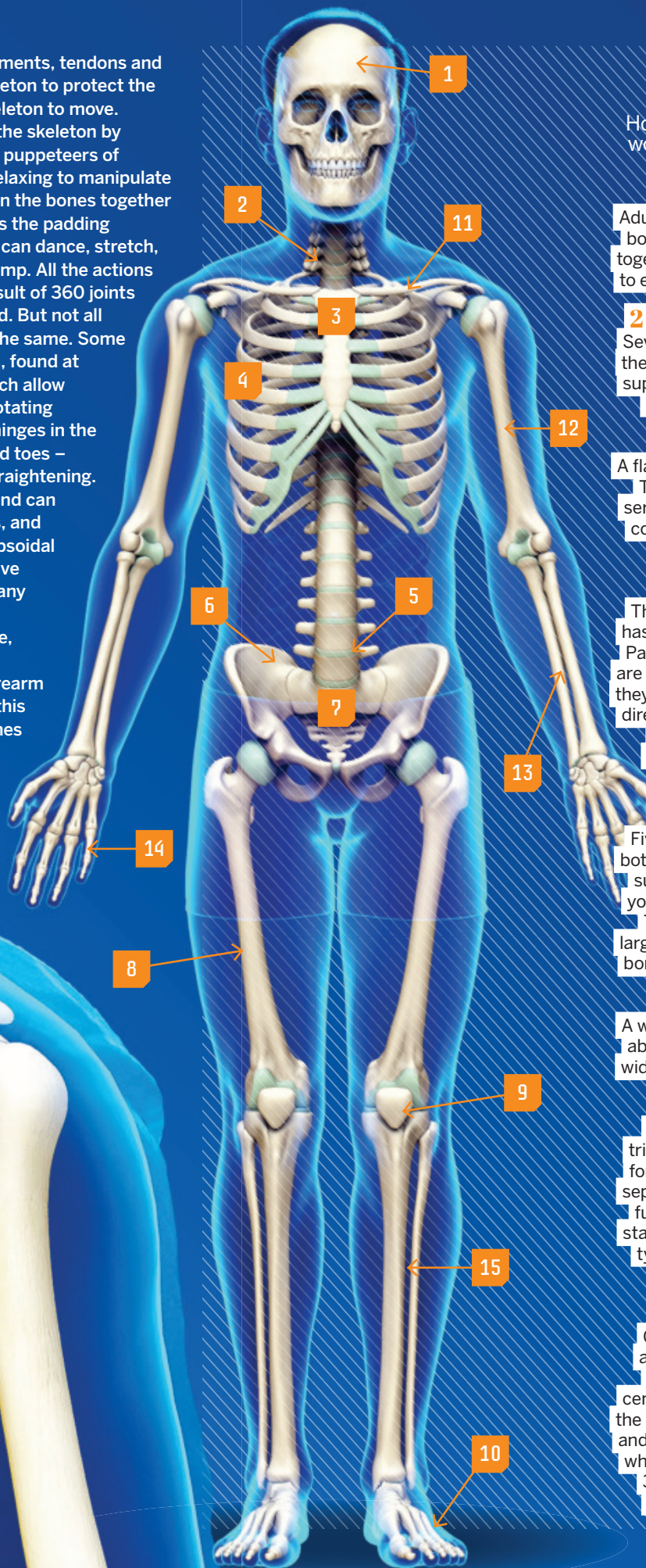
**S**keletons are often associated with death as part of the body you rarely see during life. However, you might be surprised to learn that the skeleton is living tissue. Far more than stiff, biological scaffolding, the skeleton comes with its own network of blood vessels, cells, proteins and minerals, continuously transforming and self-repairing to keep your body strong and healthy. The bones that make up your skeleton connect to form shields around delicate organs. The skull seals up when a baby is three months old and its joints close to complete the brain's armour. Meanwhile, the ribs cross over the heart and lungs like the bars of a cage and a string of vertebrae conceal your spinal cord. Bones also give the body structure. But the skeleton would fall limply into a pile of bones without the assistance of the rest of the skeletal system.

**“The bones that make up your skeleton connect to form shields around delicate organs”**



**DID YOU KNOW?** You are born without kneecaps. These bones form from cartilage at age two to five

Muscles, cartilage, ligaments, tendons and joints connect to the skeleton to protect the bones and enable the skeleton to move. Muscles are attached to the skeleton by tendons and serve as the puppeteers of bones, contracting and relaxing to manipulate joints, while ligaments join the bones together and cartilage tissue forms the padding between them. The body can dance, stretch, crouch, grab, poke and jump. All the actions you can perform are a result of 360 joints being perfectly positioned. But not all the skeleton's joints are the same. Some are ball-and-socket joints, found at the shoulder and hip, which allow backward, forward and rotating movements. Others are hinges in the fingers, knees, elbows and toes – limited to bending and straightening. The neck is a pivot joint and can perform limited rotations, and wrist joints are called ellipsoidal joints. Ellipsoidal joints give you flexibility to move in any direction except pivotal movements – for example, your wrist can't rotate independently of your forearm bones. When combined, this intricate collection of bones and joint structures grants you the ability to interact with the world.



## THE BONES

How a connected collection of bones works together to hold up your body

### 1 SKULL

Adults have 22 skull bones, which fuse together and harden to encase the brain.

### 2 CERVICAL SPINE

Seven vertebrae at the top of the spine support the weight of your head.

### 3 STERNUM

A flat, 15-centimetre T-shaped bone serves as a central connection point for the ribs.

### 4 RIBS

The human body has 12 pairs of ribs. Pairs one to seven are called true ribs – they're the only ones directly connecting the spine to the sternum.

### 5 LUMBAR VERTEBRAE

Five bones at the bottom of the spine support most of your body weight. These are the largest and thickest bones in the spine.

### 6 PELVIS

A woman's pelvis is about 25 per cent wider than a man's.

### 7 SACRUM

This singular triangular bone is formed when five separate vertebrae fuse together to stabilise the pelvis, typically before age 25.

### 8 FEMUR

Growing to an average length of around 46 centimetres, this is the longest, heaviest and strongest bone, which can support 30 times your body weight.

### 9 PATELLA

The kneecap is a shield for knee joints. Tendons, ligaments and muscles attach to move the knee.

### 10 FOOT

With 52 bones, a quarter of your total adult bone count is in your feet.

### 11 CLAVICLE

These long, curved collar bones connect your arms to your central body. They rotate when arms are lifted and are the most fracture-prone.

### 12 HUMERUS

This is the only bone in the upper arm, holding 13 muscles in place.

### 13 ULNA AND RADIUS

These two bones make up the forearm and assist with wrist and elbow movements. The ulna is slightly longer.

### 14 HAND

There are 27 bones in the hand, 14 of which are in the fingers.

### 15 FIBULA AND TIBIA

The tibia is a thicker, more weight-bearing bone in your shin, while the fibula is positioned on the outside to stabilise the ankle.

**Did you know?**

Joints in the skull don't move



## CUSHIONING CARTILAGE

Between the bones of the skeleton is a flexible type of connective tissue called cartilage. This serves as a shock-absorbing layer for the bones, reducing the impact of skeletal movement on the joints. Cartilage can also form much of entire organs, such as the ear. The cartilage found between the bones of the skeleton is called articular cartilage. Around 80 per cent of articular cartilage is made of water, which makes it highly elastic and flexible. The tissue is smooth and reduces the friction caused by two bones moving against each other. As a person ages, they begin to lose some of their cartilage as it dries out, which makes it more easily damaged. In old age, it's also more difficult for the body to repair and replace damaged cartilage tissue. When the skeleton loses cartilage, the body becomes stiffer, more difficult to move and joint pain increases.



This model of a knee joint shows the protective cartilage surrounding bones

### 2 COLLATERAL LIGAMENTS

Ligaments connect tendons to bones. These ligaments stabilise the toe joints to keep them straight and prevent excessive movement.

# MAKING MOVEMENTS

How a coordinated system of muscles, tendons and ligaments creates movement in the skeleton

### 7 MUSCLES

Muscle tissue contracts to generate force. They are attached to bones via tendons. As they shorten, they pull tendons that move the connected bone.

### 5 CALCANEAL TENDON

Also called the Achilles tendon, this tissue connects the calf muscle to the heel bone so you can stand on your tiptoes.

### 1 EXTENSOR DIGITORUM LONGUS TENDONS

These fibrous tissues connect muscle to the bones to extend toes and lift the foot upwards.

### 3 FIBULARIS TERTIUS TENDON

The tendon lifts the outer foot bone upwards when the fibularis tertius muscle contracts. This balances the foot when walking.

**“Muscles, cartilage, ligaments, tendons and joints protect the bones and enable the skeleton to move”**

**DID YOU KNOW?** The stapes is found in middle ear and is the human body's smallest and lightest bone

## RED AND YELLOW BONE MARROW

There are two types of bone marrow. Red bone marrow is the type responsible for producing red blood cells, white blood cells and platelets – cell fragments in blood that help it clot. Red blood cells carry oxygen around the body's organs, while white blood cells make up our immune systems to kill infections and maintain health. Red bone marrow is constantly producing new cells to replace older ones as they die. Meanwhile, yellow bone marrow stores fat in the bones, which the skeleton uses for energy. Like red bone marrow, yellow bone marrow can produce red blood cells, but it only does this in emergency situations of extreme blood loss. To do so, the yellow bone marrow converts itself into red bone marrow. A person is born solely with red bone marrow. Around age seven, half of it is exchanged for yellow bone marrow.



### 6 INFERIOR EXTENSOR RETINACULUM

This connective tissue keeps the extensor muscles and tendons in place.

6

## WHAT'S IN YOUR BONES?

Spongy tissue inside the skeleton produces blood cells and stores nutrients

### A SPONGY BONE

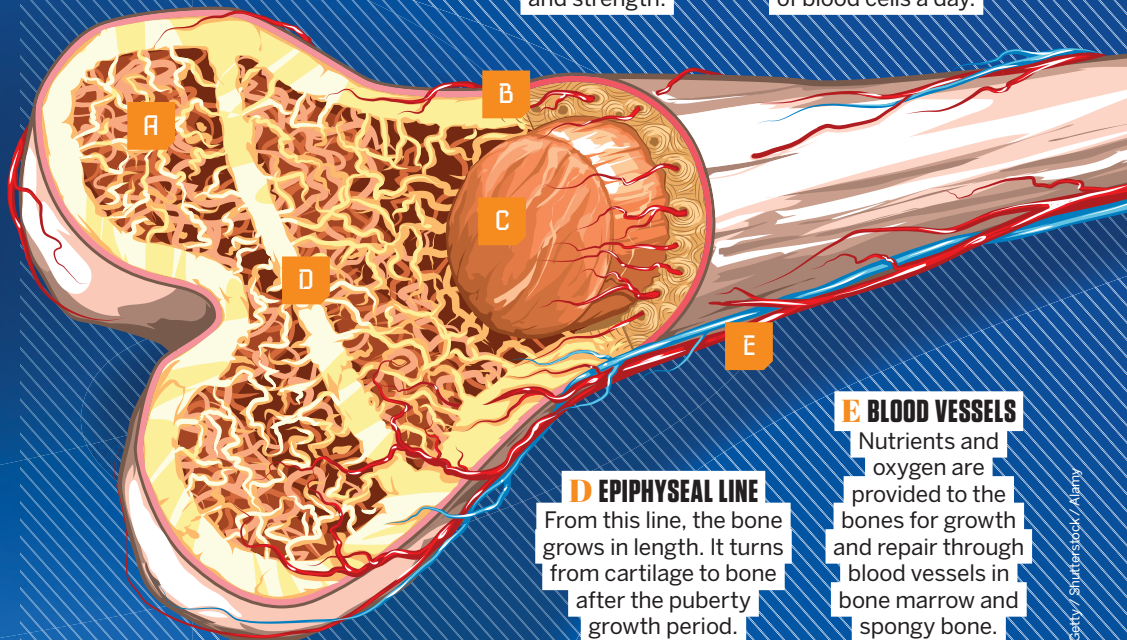
20 per cent of the skeleton is spongy bone, with a lattice structure of irregular cavities. This provides structural support while remaining lightweight.

### B COMPACT BONE

The outer layer of the skeleton is hard and dense, giving bones protection and strength.

### C BONE MARROW

This soft, fatty tissue forms at the centre of bones and contains stem cells. These cells produce billions of blood cells a day.



### D EPIPHYSEAL LINE

From this line, the bone grows in length. It turns from cartilage to bone after the puberty growth period.

### E BLOOD VESSELS

Nutrients and oxygen are provided to the bones for growth and repair through blood vessels in bone marrow and spongy bone.

### 4 INFERIOR FIBULAR RETINACULUM

This is connective tissue that secures tendons to stop them moving out of place.

4

### Did you know?

60 to 70 per cent of white blood cells are made by red bone marrow



# MAINTAINING SKELETAL HEALTH

As you grow, and throughout adulthood, your lifestyle habits impact the health of your bones. Some of the vitamins and minerals required by your skeleton include vitamin D and calcium, which you can source from the foods you eat. Adults need to consume 700 micrograms of calcium a day to maintain optimal bone health, as calcium phosphate is used to harden and strengthen bones. Calcium can be sourced from foods such as milk, cheese, green leafy vegetables, tofu and soya beans. Vitamin D helps the body absorb calcium, and adults need ten micrograms of this. This can be obtained through selected foods, such as oily fish, egg yolks and fortified foods, but much of this vitamin is absorbed by being in the Sun. Vitamin D is made from cholesterol in the skin. As ultraviolet rays penetrate the skin, they interact with cholesterol to produce the vitamin.

“Adults need to consume

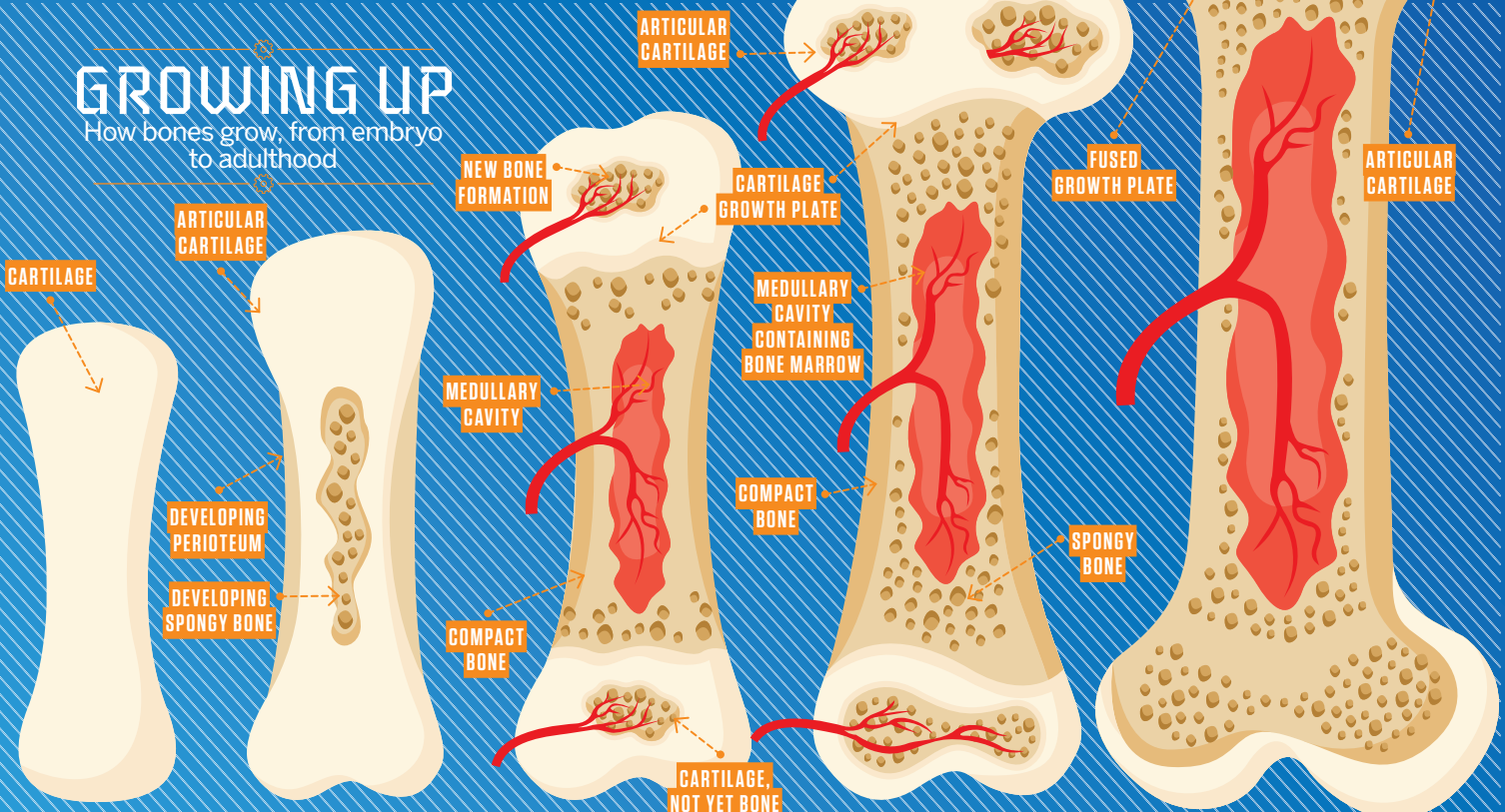
700 micrograms of calcium a day”



Your body can't make its own calcium, so high-calcium food sources are essential

## GROWING UP

How bones grow, from embryo to adulthood



### 1 EMBRYO

Bones begin as cartilage. While in the womb, some of this cartilage gradually gets replaced by bone in a process called endochondral ossification.

### 2 NEWBORN

A newborn baby has softer, more flexible bones than children and adults, as most of their structure is still cartilage. Spongy bone begins to develop at the centre.

### 3 CHILD

The growth plates, where new bone tissue is generated during childhood as bones grow rapidly. Bone marrow accumulates at the centre of bones.

### 4 TEENAGER

Bone density increases drastically, triggered by hormonal changes during puberty. Towards the end of puberty, growth plates become inactive. Bone marrow is fully developed.

### 5 ADULT

The bones don't need to grow anymore, so they are fully matured and hardened. Bone density reaches its peak in early adulthood.

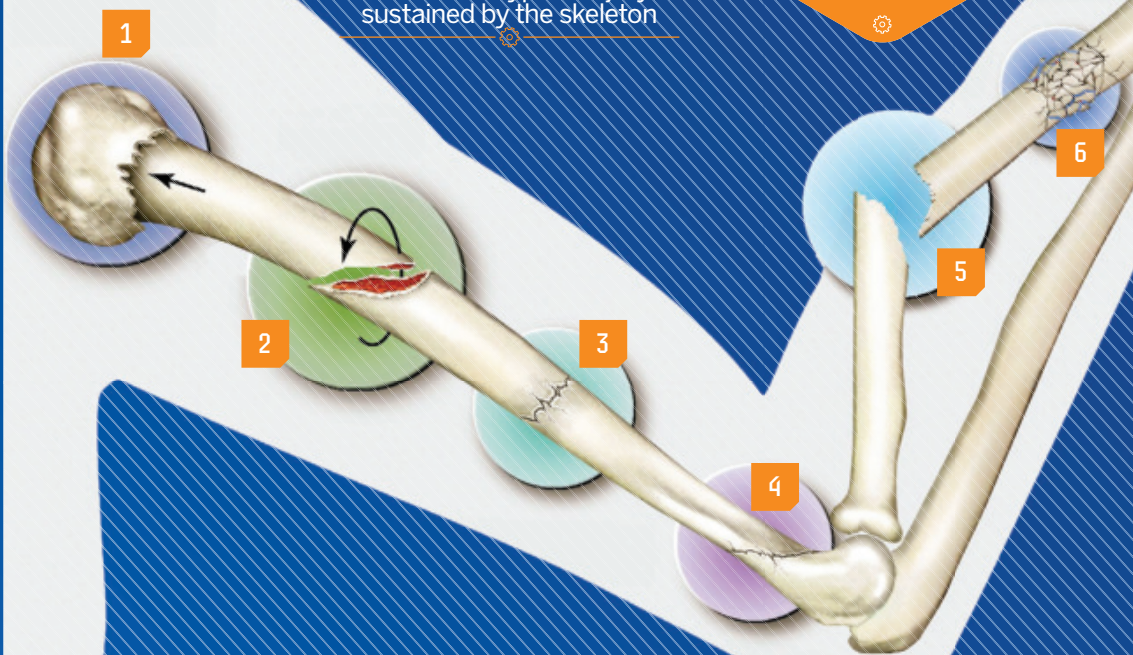
**DID YOU KNOW?** The only bone not connected to another is the hyoid at the base of your tongue

## BONE BREAKS

How different types of impacts dictate the type of injury sustained by the skeleton

**Did you know?**

Around 50 per cent of adult bone breaks are in the arm



### 1 IMPACTED

An impacted fracture is caused when two ends of a broken bone are forced into each other. It is common in children under 12, often from incidents such as falling forcefully.

### 2 SPIRAL

If a bone is twisted forcefully, it can break in a spiral pattern. This can occur in sporting incidents that cause a limb to rotate at the centre of a bone.

### 3 TRANSVERSE

This is a horizontal break, perpendicular to the bone's length. It is caused when two forces are applied in opposing directions.

### 4 OBLIQUE

Oblique fractures form at an angle and can arise when the bone is suddenly impacted by an object at an angle, such as during a car accident.

### 5 COMPLETE

Complete breaks can be at any angle. To be complete, the bone has to be fully divided in two. The pieces need to be realigned to heal, as they are no longer in contact.

### 6 COMMINUTED

A comminuted fracture produces three or more bone fragments. This is caused by high-impact collisions and can cause bones to shatter.

## HORMONAL REGULATION

As well as providing a sturdy frame for your body tissue and maintaining your circulatory and immune systems, the skeleton plays a part in controlling some chemical messengers called hormones. One of the hormones produced by bone-forming cells called osteoblasts is osteocalcin. This hormone helps the body regulate your energy, metabolism and fat storage. Other cells in the bone called osteocytes are mature bone cells which release the fibroblast growth factor-23 (FGF23) hormone. FGF23 regulates the levels of the mineral phosphate in the blood.



Osteoblasts make up less than five per cent of all bone cells

# 5 FACTS

## SKELETAL CONDITIONS

### 1 OSTEOPOROSIS

This condition is caused by a reduction in bone mass and density, often in correlation with old age. It makes the skeleton more injury-prone.



### 2 ARTHRITIS

Arthritis is the inflammation of the joints, causing painful swelling and stiffness. It can develop over time as joints wear down or can be an autoimmune disorder called rheumatoid arthritis.



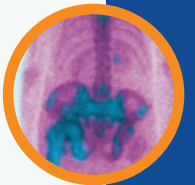
### 3 SCOLIOSIS

Sometimes, the spine grows in a more curved shape than usual. Scoliosis can cause back pain and sometimes impact breathing as the spine protrudes forwards, limiting chest space.



### 4 PAGET'S DISEASE OF BONE

This chronic disorder results in bones being larger than normal. This structure makes them weaker and more fracture-prone.



### 5 RICKETS

Usually caused by vitamin D, calcium or phosphate deficiency, the symptoms of rickets are soft, weak and painful bones. It primarily affects children, delaying their growth and causing misshapen bones.





# WHAT IS MORNING SICKNESS?

## Why some pregnancies can cause nausea and vomiting

WORDS AILSA HARVEY

**D**espite its name, morning sickness can occur at any time of day during pregnancy. However, for many pregnant people, it can feel worse during the morning. The symptoms involve feelings of nausea, being sick or both, and commonly start around four weeks after conception. It's likely to ease or stop completely between weeks 12 and 20. Although it's an unpleasant addition to the early weeks of pregnancy, morning sickness usually doesn't harm a person or their child. But some cases are much more extreme. Severe vomiting during pregnancy, called hyperemesis gravidarum (HG), is more dangerous as it can cause dehydration and malnourishment. The cause of morning sickness comes down to multiple biological changes occurring at once. An influx of pregnancy hormones, blood pressure fluctuations and physical changes to the body are thought to contribute to the queasiness. Stronger scents and tastes can bring about morning sickness. To relieve this, pregnant people can stick to foods with mild flavours, eat small meals regularly, stay hydrated and rest.



### SYMPTOM SEVERITY

Around 70 per cent of pregnant people experience morning sickness, but one person's experience can greatly differ from another's. This is largely dictated by the hormone GDF15, which is produced by the embryo or foetus. The more is released, the more nausea the parent will experience. Also, if a pregnant person has encountered more of this hormone before pregnancy, the more resilient to it they're likely to be. People with the inherited blood disorder beta thalassemia usually experience little or no morning sickness. This is because the disorder causes them to have high levels of GDF15 naturally, so their bodies are used to processing the protein.



Processed foods make morning sickness worse for most

### EVOLUTIONARY PURPOSE

One theory behind the purpose of morning sickness from an evolutionary perspective is that it protects embryos from exposure to harmful substances in foods. Many feelings of nausea are brought about by strong-tasting vegetables and meat products. These are the most likely foods to contain toxins, and by vomiting a person is less likely to consume pathogen-contaminated products. Harmful microorganisms are far more deadly to the foetus in the early stages of organ development. Encountering contaminated foods in the wild through foraging and hunting was much more likely for our prehistoric ancestors, and expelling potent foods improved the chances of a healthy pregnancy.



### Did you know?

Morning sickness is more likely with twins and multiple pregnancies



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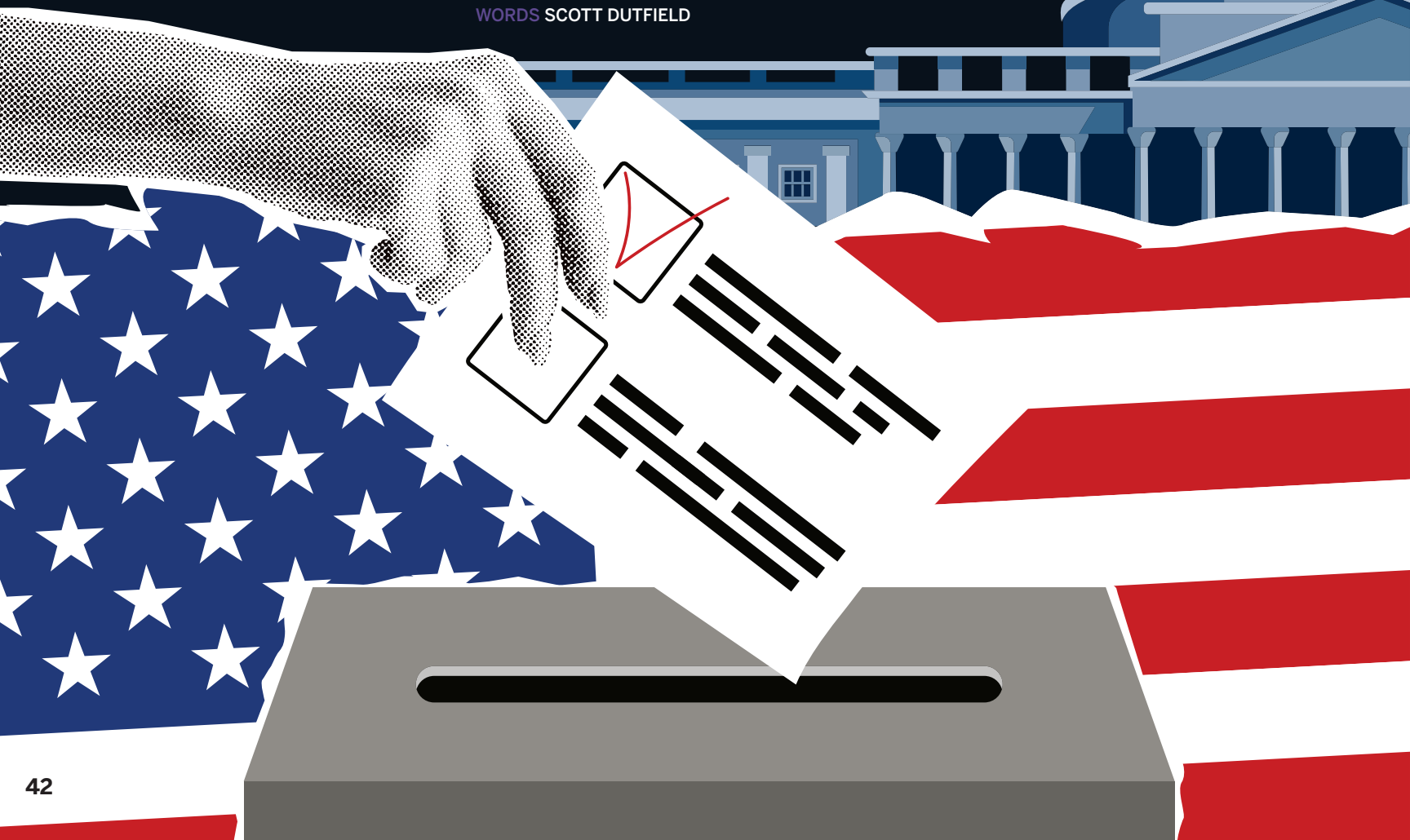
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# HOW TO ELECT THE PRESIDENT

The campaigns, votes and elections that put someone in America's most powerful office

WORDS SCOTT DUTFIELD



**DID YOU KNOW?** In 1824, Andrew Jackson won the popular vote but received less than 50 per cent of the electoral vote

Every four years, US citizens cast their vote for the person they think should hold the coveted position of president of their country.

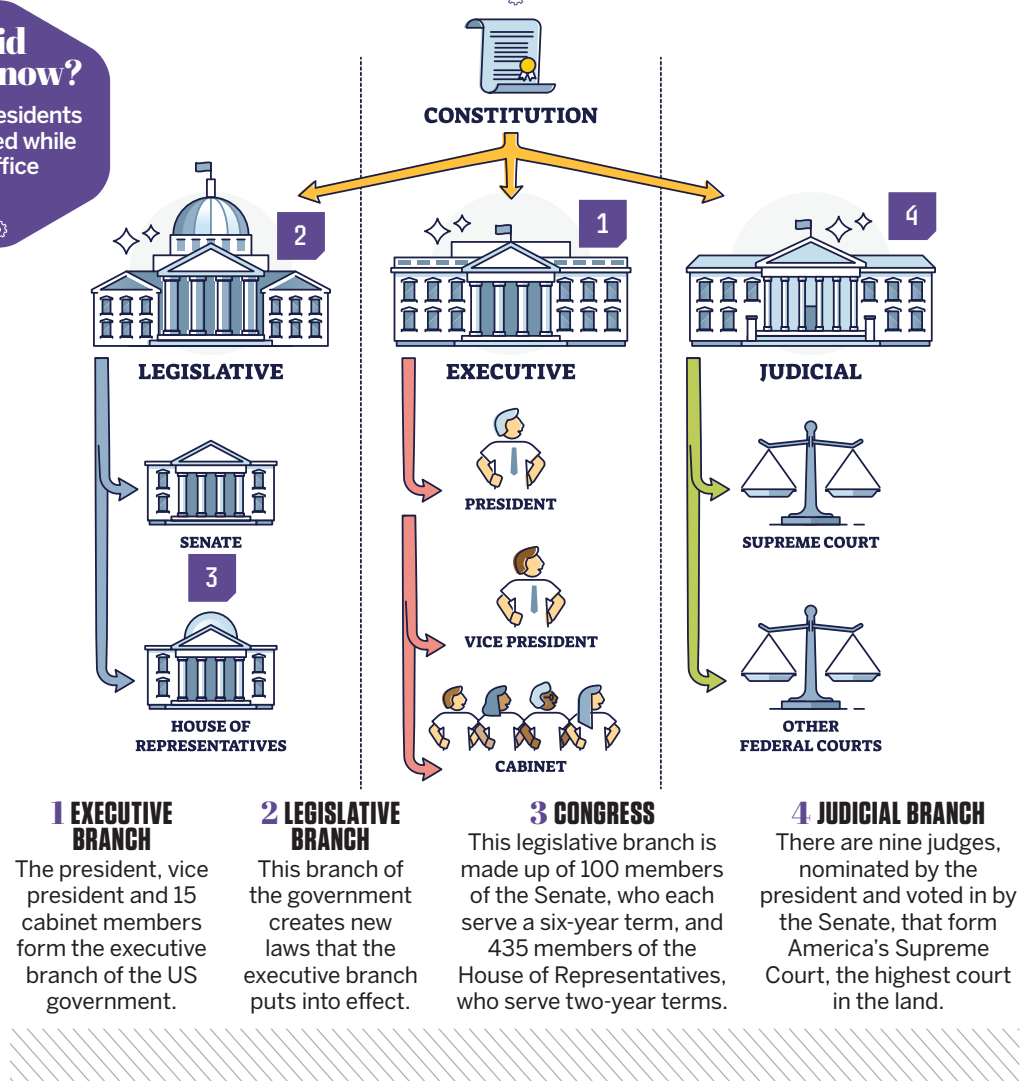
In 2024, another election is on the horizon, when the nation will decide if Democratic nominee Kamala Harris or Republican Donald Trump will be the next president to hold office. At the ballot box, Americans make their decision on who they think should be the next person to run the country. However, they're not directly voting for the next president. Instead, they're voting for members of the Electoral College, called 'electors', whose job it is to elect the president and the vice president. According to the American Constitution, electors can't be members of Congress or hold federal office and are elected by political parties.

Each state has its own number of electors, based on the state's resident population. The more citizens in the state, the more electors that state holds. For example, California has more than 40 million inhabitants and 55 electors, whereas Wyoming only has around 500,000 residents and just three electors. All but two states have a winner-takes-all policy, where all the state's electoral votes are given to the candidate that wins the state's popular vote. Maine and Nebraska differ by distributing electors within their congressional districts, along with two 'at-large' electoral votes based on the overall state-wide popular vote. Electors often pledge to their states to vote for the same presidential nominee as the result of their state's popular vote. However, that hasn't always been the case. There have been 157 'faithless electors' who, when faced with casting their electoral vote, have chosen an alternative candidate. There have been

**Did you know?**  
Eight presidents have died while in office

# THE US GOVERNMENT

How the US divides its leadership positions



Attendees at the 1787 Constitutional Convention, held in Philadelphia

**“The more citizens in the state, the more electors that state holds”**

several reasons why an elector has changed their vote, including the death of a nominee, a change in candidate within the same party or, in one case, by accident. In 1796, a Federalist elector from Pennsylvania intentionally switched their vote from Federalist nominee John Adams to Democratic-Republican Thomas Jefferson.

All in all, there are 538 electors across the country – equal to the number of House Representatives and Congress members – and a further three votes for the District of Columbia, that decide the next president. The candidate with more than half of the votes (270) wins the presidency. If on the rare



Current president Joe Biden during his inauguration on 20 January 2021



Electors from Texas casting their votes in the Capitol

occasion a single candidate doesn't get more than 270 votes, then the House of Representatives elects the president. The two-stage voting system of the Electoral College can result in a unique situation where a candidate can win the votes of the electors, despite not winning the popular vote from all 50 states. For example, in 2016 Donald Trump won the electoral vote against Democratic nominee Hillary Clinton but lost the popular vote by more than 2 million votes.

Despite its intricacies, the Electoral College has served the American people for 237 years. Having broken away from the royal rule of Great Britain during the 18th century, the infant nation of America wasn't in a hurry to live under a dictatorship. As a solution to electing a new leader and government, the Electoral College was conceived by America's Founding Fathers at a time when the majority of the world's countries didn't hold democratic elections. Political pioneers such as George Washington and Alexander Hamilton debated a new way to elect a presidential leader during the Constitutional Convention in Philadelphia in 1787. While many of the attending delegates wanted a congress to elect a president, others believed that a popular democratic vote should decide who was put into power. As a compromise between the two ideas, the Electoral College was born.

The Electoral College system was ratified with the Constitution in 1789. However, since then there have been a whole host of amendments that have changed who and how people vote for the president of the United States. For example, in 1804 the 12th Amendment to the Constitution changed the way that vice presidents were elected.

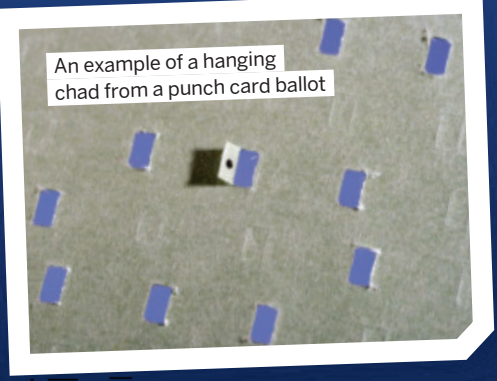
**Did you know?**

Abraham Lincoln was the tallest US president at 193 centimetres

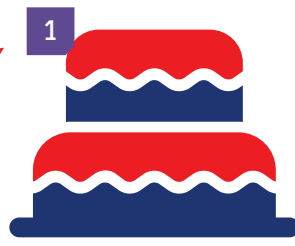
Originally, the position of vice president was held by the runner-up in the general election, who was seen as the second most qualified candidate for president. The 12th Amendment made it possible for the public to elect a vice president, rather than the position being automatically filled. In 1868 the 14th Amendment gave African Americans the right to vote, and the 19th Amendment gave women the right to vote in 1920. In 1971, the 26th Amendment lowered the voting age from 21 to 18 years old.

To date, there have been 46 US presidencies served by 45 men – this is due to President Grover Cleveland's two nonconsecutive terms as the 22nd and 24th president. Only two women have ever been put forward as a presidential nominee. Hillary Clinton was the first female nominee during the 2016 election, and current vice president Kamala Harris is the second during the 2024 race. Could 2024 be the year that history is made with the first female to step into the iconic Oval Office as president of the United States? The world will find out after voting takes place on 5 November 2024 during the 60th quadrennial presidential election.

**“In 1971, the 26th Amendment lowered the voting age from 21 to 18”**



An example of a hanging chad from a punch card ballot



**1 BASIC CRITERIA**

To be considered, a candidate needs to meet three basic requirements: to have been born in the US, be at least 35 years old and have lived in the US for at least 14 years.

**6 VP PICK**

The selected candidate announces their 'running mate' who will take up the role of vice president if elected.



**8 DEBATES**

Presidential candidates go head to head in televised debates to discuss their ideas for the future of the country.



**7 CAMPAIGN**

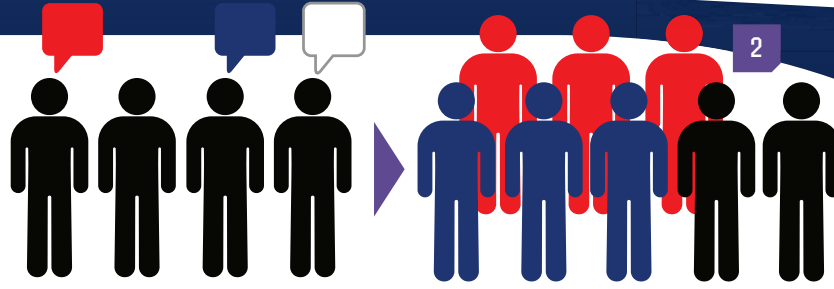
Nominees campaign on a national level while adhering to campaigning rules such as limits on spending and transparency on advertising funding.



**DID YOU KNOW?** Voting day is always the Tuesday following the first Monday in November

# THE ROAD TO THE OVAL OFFICE

Being president takes years of hard work, support from your fellow party members and the public



**2 PARTY POLITICS**  
Prospective presidents align their values and ideas for the country with a political party, such as the Democratic or Republican parties, or remain an independent politician.

**3 CAUCUS**  
Members of a political party meet, typically at the district or county level, to discuss and publicly vote on their presidential candidate picks. Delegates take the results of that vote to their party's national convention.

**4 PRIMARY**  
Much like a general election, party members across the state cast their vote in private for who they want to elect as their party's presidential candidate. Delegates for each state take the results of that vote to their party's national convention.

**5 CONVENTION**  
Each political party holds a national convention to confirm and announce their nominated candidate to the world.



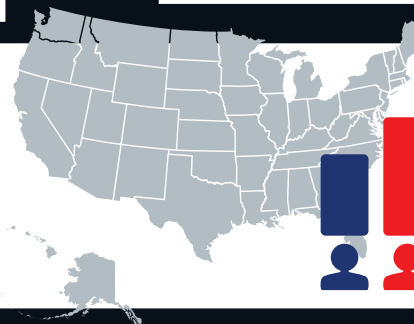
**“To date, there have been 46 US presidencies served by 45 men”**

**11 NEW PRESIDENT**  
The first president to surpass 270 electoral votes is declared the winner of the election and the next president of the United States.

**9 GENERAL ELECTION**  
The general public flock to polling stations to cast their vote for president.

**10 ELECTORS**  
Electors from around the country cast their votes, usually based on the result of their state's popular vote.

**12 INAUGURATION**  
In the January following the election, the newly elected president and vice president are inaugurated.



# THE EVOLUTION OF VOTING

**Did you know?**  
244 million Americans will be eligible to vote in 2024

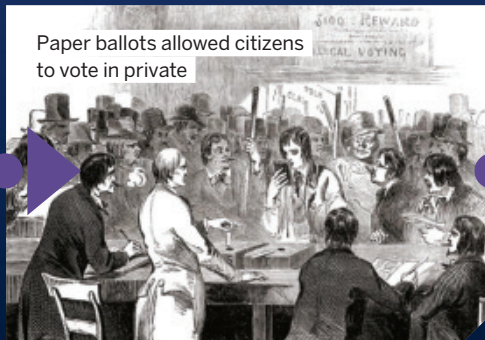
How America has changed the way voters make their presidential pick



George Washington delivering his inaugural address to Congress in 1789

## VIVA VOCE

Voting by voice, or viva voce, was standard practice for electing presidents in America's early days. George Washington, Thomas Jefferson and Abraham Lincoln were all elected by voters publicly announcing their vote. Assembled in local polling stations, people lined up to step on a platform and verbally cast their vote, which was then recorded and counted. In doing so, votes weren't private, and the voter's name, address and choice were made public record. This practice was still used up until 1891, when the last state to use the method, Kentucky, switched to paper ballots.



Paper ballots allowed citizens to vote in private

## PAPER BALLOTS

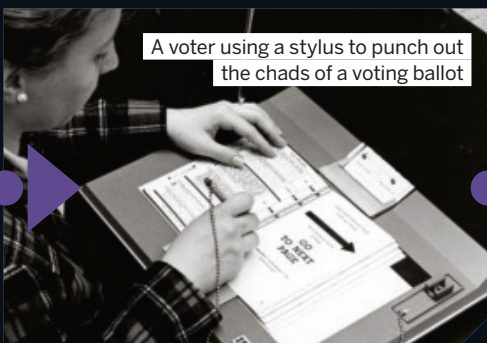
In the early 19th century, hand-counted paper ballots were introduced. Initially, ballots were just blank pieces of paper for people to write their votes on. Over time, political parties preprinted train ticket-sized ballots for voters to mark an X next to their choice. However, these ballots did not include all political parties. As an idea imported from Australia, the first private, non-partisan paper ballots were introduced after the presidential elections in 1884. By 1910, all American states had adopted the 'Australian ballot'.



A voter stepping into a lever machine voting booth in 1965

## LEVER MACHINES

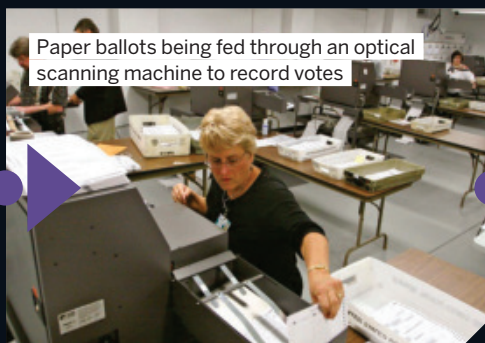
In 1892, inventor Jacob H. Myers introduced a lever-operated voting machine. Within the private booth, next to the name of each candidate was a small lever for voters to pull. The levers allowed voters to change their minds before pulling a large final lever to lock in their decision and automatically open the booth curtain. With each final pull of the voting lever, the votes for the candidate were tallied by an odometer-like counter and the machine was reset for the next voter. Lever voting machines were used in some states up until 1980 before they were widely replaced by punch card voting.



A voter using a stylus to punch out the chads of a voting ballot

## PUNCH CARD

The 1960s were the heyday of punch card voting. Much like the lever machine, punch card voting has mostly been made redundant, although it's still used at state-level elections. Using a preprinted card, votes are cast by dislodging a re-scored rectangle next to a candidate, called a 'chad'. Ballots are then dropped into the ballot box and counted using card readers that 'detect' the placement of the chad on the card and record a vote for the corresponding candidate. One of the biggest drawbacks of punch card voting is that chads that have not been completely punched out, known as 'hanging chads', can cause problems. During the extremely close 2000 election between Al Gore and George W. Bush, the punch card ballots in Florida were recounted. Officials had to painstakingly recount by hand and decide if hanging chads were valid votes or not.



Paper ballots being fed through an optical scanning machine to record votes

## OPTICAL SCAN BALLOTS

Giving the paper ballot an upgrade, by the late 1990s, optical scan ballots were commonly used. Black pen in hand, voters fill in an oval next to the name of the candidate they want to vote for on a paper ballot. The ballot is then loaded into an optical scanner to tabulate the votes on the ballots. It does this by using the master barcode on the ballot as a fixed point on the paper and determines the location of the marked oval using grid coordinates. The scanner divides the ballot into a certain number of columns and rows. When it detects a marked oval it takes note of its location, such as column eight and row two. That location translates to a code - '0802', for example - which is attributed to a candidate and records the vote.



A touchscreen DRE voting machine in the Staples Center in Los Angeles

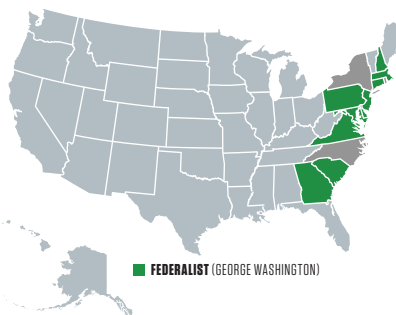
## DIRECT RECORDING ELECTRONIC (DRE) VOTING MACHINES

Now commonplace around the US, DRE voting machines use an electronic interface, such as a touchscreen tablet, to digitally record votes. Votes are stored on the DRE machine's removable hard drive and are then tabulated to produce a popular vote result. Some DRE machines are also equipped with a voter-verified paper audit trail printer to produce a physical copy of each vote for any recounts that may be required. The use of electronic voting machines has been rejected by a number of countries around the world, as well as some American states, such as California. This is largely due to a lack of voting transparency and fear of the potential threat of digital interference.

**DID YOU KNOW?** The 1876 election had a voter turnout of 82.6 per cent, the highest in history

# TEN KEY US ELECTIONS

These historic election results are depicted on maps with modern-day state boundaries, as opposed to the actual state boundaries at the time of each election

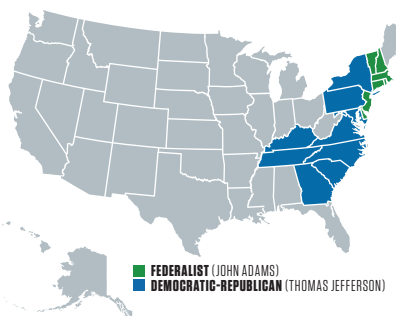


## 1789

### THE FIRST FEDERALISTS

George Washington won the first presidential election as a member of the Federalist Party. Three of the original 13 colonies did not partake in the vote.

FEDERALIST (GEORGE WASHINGTON)

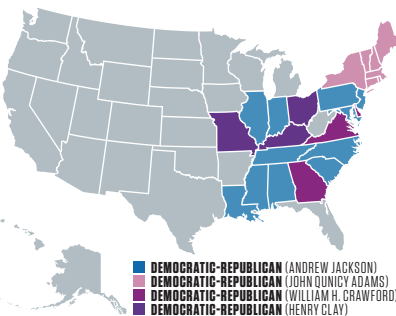


## 1800

### DEMOCRATIC-REPUBLICAN WIN

Vice president Thomas Jefferson of the Democratic-Republican party won against Federalist incumbent John Adams. 16 states took part in the vote.

FEDERALIST (JOHN ADAMS)  
DEMOCRATIC-REPUBLICAN (THOMAS JEFFERSON)

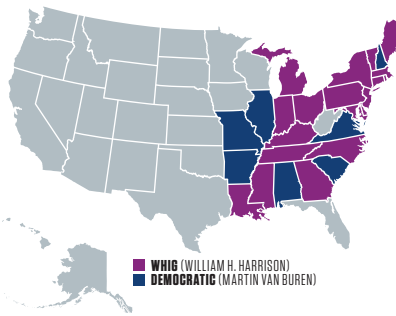


## 1824

### NO OBVIOUS WINNER

Without a clear winner of the election, the House of Representatives was called into action for the first time to select a president, which they decided was John Quincy Adams.

DEMOCRATIC-REPUBLICAN (ANDREW JACKSON)  
DEMOCRATIC-REPUBLICAN (JOHN QUINCY ADAMS)  
DEMOCRATIC-REPUBLICAN (WILLIAM H. CRAWFORD)  
DEMOCRATIC-REPUBLICAN (HENRY CLAY)

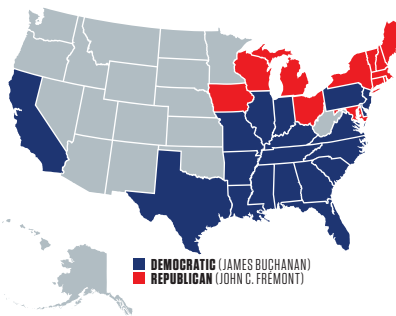


## 1840

### WHIG WIN

Under the newly unified Whig Party, William H. Harrison won the election against Democratic president Martin Van Buren, who was seeking re-election.

WHIG (WILLIAM H. HARRISON)  
DEMOCRATIC (MARTIN VAN BUREN)

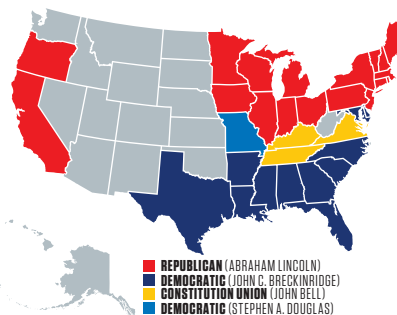


## 1856

### DEMOCRATS VS REPUBLICANS

The Whig Party collapsed and its members joined the newly formed Republican party. For the first time, Democrats and Republicans went head to head. James Buchanan won the election.

DEMOCRATIC (JAMES BUCHANAN)  
REPUBLICAN (JOHN C. FREMONT)



## 1860

### REPUBLICAN WIN

The first Republican win came with President Abraham Lincoln. However, Lincoln only received 40 per cent of the total popular vote during a time when the nation was divided and on the brink of civil war.

REPUBLICAN (ABRAHAM LINCOLN)  
DEMOCRATIC (JOHN C. BRECKINRIDGE)  
CONSTITUTION UNION (JOHN BELL)  
DEMOCRATIC (STEPHEN A. DOUGLAS)

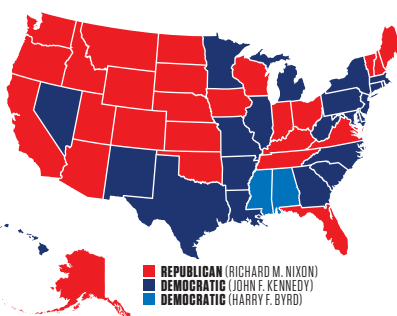


## 1936

### BLUE WAVE

Democratic nominee Franklin D. Roosevelt received the largest electoral victory to date while the country was in its eighth year of the Great Depression.

DEMOCRATIC (FRANKLIN D. ROOSEVELT)  
REPUBLICAN (ALFRED M. LONDON)

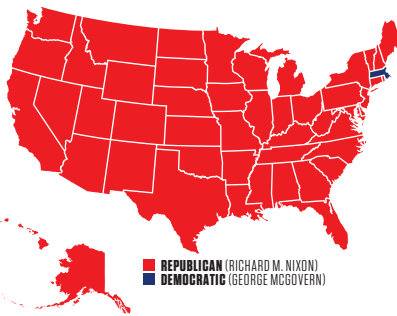


## 1960

### ALL 50 STATES

America welcomed Alaska and Hawaii in 1959. For the first time, all 50 states took part to elect the Democratic nominee John F. Kennedy as president.

REPUBLICAN (RICHARD M. NIXON)  
DEMOCRATIC (JOHN F. KENNEDY)  
DEMOCRATIC (HARRY F. BYRD)

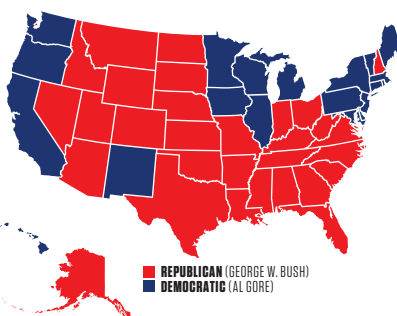


## 1972

### RED WAVE

Republican Richard Nixon won the election with 520 electoral votes. Nixon received 18 million more total votes than his Democratic opponent George McGovern.

REPUBLICAN (RICHARD M. NIXON)  
DEMOCRATIC (GEORGE MCGOVERN)



## 2000

### ONE VOTE OVER THE LINE

Receiving just 271 electoral votes, Republican George W. Bush won the election. This was the first time a president won the electoral college, but did not win the popular vote.

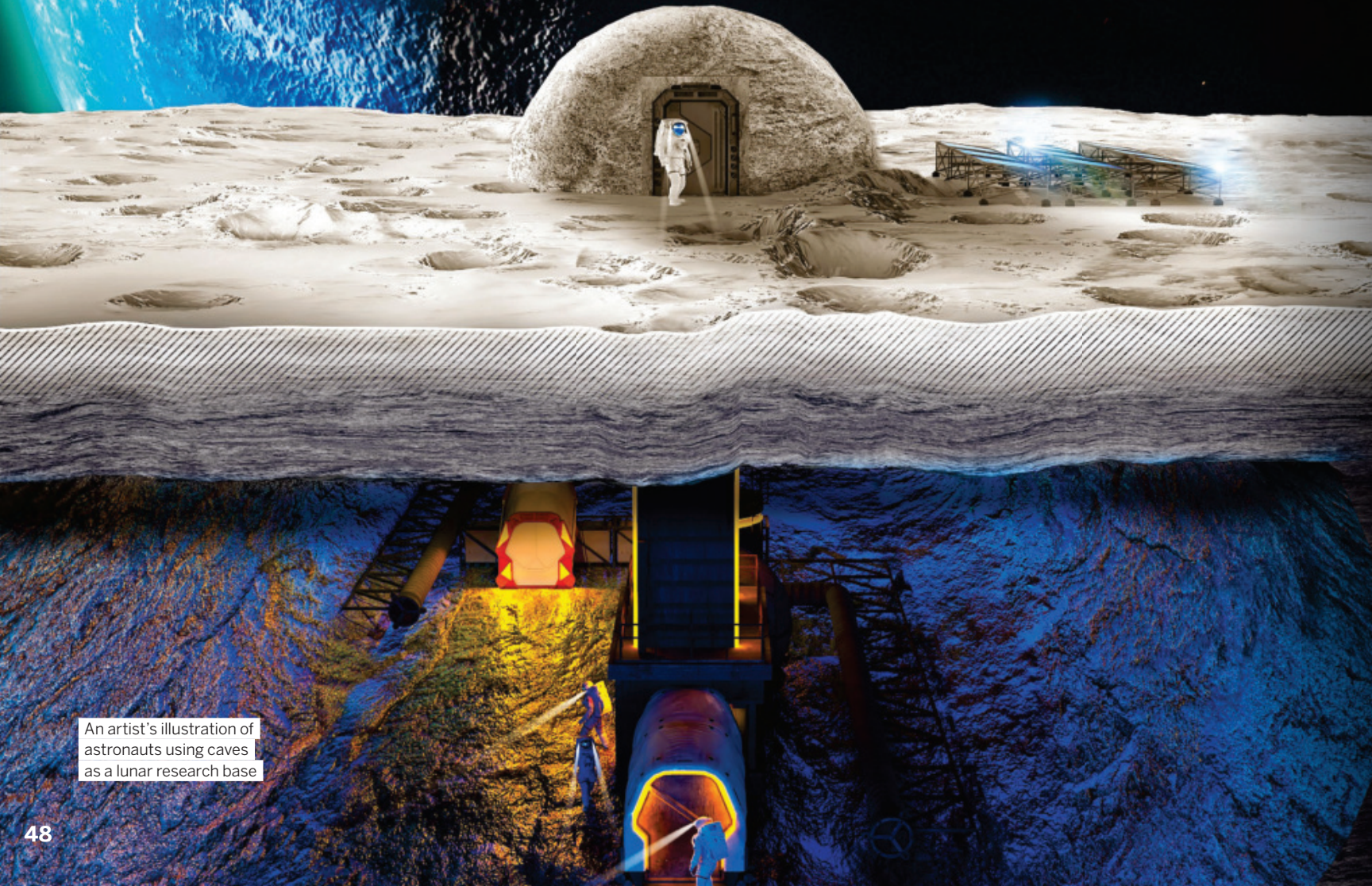
REPUBLICAN (GEORGE W. BUSH)  
DEMOCRATIC (AL GORE)



# EXPLORING THE MOON'S CAVES

Earth's rocky neighbour is home to a network of unexplored caves, and scientists are keen to take a peek inside

WORDS SCOTT DUTFIELD



An artist's illustration of astronauts using caves as a lunar research base

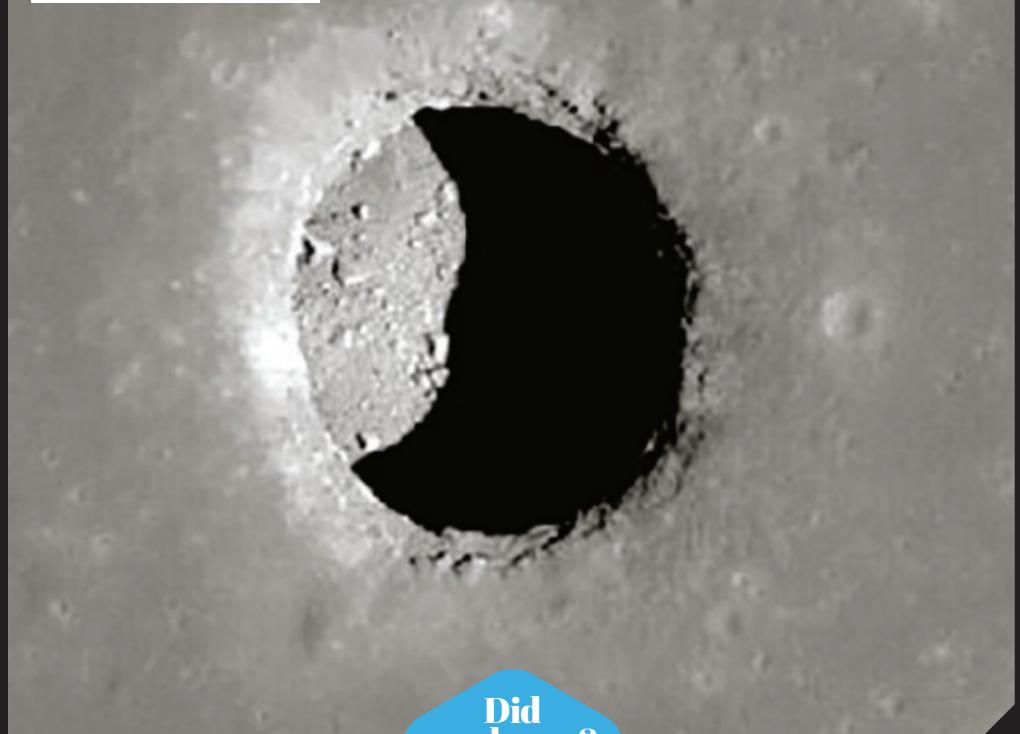
## DID YOU KNOW? Each year, the Moon moves around 3.8 centimetres away from Earth

**A**cross the surface of the Moon, there are as many as 200 dark pits that lead to networks of lunar caves that formed billions of years ago. After a Mars-sized rock plummeted into the still-forming Earth around 4.6 billion years ago, pieces of rocky ejecta formed what we now know as the Moon. Up until around 2 billion years ago, our natural satellite was a much more turbulent place, facing constant meteorite bombardment and widespread volcanism. A consequence of this volcanic period was the formation of a network of lunar caves beneath the surface, which scientists have only recently discovered. Unlike the many different caves formed on Earth, the rock in the lunar caves hasn't been carved by erosive forces such as wind and water. Instead, during its volcanic phase, lava flows created long, cavernous structures beneath the surface, much like lava tube caves found on Earth.

These lava caves are not only a fascinating part of the Moon's history, but also offer a potential haven for future astronauts looking to build a base on the Moon. As soon as 2026, astronauts on NASA's Artemis III mission could set foot on the lunar surface for the first time in more than 50 years. The mission to the Moon will see four astronauts propelled from Earth aboard SpaceX's Starship and NASA's Space Launch System (SLS), landing in the Moon's south polar region. For 30 days, the astronauts will collect lunar samples and conduct experiments before returning to Earth. Along with a lack of oxygen and weak gravity, the Moon-bound astronauts will have to contend with frequent impacts from meteorites and surface temperatures that fluctuate from 127 degrees Celsius to -173 degrees Celsius. Lunar caves, however, can offer some relief from some of these extreme conditions, providing shelter from meteorites and an average temperature of around 17 degrees Celsius.

In 2024, the first lunar tunnel that could be accessed by humans was discovered. It's

A view of the 400-metre-wide pit in Mare Tranquillitatis, taken by NASA's Lunar Reconnaissance Orbiter



### Did you know?

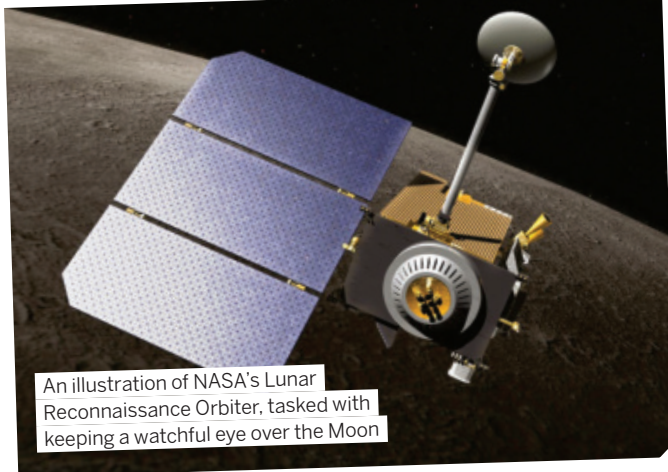
12 astronauts have walked on the Moon

estimated that the cave is up to 80 metres long and around 45 metres wide. However, it'll be quite the abseil to reach, as the opening is around 175 metres below the surface. Pits like this might be ideal candidates for future lunar bases. But before that can happen, scientists need to know more about them. Since 2019, the European Space Agency (ESA) has been looking for a way to explore the depths of these lunar lava caves with the launch of the public Open Space Innovation Platform (OSIP).

The OSIP allows scientists and engineers to submit their ideas on how to detect, map and explore the caves. One of the most promising ideas was to use the RoboCrane, created by

the University of Oviedo in Spain, in conjunction with the 'hamster ball-like' Daedalus robot, created by the University of Würzburg in Germany. The RoboCrane would be used to lower Daedalus into a lunar cave, where the rover would be able to roll around, recording vital information about its surroundings as it goes.

Together, RoboCrane and Daedalus could be the dream team we need to traverse the lunar tunnels and shine a light on what's inside the mysterious caves. It's possible that the robotic pair could be sent to the Moon aboard the Ariane 6 rocket as soon as 2033 and deployed to the surface by the ESA's European Large Logistics Lander.



An illustration of NASA's Lunar Reconnaissance Orbiter, tasked with keeping a watchful eye over the Moon

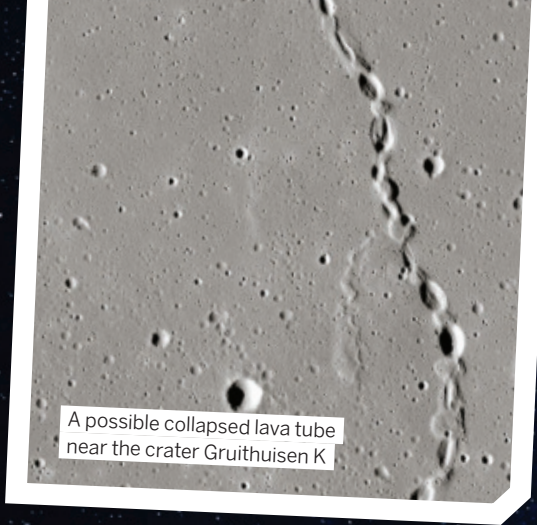
## FIRST FINDINGS

In 2010, NASA's Lunar Reconnaissance Orbiter (LRO) made a surprising discovery. While orbiting the Moon, the spacecraft's Miniature Radio-Frequency (Mini-RF) instrument uncovered a cave that extended around 60 metres from a pit. The pit was originally spotted in 2009 by the Japan Aerospace Exploration Agency (JAXA), sparking hope of possible subterranean caves on the Moon. The site of the pit is around 230 miles from where the first humans landed on the lunar surface, in a region called Mare Tranquillitatis – the Sea of Tranquility. In 2024, scientists reanalysed the 2010 radar data and found evidence of another cave 230 miles from the 1969 Moon landing site. This cave could extend for miles beneath Mare Tranquillitatis.



# ROBOT SPELUNKER

How two robots will tackle the lunar terrain to uncover the secrets of the cave



A possible collapsed lava tube near the crater Gruithuisen K



1

## 1 ROBOCRANE

The RoboCrane is a lunar rover with an extending crane system built in. It also acts as a communications link and power supply during the mission.

“Lunar caves can offer some relief from some of these extreme conditions”

## 5 DATA COLLECTION

Along with mapping the caves, Daedalus is equipped with temperature sensors and a radiation dosimeter to gather vital environmental data.

5

## 4 MAPPING THE CAVE

Daedalus is equipped with light detection and ranging technology and a camera to map out its surroundings and navigate the cave.

4

**DID YOU KNOW?** The Apollo 11 astronauts said the Moon smelled metallic

**Did you know?**  
The Moon is the second-densest satellite in the Solar System



**2 PIT**  
Lunar caves can be accessed by 'skylight' pits that have vertical openings.

**3 LOWERING DAEDALUS**  
The scissor-like crane extends over the pit. The Daedalus rover will be lowered into the cave.

**9 RECHARGE**  
At the head of the RoboCrane is a wireless recharge point for Daedalus to top up on power.

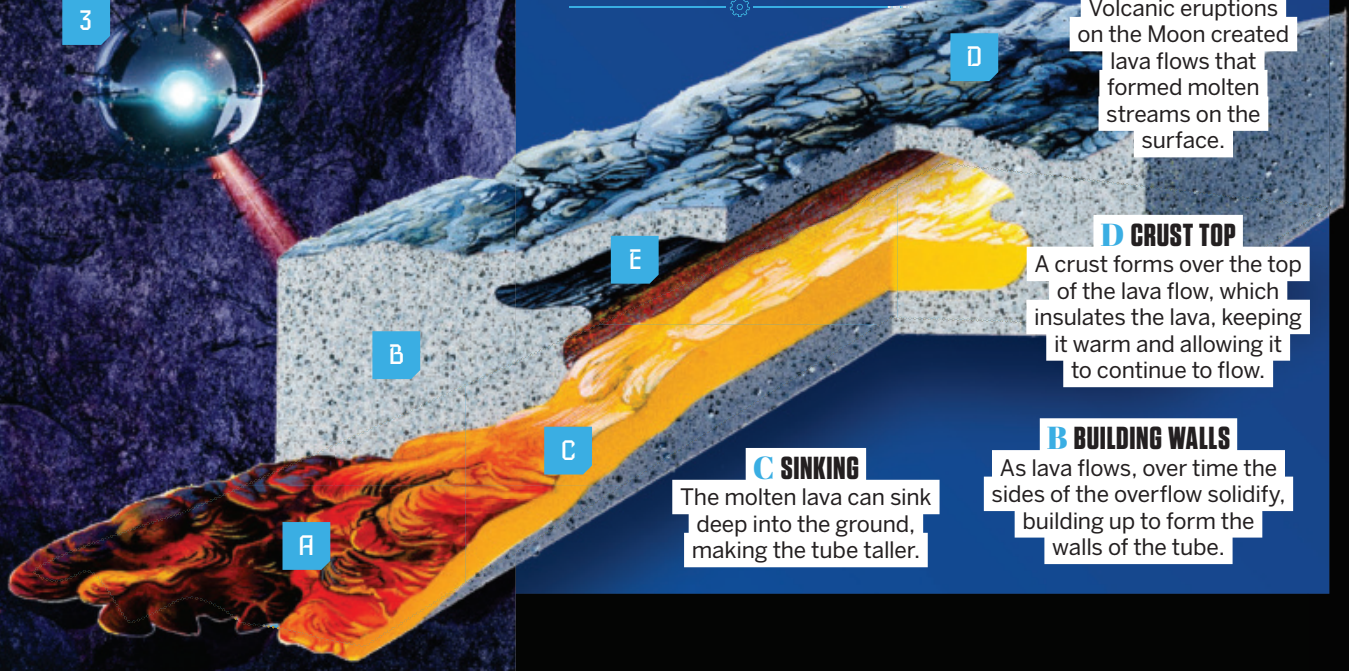
**7 ROVER EYES**  
Within the Daedalus rover there are four optical cameras providing a 360-degree view around the sphere.

**6 PROTECTION**  
The Daedalus rover has a plastic sphere to shield its internal instruments from lunar dust.

**8 ROLLING AROUND**  
For movement, the spherical rover uses motors and a series of small extending poles to pull and roll its way around the cave.

## CARVED BY LAVA

How molten rock shaped tube-like caves on the Moon



**E EMPTY TUBE**  
Once the eruption is over and the lava flow has subsided, what remains are cavernous tubes beneath the surface.

**A LAVA FLOW**  
Volcanic eruptions on the Moon created lava flows that formed molten streams on the surface.

**D CRUST TOP**  
A crust forms over the top of the lava flow, which insulates the lava, keeping it warm and allowing it to continue to flow.

**B BUILDING WALLS**  
As lava flows, over time the sides of the overflow solidify, building up to form the walls of the tube.

**C SINKING**  
The molten lava can sink deep into the ground, making the tube taller.



# THE LIFE CYCLE OF A STAR

They're formed from swirling clouds of gas and dust and often end their lives with an epic explosion. The life of a star is far from dull

WORDS DUNCAN GEERE

In the inky blackness of interstellar space, a cloud of gas and dust sits motionless. It has remained that way for billions of years, occasionally jostled by the weak gravitational ripples of events in its galactic neighbourhood. More time passes and nothing much continues to occur. But eventually a much larger ripple passes through the cloud – a shock wave caused by a distant supernova, perhaps, or a collision with another gas cloud. This disturbance pushes the material together, and it begins to contract under its own gravity.

The dust in the cloud, which mostly comprises hydrogen and helium atoms, begins to clump together, orbiting around itself. It pulls in more and more material from the cloud, otherwise known as a nebula. As these clumps grow larger, the pressure of all this material being compressed together causes the temperature to rise – gravitational energy is converted into heat energy. The fragments continue to grow and grow, getting hotter and hotter until they become a giant, rotating sphere of superhot gas. And thus, a star is born.

Or, to be more precise, a protostar. Whether this protostar becomes a star like our Sun depends on how much material has collected inside it. Protostars that have less than eight per cent the mass of our Sun fail to reach high enough temperatures for the nuclear fusion of hydrogen into helium, which occurs at around 10 million degrees Kelvin. But some of these 'failed stars' – ones around 13 times the size

## Did you know?

The brightest star in the night sky is Sirius, the 'Dog Star'



## WHEN WILL THE MILKY WAY PRODUCE ITS NEXT SUPERNOVA?

The last supernova in our galaxy we're confident took place was Kepler's Supernova in 1604. It was visible to the naked eye and shone brighter than everything in the night sky except Venus and the Moon. Astronomers at Ohio State University predict there is a 100 per cent chance of a Milky Way supernova within the next 50 years – but only a 20 per cent chance it will be visible to the naked eye.

**DID YOU KNOW?** Brown dwarfs can be between 13 and 75 Jupiter masses

**MESSIER 82**

This starburst galaxy is a veritable star factory. In the galaxy's centre, stars are born ten times faster than in the Milky Way.



The light reaching Hubble hasn't been refracted through our planet's atmosphere

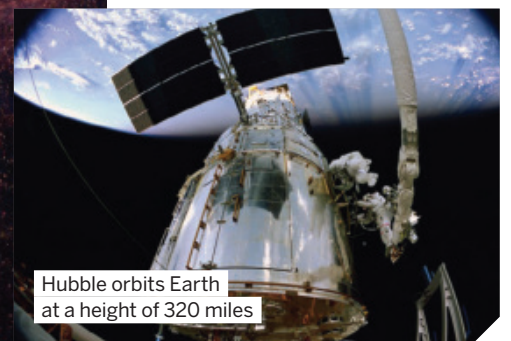


## HOW HUBBLE SEES DISTANT STARS

Without Earth's atmosphere to contend with, space telescopes have a much clearer view. The Hubble Space Telescope has been key in furthering our understanding of stars' life cycles. It has imaged many stars during different phases of their lives, including the photogenic nebulae in which they're born. One of its finest hours came in 1995, when astronomers pointed the telescope at an area of complete darkness. The result was the Hubble Deep Field – a stunning view of almost 3,000 galaxies of varying shapes, sizes and colours, enabling us to see what the universe looked like a billion years ago.

Hubble was launched in 1990 with the objective of seeing past our planet's thick, distorting atmosphere to get a clear view of the heavens. Within weeks, however, a problem was identified – the mirror inside the telescope was slightly the wrong shape. A solution was devised that effectively put a pair of glasses on the telescope, correcting its optics. This was launched in 1993, and Hubble was ready for action. Hubble orbits Earth in the upper atmosphere, and is expected to fall back to Earth before 2040. Its successor, the James Webb Space Telescope, launched in December 2021.

**“The hydrogen collected by a star's core is transformed into helium and energy when forced together under pressure”**



Hubble orbits Earth at a height of 320 miles



# STELLAR GIANTS

In the grand scheme of things, the star that dominates our Solar System and comprises 99.8 per cent of its mass is stellar small fry

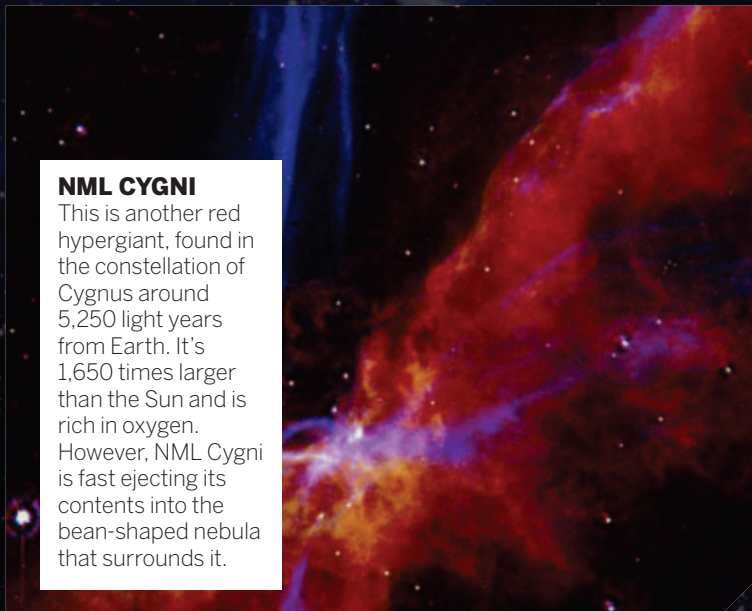
The Sun looms so large over our planet that it can be difficult to believe it is a dwarf star – a yellow dwarf, to be precise. From space, free of the light-scattering influence of Earth's atmosphere, it actually appears white. Further afield there are stars over 1,000 times larger than our Sun.

**“If placed in the centre of the Solar System, UY Scuti would engulf everything up to Jupiter and halfway to Saturn”**



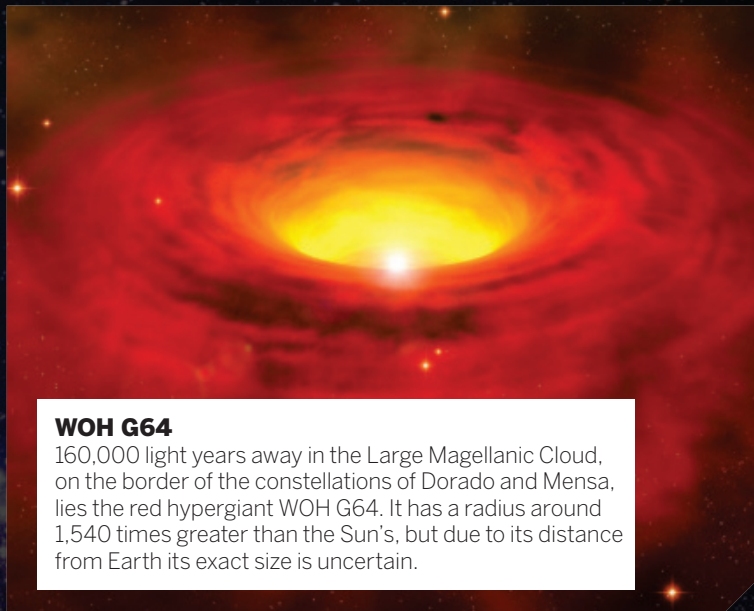
### UY SCUTI

UY Scuti is a red hypergiant in the Scutum constellation, approximately 1,708 times larger than our Sun. It is shrouded from Earth by cosmic dust. If placed in the centre of our Solar System, it would engulf everything up to Jupiter and halfway to Saturn.



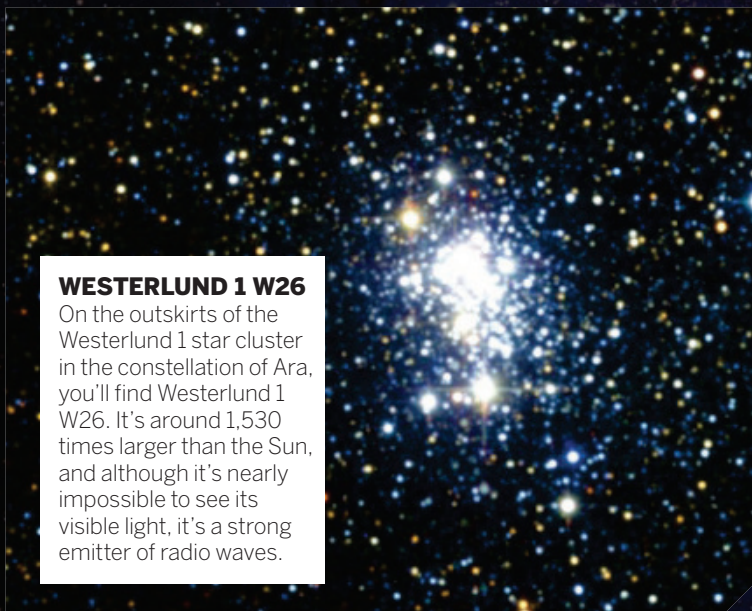
### NML CYGNI

This is another red hypergiant, found in the constellation of Cygnus around 5,250 light years from Earth. It's 1,650 times larger than the Sun and is rich in oxygen. However, NML Cygni is fast ejecting its contents into the bean-shaped nebula that surrounds it.



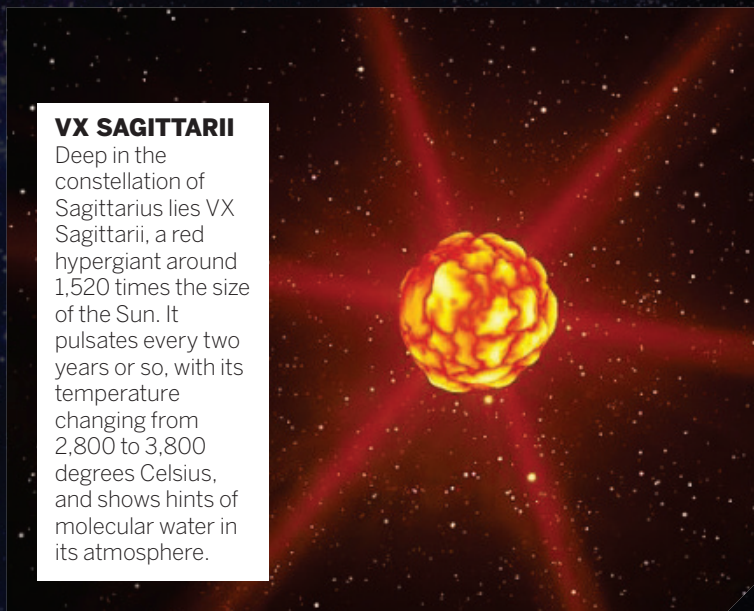
### WOH G64

160,000 light years away in the Large Magellanic Cloud, on the border of the constellations of Dorado and Mensa, lies the red hypergiant WOH G64. It has a radius around 1,540 times greater than the Sun's, but due to its distance from Earth its exact size is uncertain.



### WESTERLUND 1 W26

On the outskirts of the Westerlund 1 star cluster in the constellation of Ara, you'll find Westerlund 1 W26. It's around 1,530 times larger than the Sun, and although it's nearly impossible to see its visible light, it's a strong emitter of radio waves.



### VX SAGITTARII

Deep in the constellation of Sagittarius lies VX Sagittarii, a red hypergiant around 1,520 times the size of the Sun. It pulsates every two years or so, with its temperature changing from 2,800 to 3,800 degrees Celsius, and shows hints of molecular water in its atmosphere.

## DID YOU KNOW? Brown dwarf stars aren't actually brown – the name was proposed as a midpoint between red and black

of Jupiter – are hot enough to fuse deuterium, an isotope of hydrogen, and become brown dwarfs instead. Those that are smaller become planets, either pulled into orbit around a larger object or left to wander space alone.

But the largest fragments – the ones that do manage to achieve hydrogen fusion – begin to stabilise. The energy that their core releases balances out their gravity, preventing further collapse. In this phase, the hydrogen collected by the core is slowly transformed into helium and energy when the hydrogen atoms are forced together under the immense gravitational pressure. How long this takes depends on how hot the star is. Large supergiant stars can burn through their fuel after a few million years, whereas relatively cold, low-mass red dwarfs can remain in this 'main phase' for trillions of years. Our star, the Sun, is thought to be about halfway through its 10-billion-year life span. What happens when the hydrogen supply finally runs out depends on the size of the star.

We've never observed this process in a low-mass star because it takes such a long time for the main sequence to complete. In fact, the universe isn't even old enough for that to have happened yet. However, computer modelling suggests that these stars will gradually increase in temperature and brightness before slowly collapsing into white dwarfs – a ball of matter about the size of Earth, but with far greater mass. Without fuel, the core slowly cools over billions of years into a black dwarf, a dense ball of matter that no longer emits heat or light.



Vast clouds of dust eventually collapse in on themselves, resulting in the formation of protostars

**Did you know?**  
Proxima Centauri is the second-closest star to Earth

Mid-sized stars such as the Sun are destined to become red giants. Their cores collapse as their internal pressure is no longer sufficient to hold against gravity. The energy released in this collapse heats the regions just outside the core, enabling these sections to start burning their hydrogen and allowing fusion to continue. This heats up the core even further, to a point at which the fusion of helium can begin. The outer layers expand, begin to cool and become dimmer. Eventually, the

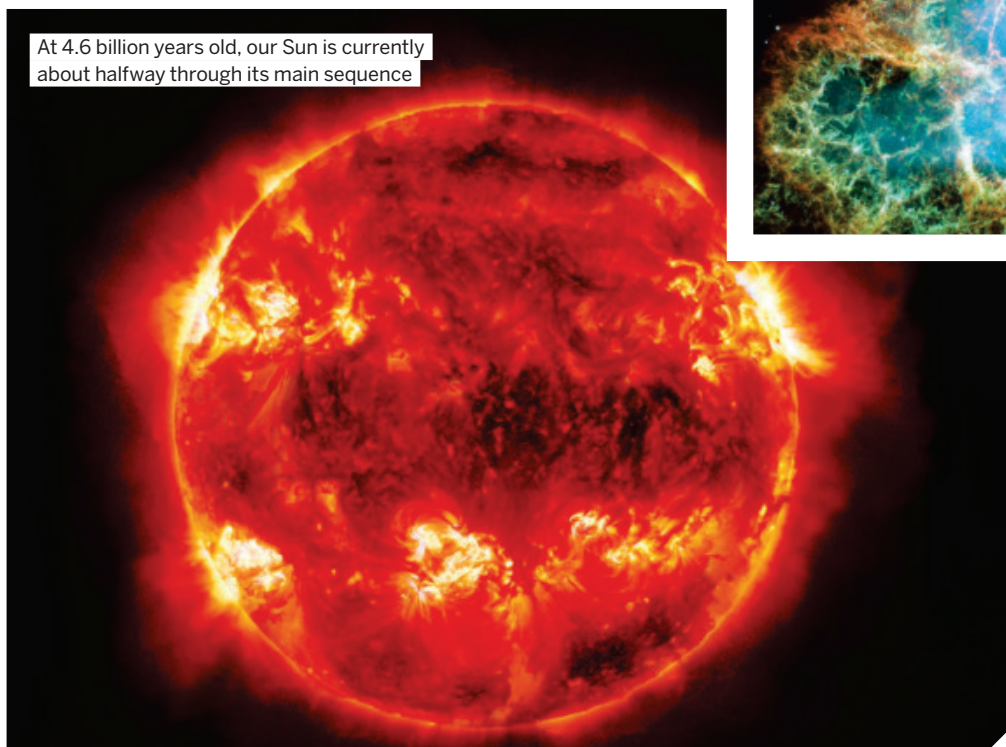
helium runs out as well, and the outer layers begin to drift away from the core, forming a planetary nebula. What's left of the core becomes a white dwarf.

Larger stars end their lives in a rather more spectacular fashion. Their cores are far hotter, fusing the hydrogen into helium in a fraction of the time it takes for smaller stars. The helium then ignites and fuses into carbon, which ignites and fuses into neon, and so on up the periodic table until it hits iron. At this point, more energy is used up in creating the iron than is released when it's formed, halting the process and setting off a supernova – the largest explosion in the universe.

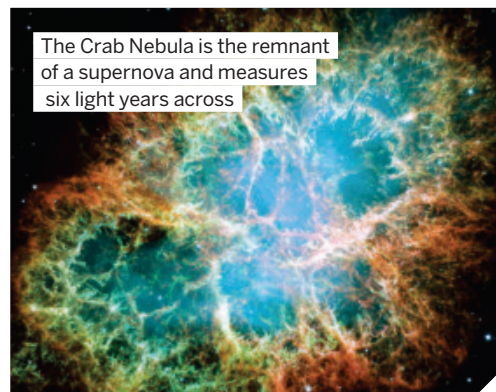
In a supernova, the star's core undergoes a sudden, catastrophic collapse. The energy released in the process spews all of the

elements created in the star, as well as a few new ones formed in the heat of the explosion, far out into space. Every atom of every one of the heavy elements – and in astronomical terms, that's anything heavier than hydrogen and helium – on Earth was originally forged in the heat of one of these titanic events.

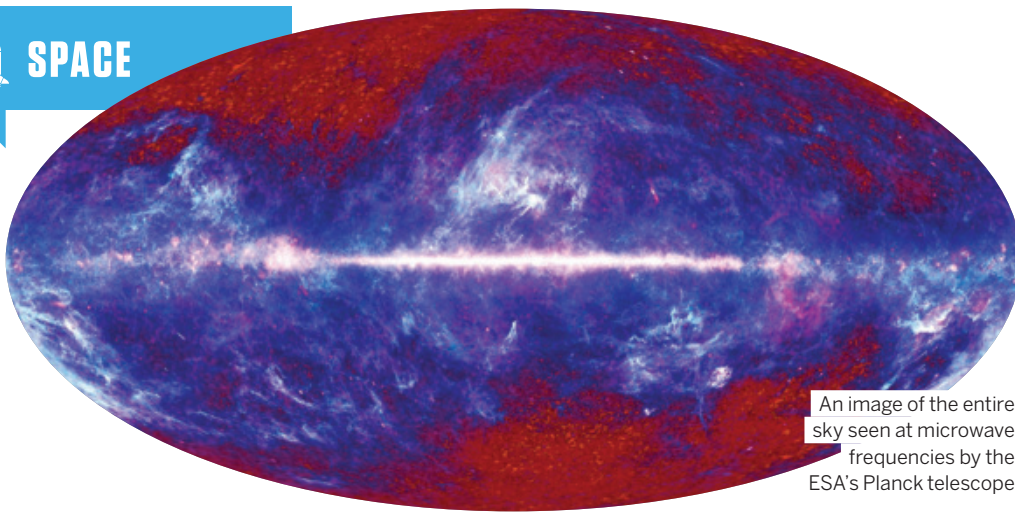
What's left behind is either a tiny, ultra-dense neutron star – an object with twice the mass of the Sun crammed into a space about the width of the English Channel – or something denser still, a region of space-time that prevents anything, including light, from ever escaping. If that happens, that original cloud of gas will live out the rest of eternity as a black hole.



At 4.6 billion years old, our Sun is currently about halfway through its main sequence



The Crab Nebula is the remnant of a supernova and measures six light years across



An image of the entire sky seen at microwave frequencies by the ESA's Planck telescope



Another way to study the CMB is by using balloon-borne experiments

# WHAT IS THE COSMIC MICROWAVE BACKGROUND?

It's the oldest thing in the universe that astronomers can still observe

WORDS ANDREW MAY

**A**stronomical telescopes are a bit like time machines – the more distant an object is, the further back in time we see it. That's because photons of light, as well as radio waves and other forms of radiation, travel through the universe at a finite speed. On the face of it, this means that a sufficiently powerful telescope ought to be able to show us the very beginning of the universe – the Big Bang itself. Unfortunately, this isn't the case, because in its earliest stages the universe was filled with an opaque, superhot plasma, not unlike the inside of a star. It was only when it had cooled to the point that ordinary atoms could exist that the universe became sufficiently transparent for us to see anything of it today. This happened around 380,000 years after the Big Bang, which sounds like a long time, but is really only a tiny fraction of its current age of 13.8 billion years. As amazing as it sounds, we can still see the primordial radiation that was emitted way back in that dim and distant time – what

astronomers refer to as the cosmic microwave background (CMB).

When the radiation was first emitted, it would have had a similar wavelength to the light we see from the Sun. But as the universe has expanded, it's been stretched out by a factor of 2,000 or so. This means we now see the CMB in the microwave band, with a wavelength of around one millimetre. Over the course of billions of years it's also become very faint, making it difficult to detect even with the most powerful radio telescopes. In fact, the CMB was predicted theoretically as a direct consequence of the Big Bang two decades before it was detected observationally.

That discovery was a great moment in the history of cosmology because it confirmed a clear-cut prediction of the Big Bang theory while being virtually impossible to explain within the competing 'steady-state' model of the universe. While the mere discovery of the CMB back in the 1960s told astronomers

## Did you know?

Max Planck was the originator of quantum theory



something important about the way the universe began, they've continued to study it intently ever since. There are two reasons for this. Most importantly from a cosmological point of view, the large-scale structure of the CMB, seen over the entire sky, contains valuable information about the quantities and distribution of dark energy, dark matter and ordinary matter in the universe.

At the same time, astronomers are also interested in smaller scale fluctuations within the CMB, as these eventually led to the formation of galaxies and galaxy clusters. There's a practical problem, however, in that water molecules within Earth's atmosphere tend to absorb microwave radiation, as well as producing emissions of their own at these wavelengths. So the best place for a CMB telescope is outer space – or failing that, a very dry location such as the South Pole or the Chilean Andes.

## CMB TIMELINE

1948

George Gamow and colleagues predicted the CMB's existence as an inevitable consequence of the Big Bang.



1965

Radio astronomers Arno Penzias and Robert Wilson accidentally discovered the CMB while working on an unrelated project.



1978

Penzias and Wilson were awarded the Nobel Prize in Physics for their discovery.

1988

The first CMB experiment at the South Pole, the Advanced Cosmic Microwave Explorer, or ACME, started up.

1989

Launch of the first major space-based CMB telescope, NASA's Cosmic Background Explorer (COBE).



**DID YOU KNOW?** Over millions of years the CMB will slowly get fainter, but will never disappear entirely

## STUDYING THE CMB FROM SPACE

The European Space Agency (ESA) launched its Planck mission to map the CMB from space in 2009. It followed two earlier NASA missions, COBE and WMAP, and improved on both in terms of resolution and sensitivity. Planck also had a wider wavelength coverage, observing in nine bands ranging from one centimetre down to a third of a millimetre. Named after 20th-century physicist Max Planck, the ESA's spacecraft was large, at 4.2 metres across. Like NASA's James Webb Space Telescope, Planck wasn't located in Earth orbit, but at the second Sun-Earth Lagrange point, known as L2, which is one of several places between Earth and the Sun where gravity balances out. Here, Planck maintained a constant distance from Earth of approximately a million miles – four times further than the Moon – on the opposite side of Earth from the Sun. It's an ideal place for a telescope because it's protected from strong sources of heat and radio waves and has an unobstructed view of the whole sky.



An ESA artist's impression of the Planck telescope in space

## THE SOUTH POLE TELESCOPE

The most powerful ground-based telescope dedicated to observing the CMB is in a unique location



### 1 PRIMARY MIRROR

Around five metres in diameter, this large mirror gives the telescope a high-resolution view of the CMB.

### 2 RECEIVER

After bouncing off two more mirrors, the microwaves enter the telescope's detector here.

### 3 CMB

This spans the whole sky, as shown in this map created by NASA's WMAP space telescope.

### 4 CMB FLUCTUATIONS

This fine-scale structure within the CMB is what the South Pole Telescope is mainly designed to study.

### 5 AMUNDSEN-SCOTT SOUTH POLE STATION

This US-run scientific research station is precisely located at Earth's geographic South Pole.

### 6 HIGH ALTITUDE

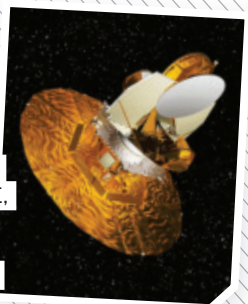
The telescope stands at an altitude of 2,835 metres, where the air is thin and dry.

### 7 TELESCOPE MOUNT

This can be rotated to allow the mirror to observe any desired point in the sky.

**2001**

Launch of NASA's successor to COBE, the Wilkinson Microwave Anisotropy Probe (WMAP).

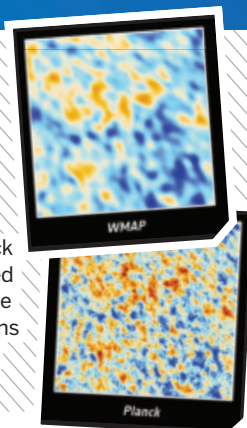


**2005**

The Arcminute Microkelvin Imager, a CMB observatory located near Cambridge in the UK, became operational.

**2009**

The ESA's Planck telescope arrived at L2 to continue CMB observations where WMAP left off.



**2011**

The first major survey by the South Pole Telescope was completed.

**2018**

The final results from Planck, which ceased collecting data in 2013, were published.



# CRAZY

## ANIMAL DEFENCES

From mesmerising distractions to bizarre biological weapons, here are some of the wild ways that animal species fight and deter predators

WORDS AILSA HARVEY

### PHYSICAL FIGHTERS



#### KITTED-OUT CRUSTACEAN

The boxer crab travels prepared when it ventures across the ocean floor. Well-armed to better its chances against a predatory attack, the crab wields two sea anemones on its front claws like boxing gloves. Carrying these sizable anemones with them acts as a deterrent to predators by making the crab look bigger and stronger. But on the occasion the crab is approached by an attacker, it will punch its claws outwards. The anemones have tentacles that can sting the predator and help keep the boxer crab safe. The anemones also benefit from this symbiotic relationship with the crab. They're perfectly healthy and safe while held by the claws, and as the crab moves it drags the anemones along the seabed, enabling them to collect food particles in their tentacles.

The boxer crab is also known as the pom-pom crab

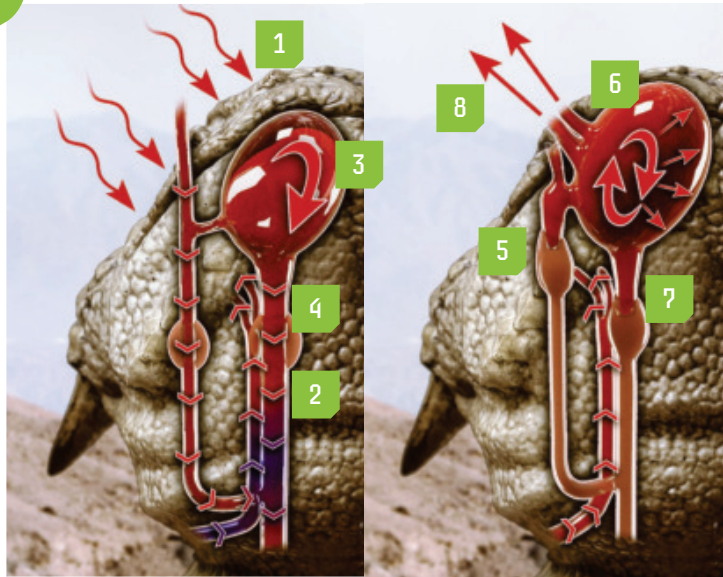
**DID YOU KNOW?** Once emptied, a hagfish's slime glands take three to four weeks to refill



**Did you know?**  
The horned lizard sprays blood up to 1.5 metres

## BLOOD SHOOTER

The regal horned lizard builds up pressure in its head to squirt blood out of its eyes



### 1 HEAT

A basking lizard absorbs heat from the Sun. This causes blood vessels to dilate and increases blood flow to the head.

### 2 NORMAL BLOOD FLOW

Blood flows from the heart to the head through veins around the eyes and through the rest of the body.

### 3 VENOUS SINUS

In the sinus around

the eyes, blood is collected. This helps maintain blood pressure.

### 4 RELAXED CONSTRICTOR MUSCLE

Muscles around the eyes are relaxed when blood flows normally.

### 5 RESTRICTED FLOW

The blood flow from heart to head is cut off so that blood starts to pool in the venous sinus.

### 6 PRESSURE BUILD

Blood pressure in

the venous sinus increases where the blood is trapped.

### 7 CONTRACTED MUSCLES

The constrictor muscles squeeze the venous sinus to stop blood flowing at the head.

### 8 BLOOD SQUIRT

The buildup of pressure forces the thin capillary walls to rupture and a stream of blood shoots from beneath the skin around the eyes.



A regal horned lizard after shooting blood from its eyes

## PIERCING PROTECTION

The Spanish ribbed newt has developed a mechanism that enables it to turn its protective ribs into external weapons. When threatened, this amphibian forces its rib bones outwards until it pierces the skin on its back. This may seem like an extreme response, but it's only performed as a desperate last attempt. As its first line of defence, the newt tries to wriggle free of any grasp a predator has on it. If that fails, it

secretes a toxin from its neck and along the sides of its body. This is strong enough to kill animals such as rodents. These secretions also help the animal move free of predators by making the texture of its skin more slippery. If these techniques don't work, the newt arches its back and uses its back muscles to force the pointed ends of its ribs through dotted patches of skin along its sides.

As the Spanish ribbed newt punctures itself with its own ribs, it releases antimicrobials to prevent infection





**2 PECTORAL SHIELD**

The pectoral shield defends vital organs in the chest and provides structure when the armadillo rolls into a ball, covering the upper body and shoulders.

# ARMADILLO ARMOUR

This mammal is covered in protective bony plates hard enough to deflect bullets

**3 MOVEABLE BANDS**

This part of the armour is segmented to provide flexibility for moving and curling up. There are usually 7 to 11 bands.

**4 PELVIC SHIELD**

This protects the rear of the body, such as the back and hips.

2

3

4

5

**1 CEPHALIC SHIELD**

Over the head of the animal, this thick, bone-like structure is covered with keratin and protects the head during burrowing.

1

**5 CAUDAL SHEATH**

Overlapping plates cover the entire tail. This keeps it flexible and strong.

6

**6 SKELETON**

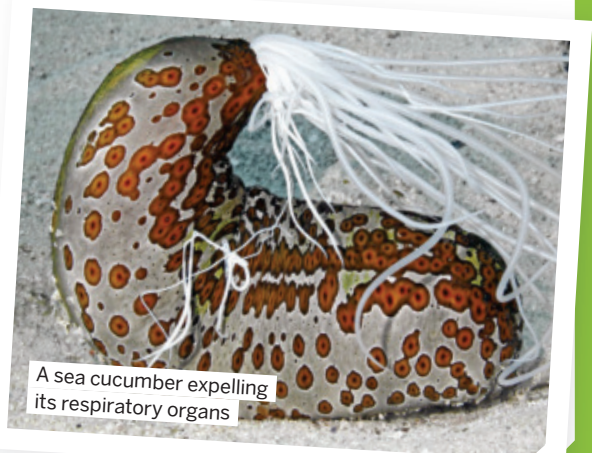
The skeleton includes short limbs with powerful curved claws for burrowing. The skull is flat and elongated for digging and foraging.

## TRICKY TACTICS

### ORGAN-RELEASING SEA CUCUMBER

The sight of a living thing's internal organs emerging outside of its body might indicate that an animal has lost a fight. However, in the case of the sea cucumber, expelling its respiratory or digestive organs is a deliberate tactic. Sea cucumbers are scavenging marine animals with long bodies resembling cucumbers. Without extensions like moveable limbs to block or fight predators, the sea cucumber forcefully

ejects its own guts through its anus. This technique is called evisceration and exposes predators to the toxins covering the organs. This irritates the predators to deter them or causes them to get tangled up. If this defensive mechanism saves the sea cucumber's life, it goes on to regenerate the lost organs. This process uses masses of energy, however, so the spectacle is only witnessed in desperate situations.



A sea cucumber expelling its respiratory organs

**DID YOU KNOW?** The boxer crab only grows to around 13 millimetres wide

## SLIMY SUFFOCATION

Lurking around the seafloor off the coast of the north Pacific are eel-shaped fish called hagfish. Inside each fish are large slime glands, which can release great volumes of suffocating slime through their long body's 90 to 200 slime pores. This slime is usually only released if a hagfish is in distress. When predators approach the fish, it will release slime in defence. Taking a closer look at the slime reveals that it's made up of mucus and protein threads. As it leaves the hagfish's body and makes contact with seawater, the slime expands to 10,000 times its original volume within one second. This is enough to cover larger predators and clog up their gills. This causes the predator to release the hagfish, which then ties itself into a knot, like an eely pretzel. This helps it protect its own gills from the self-produced slime as it swims away to safety.

Sliding a knot along its body also helps the hagfish remove parasites



Hagfish have smooth, scaleless bodies



**Did you know?**  
Hagfish have four hearts



Vinegar can help remove hagfish slime

## STEALTHY ESCAPE

Like humans, most animals will act in a fight-or-flight response to danger. One animal that takes the flight option to a new level is the Venezuelan pebble toad. When approached by a predator, this toad first curls up into a round shape, disguising itself as a lifeless pebble. If this isn't enough, and danger comes too close, the toad then rolls its curled-up body off the edge of a nearby cliff – a descent that it can survive, but its predators wouldn't dare follow. This drop-and-roll technique suits the toads' habitat atop the tepui mountains of South America. Tepui are flat, table-topped mountains that tower high above the rainforest below.



The pebble toad blends in with rocks



# GREAT FAKER

Using the defence strategy of feigning death, opossums become natural actors when faced with a threat. Because many animals will only eat prey that they have killed themselves, these marsupials will pretend to be dead if a predator ventures too close to them. This is a last resort, however, and isn't acting at all. The process of death-feigning is involuntary and brought on by stress. First, opossums will hiss and growl at other animals to scare them away. But if the predator continues to threaten them, this is when the opossum falls limply to the floor, flops its tongue out the side of its open mouth, half closes its eyes and even emits a foul stench from its anus to smell convincingly like a decaying animal. This usually puts the predator off the potential meal.



This opossum has tricked an attacking dog

# CHEMICAL WARFARE

## BOMBS AWAY

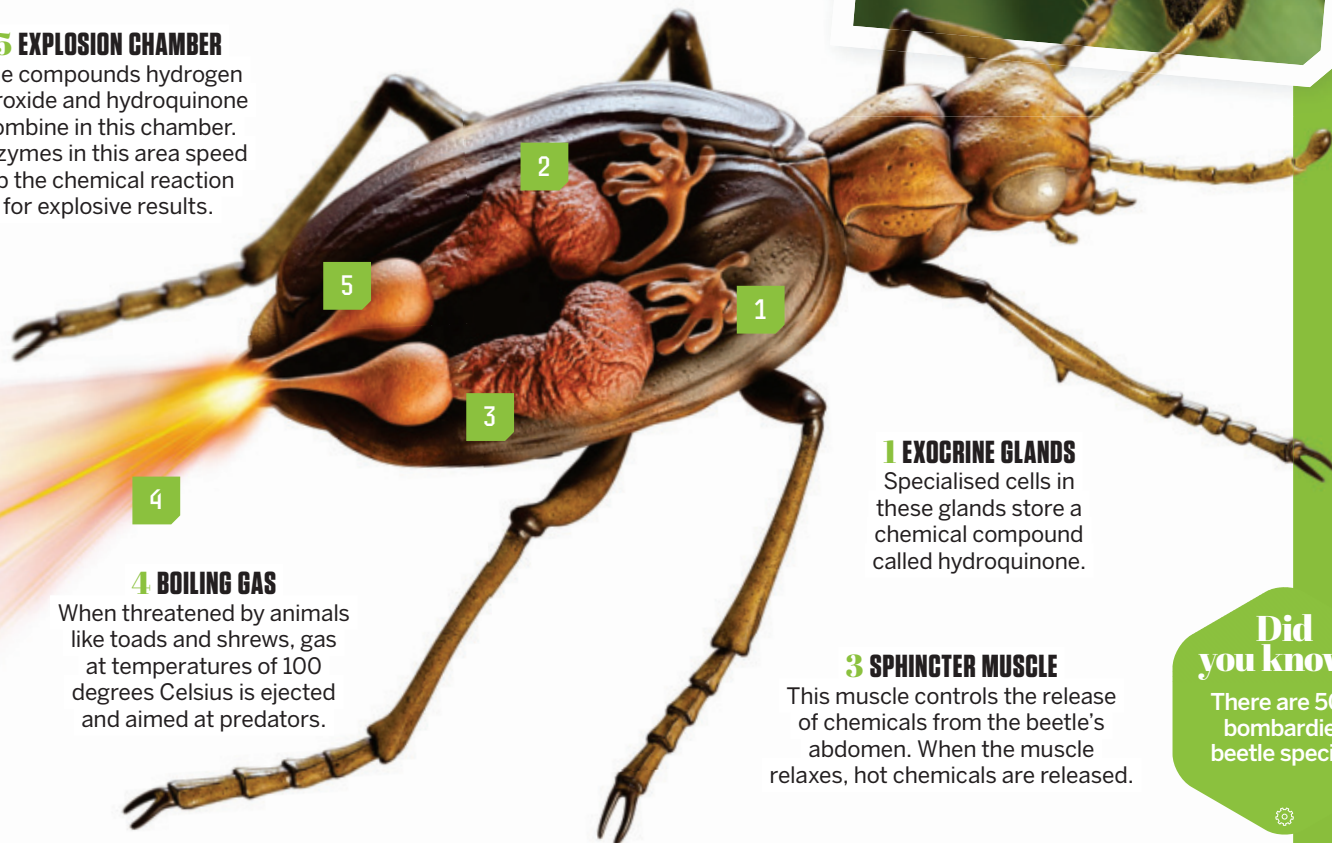
The bombardier beetle is capable of producing a sizeable scalding spray



There are 500 species of these explosive beetles

**5 EXPLOSION CHAMBER**  
The compounds hydrogen peroxide and hydroquinone combine in this chamber. Enzymes in this area speed up the chemical reaction for explosive results.

**2 VENTRAL GLANDS**  
These glands contain peroxide-producing cells. Here, hydrogen peroxide is produced and stored.



**1 EXOCRINE GLANDS**  
Specialised cells in these glands store a chemical compound called hydroquinone.

**4 BOILING GAS**  
When threatened by animals like toads and shrews, gas at temperatures of 100 degrees Celsius is ejected and aimed at predators.

**3 SPHINCTER MUSCLE**  
This muscle controls the release of chemicals from the beetle's abdomen. When the muscle relaxes, hot chemicals are released.

**Did you know?**  
There are 500 bombardier beetle species



Octopus ink contains the compound tyrosinase to burn predators' eyes



Exploding ants point their abdomens upwards before attacking

© Wikimedia Commons / Bernard DUPONT

## EXPLOSIVE SACRIFICE

While some animals live a solitary life and deploy defences for sole survival, other animals are programmed to protect their colony above all else. One dramatic case of this is the exploding ant, or *Colobopsis explodens*. The exploding ant houses specialised glands that produce a combination of chemicals and toxic formic acid. If one of these ants detects a threat to its colony, it contracts its sphincter muscles to build up internal pressure. The gland then ruptures, releasing the toxic contents and creating an explosive release of chemicals that covers predators in irritants. This process turns the predator away or provides an escape window for the rest of the colony as the predator deals with their discomfort. Unfortunately, for the martyr ant this means the end of its life, but it has ensured its colony's survival.

**“Squids and octopuses can release an inky substance into the water”**

## CREATING CLOUDS

The ocean is filled with masterful escape artists. Pygmy sperm whales, squids and octopuses can all release an inky substance into the water to conceal their retreat. The pygmy sperm whale produces a dark red-brown ink in a sac in its intestines. When faced with danger, the whale releases 12 litres of this ink through its anus, producing a dark cloud in the surrounding waters. Predators can become confused by the sudden change in the water, and the movements of the whale are obscured. By the time the ink dissipates, the pygmy sperm whale will have created space between itself and its predator – and perhaps even have vanished from view. Squids and octopuses perform the same trick. Squid and octopus ink sacs contain melanin and mucus, which is directed out of their bodies through a syphon. The mucus gives the excretion a thicker consistency, clumping the melanin together to form unusual or deceptive shapes. Predators can sometimes mistake the compact ink for the squid or octopus itself while the escape takes place.

## A SICK TRICK

Northern fulmars are soaring seabirds that use their bizarre biology to protect themselves in the air and as chicks before they can fly. Rather than relying on sharp beaks and dagger-like claws, these birds projectile-vomit onto predators to keep them away. This foul-smelling and oily substance damages and clogs the insulating feathers of birds and sticks to the fur of ground animals. The strong smell of the oily vomit alone can be enough to keep animals away from vulnerable nests. For other animals, the sticky sick limits the predator's mobility. Fulmars produce this substance in the stomach even when there is no food, so it can be delivered at any time.



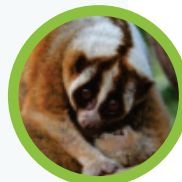
A northern fulmar projectile-vomits on intruders to defend its eggs

# 5 FACTS

## MIMICKING TECHNIQUES

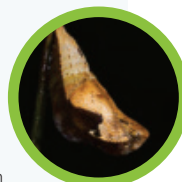
### 1 SLOW LORIS

This animal raises one of its long arms above its head and wiggles it like a venomous snake to intimidate predators. It also has snake-like markings on its head and back.



### 2 DYNASTOR BUTTERFLY

Dynastor butterfly caterpillars can lift themselves up at one end while in a chrysalis and move like the head of a snake. The chrysalis even has eye spots and a scaly pattern.



### 3 MIMIC OCTOPUS

This sea creature can change its colour, shape and behaviour. It has learned to contort itself into illusions of multiple marine animals.



### 4 HOVERFLY

These stingless flies have evolved to mimic the appearance of more dangerous wasps and bees to deter birds and other insects.



### 5 MILK SNAKE

The red, black and yellow patterns on this snake give it the illusion of the more venomous coral snake. Fewer predators are likely to approach it for this reason.





# WHAT IS ACID RAIN?

## Some clouds can harbour water that kills trees and melts statues

WORDS SCOTT DUTFIELD

**A**cid rain is the broad term used to describe precipitation that is more acidic than normal. Typically, rainfall has a pH of 5.6 – anything below that level is considered acid rain. Of course, clouds aren't in control of the pH of their precipitation – just like the rest of the natural world, it's impacted by pollution emitted by cars and industry. The two main gas pollutants responsible for acid rain are sulphur dioxide (SO<sub>2</sub>), released as a byproduct of the fossil fuel industry, and nitrogen oxides (NOX) from vehicle exhausts. When these gases drift into the atmosphere, they interact with sunlight and water vapour to form sulphuric acid and nitric acid mists. Under warm temperatures, the clouds of acid mist remain as vapour. However, when temperatures cool, the vapour condenses and forms acidic droplets that fall to the ground as rain or snow. But industrial pollutants aren't the only way

**Did you know?**  
Most freshwater lakes have a pH of 6.5 to 8.5

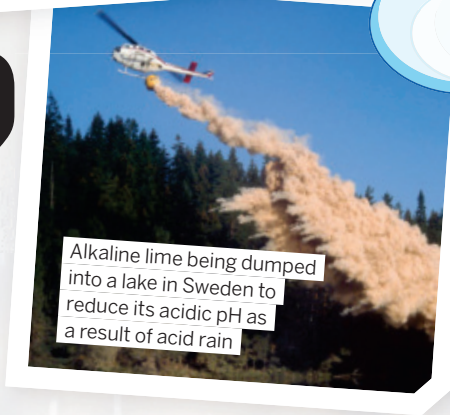
these gases enter the environment: natural sources also release SO<sub>2</sub> and NOX into the atmosphere, such as volcanoes following a massive eruption.

Once in the environment, acid rain can wreak havoc on many ecosystems. For example, if you come across a forest of dying trees, there's a good chance that acid rain has played some part in their death. Acid rain can leach toxic metals from the soil, such as aluminium. Metals like aluminium prevent trees from taking up water and nutrients from the soil, ultimately starving them to death. At higher elevations, the acidic gases that don't make it into the clouds can also coat the surface of a tree's leaves, preventing them from being able to photosynthesise.

The direct effects of acid rain on human health, on the other hand, are few. However, in their gaseous states its ingredients can lead to many harmful respiratory issues, such as bronchitis and asthma attacks.



A statue that has been corroded by exposure to acid rain



Alkaline lime being dumped into a lake in Sweden to reduce its acidic pH as a result of acid rain

**4 ACID SHOWERS**  
Acidic water vapour condenses under cooler temperatures and rains down.



4

POLLUTION

PLANTS DIE

6

**6 TREE DEATH**

Soil is contaminated with toxic metals, preventing new tree growth and killing existing forests.

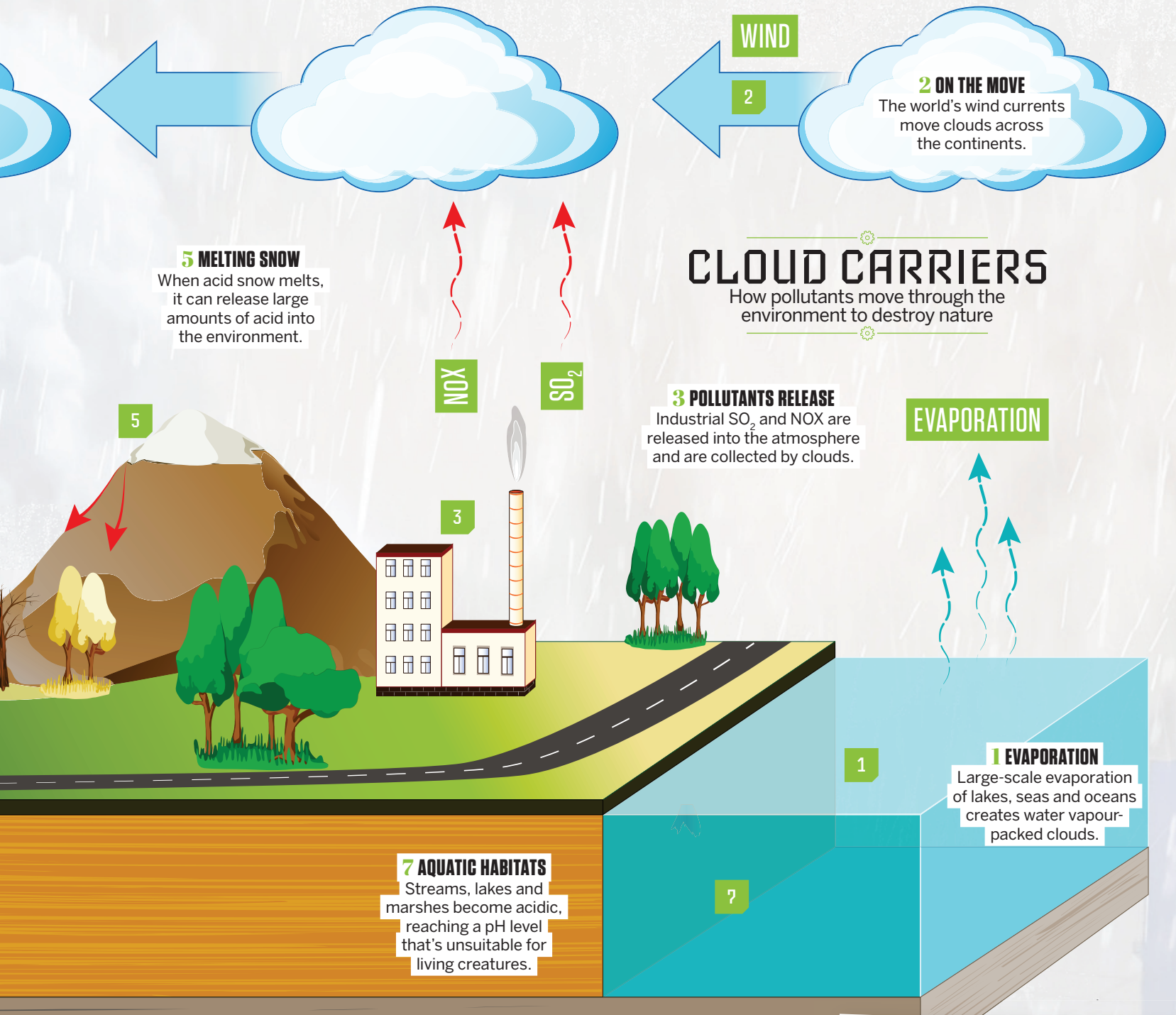
## CLEANING UP THE RAIN

It wasn't until 1963 that anyone knew what acid rain was. While studying the ecology of forests in New Hampshire, scientists discovered that rain samples were up to 100 times more acidic than they expected. At its peak, acid rain stripped forests and obliterated lakes across Europe, Canada and the US. In 1982, pH readings of 2.83 were recorded over the Great Lakes of the US and Canada. For comparison, lemon juice has a pH of between 2.0 and 3.0. During the 1990s, legislation around the world was introduced to curb the release of SO<sub>2</sub>. Between 1990 and 2017, the levels of SO<sub>2</sub> emissions released in the US plummeted by 88 per cent, thanks to the Clean Air Act of 1990. To combat the release of SO<sub>2</sub>, many fossil fuel energy plants employ sophisticated air filters and 'scrubbers' to trap and store pollutants before they reach the atmosphere.



Industries with a greater risk of pollution, such as this cement factory, use sulphur dioxide scrubbers to minimise acid rain production

**DID YOU KNOW?** Between 1990 and 2012, acid rain levels dropped by 80 per cent in the UK



## CLOUD CARRIERS

How pollutants move through the environment to destroy nature

## A MONUMENTAL ISSUE

One of the many consequences of acid rain is that it dissolves monuments and statues. When sulphuric acid and nitric acid come into contact with the materials used to build statues, such as marble and limestone, they can slowly dissolve a compound called calcite and erode the sculpture. The Leshan Giant Buddha in China is among the most afflicted by acid rain. As the world's largest stone Buddha, the statue was carved from a cliffside made of red sandstone around 1,200 years ago. A 71-metre-high symbol of eternity and

peace, the Leshan Buddha is an impressive feat of engineering. However, it's being dissolved by acid rain, leaving black and grey stains on its face and body. China is one of the world's largest fossil fuel users, which means that acid rain has already been a big environmental concern for the nation. But in 2023, 28.8 per cent of the monitored cities in China experienced acid rain, down from 44.4 per cent in 2013. Factories and power plants near the monument have been closed down to help prevent further damage.

The Leshan Giant Buddha, which was carved into a cliff during the 8th century





# THE WORLD'S LONGEST BRIDGES

Discover the incredible  
feats of engineering  
closing some of the  
biggest land gaps

WORDS AILSA HARVEY

**DID YOU KNOW?** At 391 metres, Hartland Bridge in Canada is the longest covered bridge, with a roof to stop the wood rotting



**H**umans have constructed bridges for thousands of years, helping establish trade routes across rivers and deep valleys to keep communities connected. Today's modern bridges may be bigger and longer, using advanced building techniques and materials that weren't available to ancient engineers, but they're still constructed to make isolated islands and tricky terrain more accessible.

Building record-breaking bridges is only possible with high-strength materials such as advanced steel alloys – low-alloy steel with a high strength-to-weight ratio and better corrosion resistance. Choosing this steel over alternatives allows for longer structures to be built with lower weight stress. And

the corrosion resistance helps give a bridge longevity. Computer structural simulations that take into account variables such as the specific location, bridge length, shape and type of materials can be used to determine whether a mammoth bridge project is actually viable before builders invest more time and money into the project.

To date, the world's longest completed bridge is China's Danyang-Kunshan Grand Bridge, measuring over 100 miles in length. It's designed to support high-speed trains travelling at around 186 miles per hour. China's high-speed railway network is revolutionising travel efficiency, with the bridge assisting in reducing a journey between Beijing and Shanghai that once took 12 hours to just 4.5 hours.

**Did you know?**  
Arkadiko Bridge is thought to be the world's oldest crossable bridge



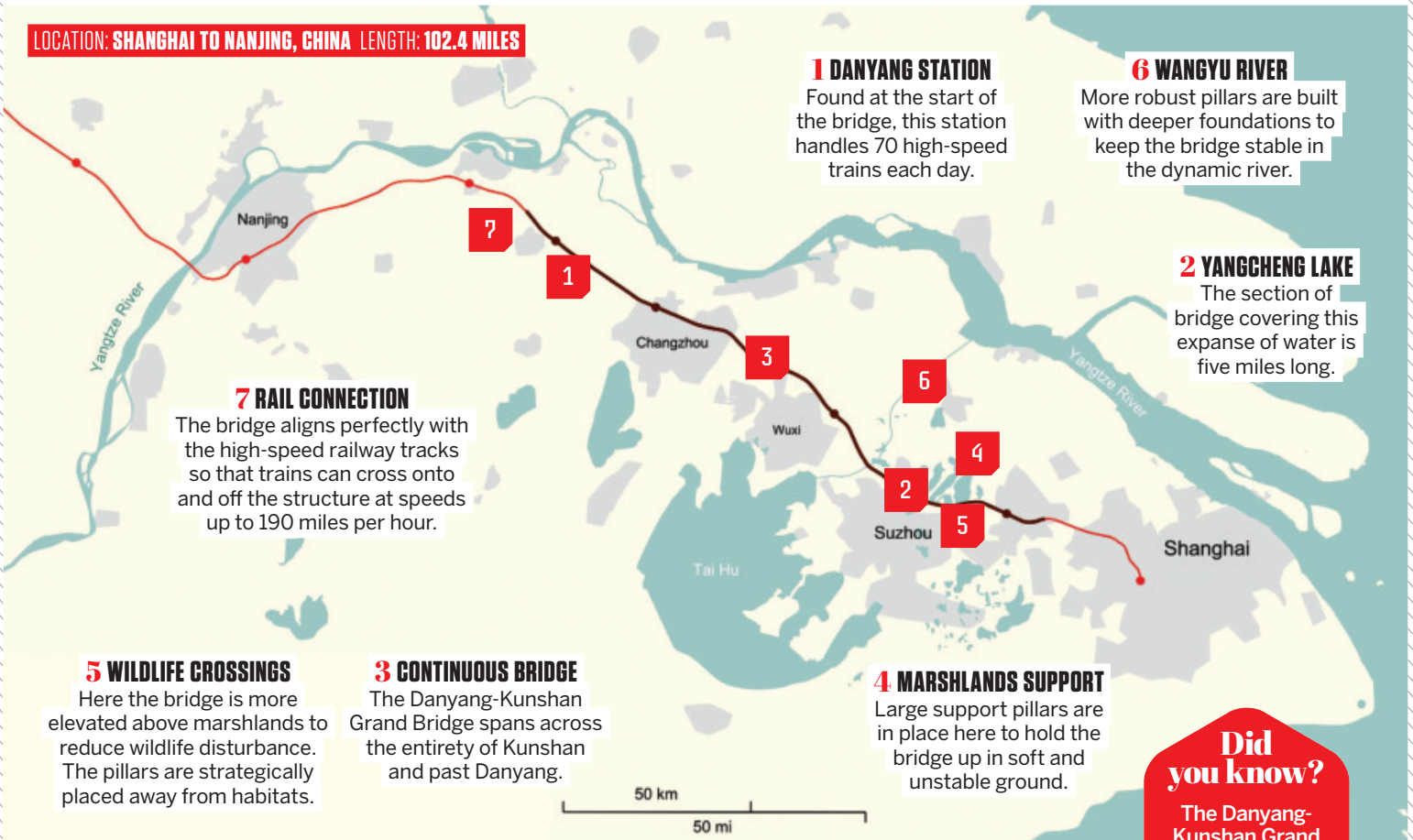
A bullet train on the Beijing-Shanghai high-speed railway crosses China's enormous Danyang-Kunshan Grand Bridge



# THE WORLD'S LONGEST BRIDGE

The Danyang-Kunshan Grand Bridge is the longest across all categories, forming part of China's high-speed rail network

LOCATION: SHANGHAI TO NANJING, CHINA LENGTH: 102.4 MILES



### 1 DANYANG STATION

Found at the start of the bridge, this station handles 70 high-speed trains each day.

### 6 WANGYU RIVER

More robust pillars are built with deeper foundations to keep the bridge stable in the dynamic river.

### 2 YANGCHENG LAKE

The section of bridge covering this expanse of water is five miles long.

### 7 RAIL CONNECTION

The bridge aligns perfectly with the high-speed railway tracks so that trains can cross onto and off the structure at speeds up to 190 miles per hour.

### 5 WILDLIFE CROSSINGS

Here the bridge is more elevated above marshlands to reduce wildlife disturbance. The pillars are strategically placed away from habitats.

### 3 CONTINUOUS BRIDGE

The Danyang-Kunshan Grand Bridge spans across the entirety of Kunshan and past Danyang.

### 4 MARSHLANDS SUPPORT

Large support pillars are in place here to hold the bridge up in soft and unstable ground.

### Did you know?

The Danyang-Kunshan Grand Bridge has 2,000 piers

## RUNNERS UP



### CHANGHUA-KAOHSIUNG VIADUCT

LOCATION: TAIWAN LENGTH: 97.7 MILES

The second-longest bridge makes up part of Taiwan's high-speed rail network. It was completed in 2007 with a focus on minimising earthquake damage. To do this, the bridge absorbs and dissipates the energy of an earthquake away from the structure itself. In doing so, it protects trains and passengers by providing a safe space for the vehicle to come to a stop.



### TIANJIN GRAND BRIDGE

LOCATION: CHINA LENGTH: 70.6 MILES

When it opened in 2011, this bridge was the second longest in the world. It's made up of 32 separate sections, each weighing 860 tonnes, that were built and installed individually. Tianjin Grand Bridge, which was completed four years after the project launched, connects Langfang and Qingxian in China and makes up another part of the Beijing-Shanghai high-speed railway.



### CANGDE GRAND BRIDGE

LOCATION: CHINA LENGTH: 65.7 MILES

This section of the Beijing-Shanghai railway is supported by 3,092 piers. Sometimes Cangde Grand Bridge's length is listed at 72 miles, as this includes other support structures and viaducts that connect to the bridge at either side.



### WEINAN WEIHE GRAND BRIDGE

LOCATION: CHINA LENGTH: 49.5 MILES

Connecting Zhengzhou and Xi'an in Weinan, China, this bridge crosses the Wei River twice. It was completed in 2008, though it was another two years before its railway line was opened. 10,000 people constructed Weinan Weihe Grand Bridge using 45,000 tonnes of steel and over 2,000,000 cubic metres of concrete.

**DID YOU KNOW?** The Danyang-Kunshan Grand Bridge cost £8 billion (\$10 billion) to build

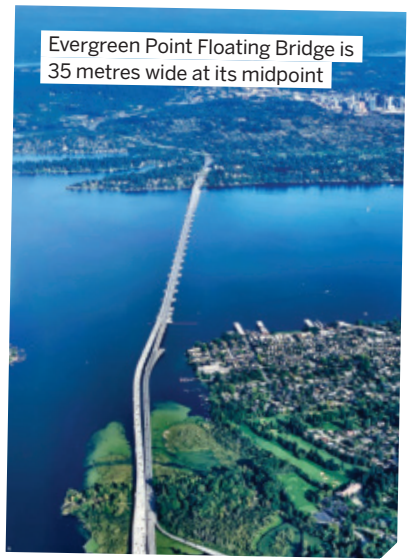
## SUSPENSION RECORD-BREAKER

**LOCATION: 1915 CANAKKALE BRIDGE, TURKEY LENGTH: 2,023 METRES**

Despite its name, the 1915 Canakkale Bridge was opened in 2022. It's named after the year the Turkish Navy defeated Britain and France in World War I and connects the Asian and European land of the country on either side of the Dardanelles Strait. This makes travel across

the region much easier by eliminating the need for a 30-minute ferry. In addition to holding the title of longest suspension bridge, the 1915 Canakkale Bridge is also the tallest bridge of its type, with 318-metre-tall towers holding up the suspended steel deck.

The 2,023-metre bridge commemorates 2023, the 100th anniversary of the Republic of Turkey



Evergreen Point Floating Bridge is 35 metres wide at its midpoint

## SKY WALKING

**LOCATION: SKY BRIDGE 721, CZECH REPUBLIC LENGTH: 721 METRES**

The longest pedestrian bridge in the world is a suspension bridge that dangles 95 metres above a drastic mountain valley drop. For those unphased by heights, this narrow crossing is a ticketed tourist attraction that has been designed as an educational experience as well as a captivating view. The total crossing time takes

around 1.5 hours, but this includes time to take in information about the history of the surrounding area, a three-hour drive from the country's capital city of Prague. The bridge took two years to build and consists of six main supporting ropes and 60 wind ropes to keep the structure in place.



Sky Bridge 721 opened in spring 2022

## FLOATING ON WATER

**LOCATION: EVERGREEN POINT FLOATING BRIDGE, WASHINGTON LENGTH: 2,350 METRES**

In Seattle, the world's longest floating bridge supports the weight of State Route 520 over Lake Washington. Floating bridges are also called Pontoon bridges and are supported only by pontoons on the water's surface. These structures are usually built when more permanent options aren't feasible. In the case of the Evergreen Point Floating bridge, the water is too deep and the silt on the lakebed too soft to build a secure bridge into. The 77 concrete pontoons are instead anchored to the bottom of the lake to keep the dual carriageway stable on the great lake.



# SEA CROSSING

After nine years of construction, the elaborate Hong Kong-Zhuhai-Macau Bridge between Hong Kong and China opened in 2018

LOCATION: HONG KONG TO CHINA LENGTH: 34.1 MILES

## Did you know?

The Hong Kong-Zhuhai-Macau Bridge is the sixth longest bridge

### 3 BOAT PASSAGE

The central area of the bridge is underwater to reduce obstacles for boats passing through the Pearl River Delta.

### 4 UNDERWATER TUNNEL

This underwater section is 4.1 miles long and is made mostly of reinforced concrete, with steel bars inside for extra strength. This is covered with waterproof sealing.

### 6 ROAD SAFETY

The road on the bridge has safety barriers and drainage systems.

### 8 STEEL TOWERS

Steel towers are anchored into the ground for stability in strong winds.

### 5 ARTIFICIAL ISLANDS

Four artificial islands made from dredged material provide structural support for underwater tunnels in the middle of sea.

### 7 CAISSONS

Large, concrete structures create a stable base for the bridge. They are constructed at dry docks and sunk to the seafloor.

### 9 BRIDGE PIERS

The bridge splits to connect to Macau and Zhuhai. Fewer concrete supports are required at the centre of this section.

**“Building record-breaking bridges is only possible with high-strength materials”**

**DID YOU KNOW?** 420,000 tonnes of steel was used to build the longest sea crossing – the equivalent of 60 Eiffel Towers

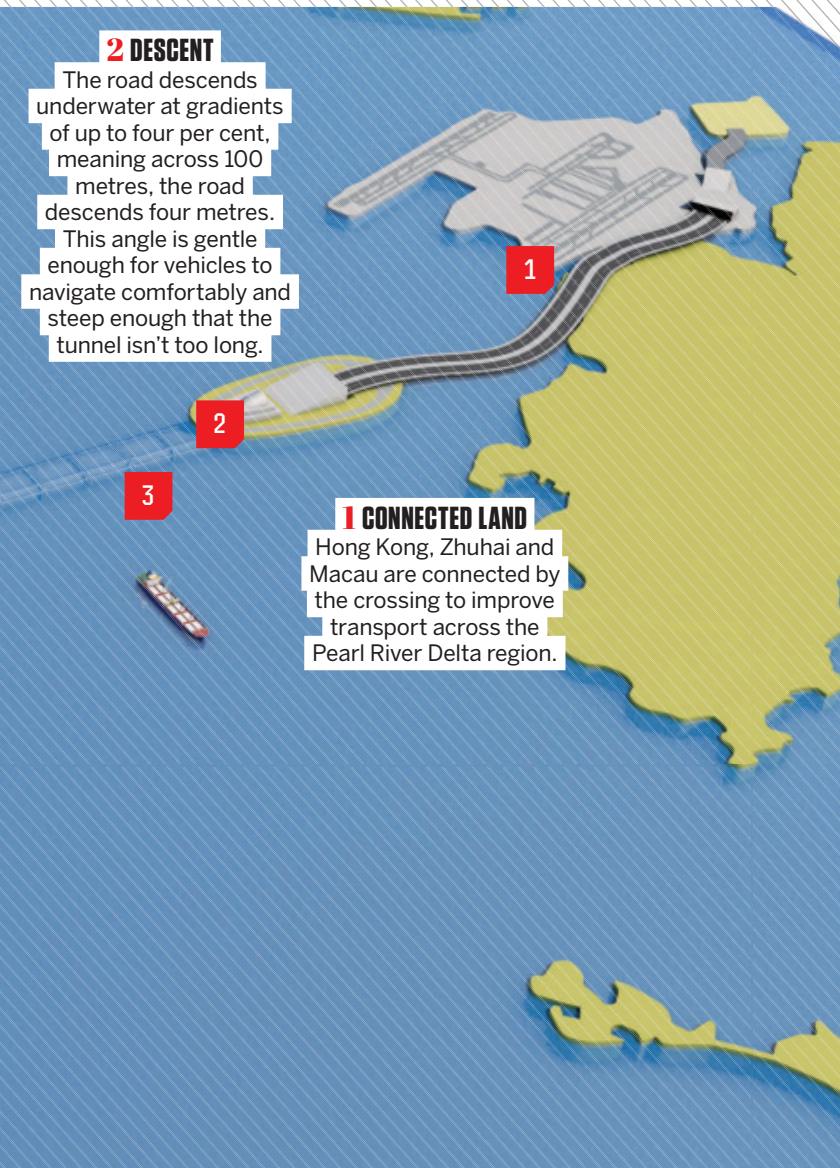
## 2 DESCENT

The road descends underwater at gradients of up to four per cent, meaning across 100 metres, the road descends four metres.

This angle is gentle enough for vehicles to navigate comfortably and steep enough that the tunnel isn't too long.

## 1 CONNECTED LAND

Hong Kong, Zhuhai and Macau are connected by the crossing to improve transport across the Pearl River Delta region.



Krämerbrücke Bridge has a width of 25 metres and a clear width of 5.5 metres between houses

## BRIDGE LIFE

**LOCATION: KRÄMERBRÜCKE BRIDGE, GERMANY LENGTH: 125 METRES**

Along the Krämerbrücke Bridge in Erfurt, Germany, are 32 houses across both sides of the crossing, making it the world's longest inhabited bridge. It was originally built in the 12th century, and its tall, narrow homes are still inhabited today. The early version of this bridge was made of wood, but kept catching fire and was rebuilt several times. Today's

more substantial Krämerbrücke Bridge was constructed from stone in the late-13th century. When this bridge became one of the only constructions to survive the ongoing fires, it became the safest place to call home. Each of the houses has three storeys, and today the ground level homes have largely been converted into river-top shops.

## CABLE-STAYED

**LOCATION: RUSSKY BRIDGE, RUSSIA  
LENGTH: 1,104 METRES**

A cable-stayed bridge is one that has its deck weight supported by straight or diagonal cables. These connect the deck directly to the vertical towers that are spaced along it, as opposed to suspension bridges that have cables suspended between the towers. The longest cable-stayed bridge, Russky Bridge, connects Russky Island and the Muravyov-Amursky Peninsula across the Eastern Bosphorus Strait in the far east of Russia. When it was constructed in 2008, it had the longest cables manufactured for a bridge at 582 metres. These long cables were essential in supporting the deck and to meet the height of the tall 320-metre towers.



The deck of Russky Bridge is 70 metres above the water



# THE POWER OF WATER

**We're hooked on fossil fuels. But hydroelectric power is becoming an increasingly important replacement for coal and oil**

WORDS IAN OSBORNE

**H**ydroelectric power meets around 15 per cent of the world's electricity needs, supplying about a billion people with power – that's comparable to 3.6 billion barrels of oil. The importance of hydropower will grow over the coming decade, with a huge number of major schemes currently under construction – as of February 2024, there are at least five in China alone. It means that although our reliance on fossil fuels is still significant – it's a hard addiction to crack, after all – hydropower is helping us decrease our dependence.

Power production is simply a process of converting energy from one form to another. In hydroelectric plants, it's the 'potential energy' of water collected in a dam that

eventually ends up as electricity. A pipe known as a penstock runs through the base of the dam. As water rushes through, the potential energy becomes kinetic energy – the energy of motion. This kinetic energy rotates a turbine in the penstock.

### Did you know?

Water becomes less dense as it forms ice



The turbine leads to a shaft that in turn leads to a generator. Inside the generator, huge magnets start to rotate past copper coils to produce alternating current (AC) electricity. Finally, this is changed to a higher voltage using a transformer and delivered to the power grid.

Although initial construction is expensive, once up and running, hydroelectric generators are cheap to run, produce zero waste and don't generate any pollution. There are over 1,500 hydroelectric power plants in use in

**DID YOU KNOW?** Water covers 71 per cent of Earth's surface, yet only 2.5 per cent of our planet's water is freshwater





The turbines at the bottom of the Hoover Dam



## HYDROELECTRIC HISTORY

Hydroelectric power plants are older than you might think – the first one made its appearance in the 1880s.

The world's first hydroelectric power plant, the Vulcan Street Plant, started operation on 30 September 1882. Located at the Appleton Paper and Pulp Company on the Fox River in Wisconsin in the US, it was built at the behest of paper manufacturer Henry J. Rogers, who was inspired by Thomas Edison's steam-powered New York plant.

The amount of electricity generated by the Fox River plant was modest, only providing enough to power a pair of paper mills and Rogers' house. On 11 November he wrote, "Gentlemen, I have used 50 lamps in my residence and have used them for about 60 days. I am pleased with them beyond expression, and do not see how they can be improved upon. No heat, no smoke, no vitiated air, and the light is steady and pleasant in every way, more economical than gas and quite as reliable."

Rogers' house is now known as the Hearthstone Historic House Museum, and still uses its original Thomas Edison light fittings.



The original Vulcan Street Plant burned down. A replica was built in its place

the US alone, making it the country's largest renewable energy source. One such plant is located on the Hoover Dam, spanning the Colorado River on the border between Arizona and Nevada. When the dam was completed in 1936, it supplied Las Vegas with the majority of its electricity, though the city has since expanded and now has to get energy from other sources as well.

There are some seriously impressive hydroelectric power plants across the world. One is the Itaipu Dam, located on the Paraná River on the border of Brazil and Paraguay. Impressively, this dam has been ranked as one of the seven wonders of the modern world by the American Society of Civil Engineers. Work on Itaipu Dam began in the early 1970s, and each month 338,000 cubic metres of concrete was used in its construction. The dam is 196 metres high and 7,760 metres long, holding back 26 billion tonnes of water. Itaipu began generating power in 1984. The total cost of building the plant was \$20 billion, but it proved to be a wise investment: annually, it supplies over a



The construction of China's Three Gorges Dam involved the flooding of some important archaeological sites

quarter of Brazil's electrical power consumption and 78 per cent of Paraguay's. The same wattage generated by a coal-powered plant would produce 61.2 million tonnes of carbon dioxide emissions.

Another colossus is the Simón Bolívar Hydroelectric Plant at Guri Dam on Venezuela's Caroni River. Built in sections between 1963 and 1986, the facility can produce as much as 50,000 gigawatt-hours of energy per year. Two main machine rooms house ten generators each. As well as being a major source of power for the region, the Guri Dam and accompanying reservoir are tourist attractions and are much loved by fishermen.

The Three Gorges Dam on the Yangtze River in China is the biggest power plant on Earth in terms of installed capacity – 22,500 megawatts compared to Itaipu’s 14,000. Completed in July 2012, its power output is currently a little behind Itaipu’s, but it looks set to overtake its South American rival in the near future. The building of the dam was a controversial project, however: about 1.3 million people were reportedly displaced, and it’s believed to have contributed to the probable extinction of the Chinese river dolphin.

Not all countries have the infrastructure to take advantage of hydroelectric power. Despite the many waterways criss-crossing its length, hydroelectricity currently accounts for less than two per cent of the UK’s electricity, and 18 per cent of its renewable energy. The British government says that opportunities to exploit hydropower on a large scale are restricted due to environmental concerns and a lack of economically viable sites. Instead, Britain is concentrating on small-scale hydro projects. Windsor Castle is one of the more famous properties to receive power from hydroelectric generators, although it temporarily had to return to the national grid over winter due to high water levels preventing an adequate drop over the weir.

The UK’s largest hydroelectric plants are pumped-storage schemes. These differ from conventional plants as they consist of an upper and a lower reservoir of water. They are fitted with a reversible turbine that pumps water back to the upper reservoir during off-peak times to refill it and ensure the plant is well-stocked throughout peak times. The biggest hydroelectric power plant of this kind in the UK is Dinorwig Power Station in Gwynedd, North Wales. It has ten miles of subterranean tunnels and a capacity of 1,728 megawatts.

New hydroelectric schemes are being planned in the UK. One Scottish power supplier has recently revealed a £3 billion (\$2.3 billion) pumped hydroelectricity storage scheme next to the world-famous Loch Ness, which is designed to capture excess power from neighbouring wind and wave farms. This energy will be used to pump water to a higher reservoir. Hydroelectric is here to stay, and we’re likely to see even more innovative ways to harness the power of water in the future.

**Did you know?**  
Guri Dam produces 70 per cent of Venezuela’s power

**“Not all countries have the infrastructure to take advantage of hydroelectric power”**



Itaipu Dam in South America is the world’s largest hydroelectric plant in terms of output

## ALTERNATIVE SOURCES OF RENEWABLE ENERGY

**Hydroelectricity isn’t our only option: these other sources can get us power without fossil or nuclear fuels**

### WIND FARMS

Windmills can be used to harness wind power and convert it into electricity. The UK’s first wind farm was set up in late 1991. By 2007, about 1.5 per cent of the UK’s energy came from wind power. A wind farm’s main disadvantage is that it needs space, and some people think that they spoil the countryside.



### SOLAR POWER

Solar panels capture energy from the Sun to generate electricity – modern versions can even function in overcast conditions. Fitting solar panels on roofs is becoming more common and can shave money off electricity bills.



### BIOMASS ENERGY

Biomass – material derived from plants – can be used as fuel in electricity generators. Proponents say that the carbon generated from burning biomass is cancelled out because the biomass crops absorb carbon from the atmosphere as they grow. However, it is not 100 per cent clean energy.



### GEOTHERMAL ENERGY

Thermal energy from within the Earth can be harnessed and is clean and cost-effective. In 2019, 15.4 gigawatts of geothermal power was generated in 26 countries. Reykjavik in Iceland heats nearly all of its buildings in this way.



### WAVE POWER

Machines that can capture energy from the motion of waves have the potential to be a good source of clean energy. Wave and tidal sources currently supply the UK with just 24 megawatts of power as of 2023, but with capacity for much more.





# FUTURE

WORDS MIKE JENNINGS

# FARMING ROBOTS

Robots are transforming farming thanks to artificial intelligence, GPS and advanced technology

Six-axis robots are crucial for farming because their precise, gentle movements pick crops without damage

**W**e've all driven past fields and seen tractors and combine harvesters, but those machines have been ploughing their own furrows for decades, and now they're a bit old-fashioned. These days, forward-thinking farmers turn to robots to plant, manage and harvest crops and look after livestock. It's no surprise when you consider the challenges facing farmers. A growing global population demands more food, climate change makes it harder to deliver predictable harvests and rising costs mean farmers need to keep operations efficient.

Early farming robots in the 1950s and 1960s were very basic. As computers developed in the 1980s, robots started performing more complex tasks like crop monitoring and harvesting, and by the 1990s they were using early artificial intelligence (AI) and machine vision technology to identify and pick fruit and handle milking in dairies. Since then, robotic

farming has become even more sophisticated, and shows no sign of stopping.

The precision and efficiency provided by agricultural robots offer big advantages. Farmers get better yields with less waste, which can sometimes make the difference between bankruptcy and survival. Robots are usually faster than humans, and they eliminate lots of repetitive, backbreaking labour. They can protect farms from labour shortages, and while initial costs can be high, they pay for themselves relatively quickly. That sounds great, but robots aren't always rosy. Initial costs can prove too lofty for many farmers, and some farmers can't use robots if they work on challenging landscapes or with more obscure crops. Many farmers don't have the technical skills required, machines can break, which halts production, and there are

environmental costs associated with these machines and the intensive farming they encourage. Also, many farmers may not be comfortable with the job losses resulting from using robots.

Nevertheless, robots are now available to perform a wide array of jobs around farms worldwide. Take the humble tractor.

One Brazilian manufacturer says it produces 'offices on wheels', and it's hard to disagree when they're packed with sensors, cameras, GPS systems and more. Planting crops can be handled by robotics.

GPS-based robots and driverless tractors navigate through fields, analyse soil quality and plant seeds precisely and efficiently to maximise yields. Harvesting robots use cameras, sensors and AI to determine if crops are ready for picking, and then robotic arms pick them without damage.

### Did you know?

By 2025, 80 per cent of commercial drones could be for farming



**DID YOU KNOW?** Population growth means we'll need to produce around 50 per cent more food globally by 2050

Six-axis robots, with joints that move in many different directions, are often deployed for these jobs. And to keep the crops healthy, fertilising robots use sensors to check for signs of disease and GPS to spread fertiliser accurately and evenly. The same kind of technology is also used to spray crops with pesticides or other chemicals – and to do so more accurately, which reduces the risk of harmful substances escaping into the wider environment. You'll even find robots prowling fields to eliminate weeds – sometimes with lasers – to ensure they don't suck up all the nutrients required by the crops.

There are plenty of uses for robots beyond fields, too. You'll find them automatically scooping manure, sanitising other machines or cleaning animal houses, and drones fly above fields to count the number of animals in a herd, ensure they have water and spot damaged fences thanks to thermal imaging, sensors and AI. Cows need milking? Send in the robots. Eggs to collect? Easily done. Robots find and gently scoop up eggs, while others monitor chicken health and even give them a gentle prod to stop them becoming sedentary.

Elsewhere on the farm, you'll find robots carrying or towing heavy loads, sorting harvested crops, analysing soil and crunching numbers to help farmers deliver better results alongside automated sensors and systems that handle environmental control.

Robotic arms and conveyors can analyse, sort and pack produce for distribution.

Robotic farming already seems futuristic, so the next generation of automated agriculture looks bright. Expect more efficient, effective

**“Robots are available to perform a wide array of jobs around farms”**

results as data analysis and AI improve. Robots will get smarter and start making better decisions with deeper

analysis. Robots will also get cheaper and become more prevalent, and multi-tasking will be more popular. It's already possible to get a single robot to plant, fertilise and harvest crops. Lots of these improvements will boost



Bee populations have declined by 30 per cent annually since 2006, so pollinator robots are a potential solution



Smaller robots take on repetitive tasks, like pushing this feed towards hungry cows



Ear, neck, leg and tail tags can improve herd health, all monitored from a phone or tablet

## HAVE YOU HERD?

You might not think it looking at them, but cows can move pretty fast, so farmers use some tasty technology to keep tabs on their herds. Devices from a company called Afimilk attach to cows' legs or necks and can monitor their eating patterns, temperature, movement, digestion and more. Farmers can get smartphone alerts about their herd while tracking them on maps. And thanks to the availability of health sensors, GPS and wireless, it's now relatively straightforward. Afimilk also offers dairy herd automation with milk measurement and analysis and an array of animal management tools to make life easier for farmers. To make life for the next generation easier, companies like Afimilk and MooCall also sell devices that alert farmers to the start of the calving process, which helps farmers improve herd health and reduce calf mortality because they know exactly what's happening and when.



## TECHNOLOGY

sustainability, with improved yields, reduced waste and better soil quality, contributing to reduced carbon footprints and healthier environments.

Drones could one day be used to plant entire fields of crops. They may also contribute to the more widespread use of cloud seeding, a process where rainfall is encouraged by introducing tiny shards of ice into existing clouds. Drones will also be able to evaluate crop health, irrigation systems and weed growth. More farmers may choose to deploy drone technology to pollinate crops because climate change is causing the number of natural pollinators, like bees, to decline dramatically – giving farmers a high-tech way to address a modern and potentially catastrophic problem. There's no doubt that robot farming is here to stay, and that it will keep addressing big problems.

### Did you know?

Robot farming can boost yields by up to 67 per cent

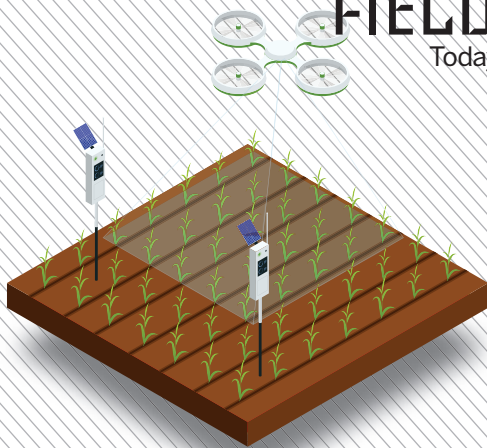


Once fruit is harvested, robots can also inspect, grade, separate and pack crops for distribution



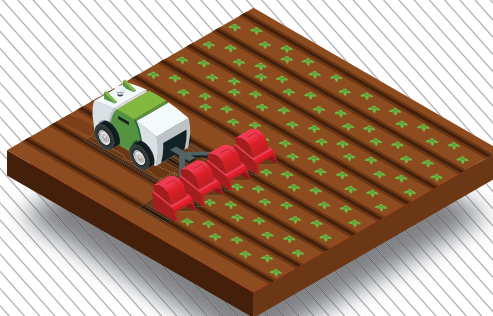
## FIELDS, YIELDS AND WHEELS

Today's most popular farming robots and how they work



### FARMING TAKES FLIGHT

Drones from companies like DJI allow farmers to precision-spray crops, detect obstacles, adapt to different terrain and survey fields to generate flight routes – all from a remote control that looks a bit like a Nintendo Switch. Elsewhere, drones can monitor crop and herd health, and some operate automatically.

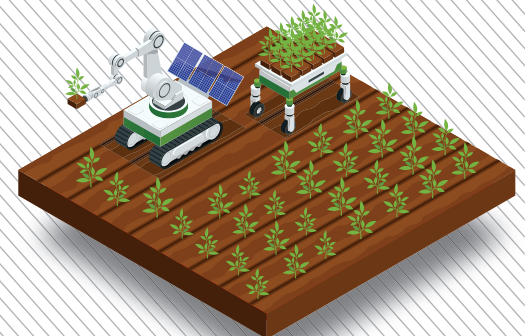


### FORGING A PATH

John Deere is working on autonomous tractors that include 360-degree cameras, powerful processors and AI systems for ploughing, planting and harvesting. Autonomous tractors improve accuracy and efficiency, electric operation reduces carbon footprint and they can boost soil health.



© John Deere



### PICK OF THE BUNCH

Six-axis robots are among the most precise, so they're used for harvesting. They can navigate fields or greenhouses, locate crops or fruit, pick gently without damage and sort the crops into quality or size categories. Farmers can use devices to manage harvesting, and AI analyses crop conditions and yields.

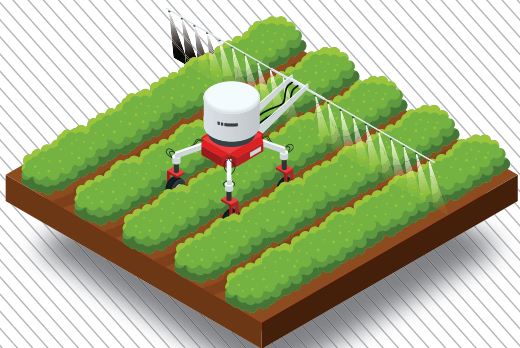


## PLOUGHING THROUGH DATA WITH AI

AI is everywhere right now, including farming. Phone apps can use AI to identify potentially harmful bugs and weeds, and many farmers use AI to sort produce for health and size and calculate the most efficient way to plant crops. On other farms, AI technology can analyse soil health and calculate which parts of a farm provide high and low-yield results. 87 per cent of US agricultural businesses already use AI, and it's easy to see why: its 'precision farming' approach allows farmers to improve yields, reduce waste and do more with less, which means better crops and healthier farms.



AI evaluates crop health, and results should improve as robot systems learn about farming

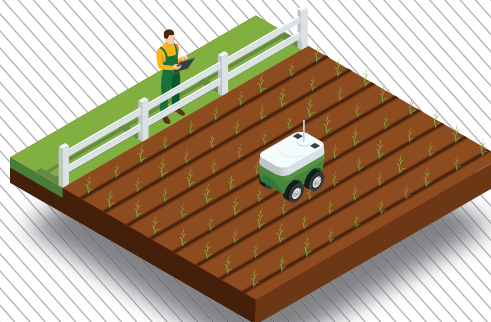


### GROWING STRONG

Fertilising robots monitor soil and crops and use GPS to ensure maximum efficiency, delivering exactly what's needed to targeted spots. Conventional methods mean reduced yields due to imprecise application. Devices like the AgileX N2 Vision implant an arm into the soil to deliver fertiliser.



© AgileX

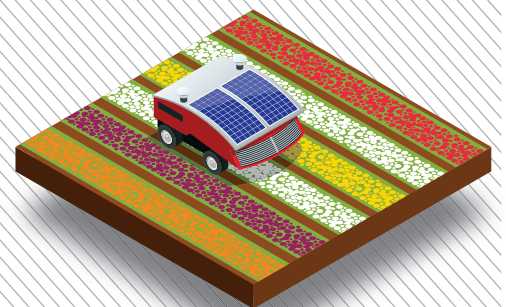


### WEEDING OUT

Weeds rob crops of valuable nutrients, so devices like the Nexus Robotics R2Weed2 use AI to distinguish crops from weeds, then remove them without disturbing other plants. The device also analyses the soil and environment and guides farmers on reducing weed growth in the future.



© Nexus Robotics



### POLLY THE POLLINATOR

Fewer natural pollinators, like bees, mean poorer yields. Robots like Polly, by Arugga AI Farming, use cameras and AI to detect plants ready for pollination, and an air-pressure mechanism starts the process. In addition, Polly monitors plants to provide alerts of disease outbreaks and handles pruning.



© Arugga

It may look funny, but the Airlander is efficient, effective and may take flight soon



Airlander uses fibre-optic control cables that are lighter, carry bigger data bandwidths and are more resilient than copper



# ON BOARD THE 'FLYING BUM'

The HAV Airlander 10 is exciting, ambitious and one of the world's biggest aircraft, but will the project ever get off the ground?

WORDS MIKE JENNINGS

**Y**ou wouldn't guess it from the name, but the Hybrid Air Vehicles Airlander 10 is a unique piece of kit – a revolutionary hybrid airship that's one of the world's longest and largest aircraft. There's another notable aspect about this aircraft: its shape. From certain angles it looks a bit rude, which is why it's been nicknamed the 'Flying Bum'. Go beyond the bum, though, and there's a remarkable story about military projects, luxury travel and incredible technology. Airlander 10 began life in June 2010 when Hybrid Air Vehicles, a British company, won a contract with the US Army to develop a craft for long-range surveillance, communications and transport.

As a hybrid airship, Airlander 10 met many of the US Army's requirements. These craft combine conventional airship design – a huge balloon filled with helium – with engines or rotors. They can carry cargo or passengers over a wide range, often for multiple days, and they're more fuel-efficient than planes. However, by October 2011, test flights were delayed,

and the US Army raised concerns about safety, deployment and even the fabric. In February 2013, the US Army ran out of patience and cancelled the project.

That could have grounded the Flying Bum, but HAV bought the prototype back and shipped it to Cardington Airfield in Bedfordshire. And while development was blighted by crashes in 2016 and 2017 – with the latter writing off the aircraft – Airlander 10 was officially completed in January 2019. HAV is now manufacturing

Airlander 10, which is viable for luxury travel, short journeys, logistics and communications. A Spanish airline has placed an order for 20 units, and Scottish and French transport companies have signed tentative agreements. British defence giant BAE Systems is also exploring the possibility of using Airlander. Its popularity is no surprise when you consider its capabilities. It can carry up to ten tonnes of cargo, stay airborne for five days and take 100 passengers on trips with huge reductions in emissions compared to planes.

## Did you know?

The Airlander can fly for two weeks without a crew

## TAKING FLIGHT

Airships and the idea of lighter-than-air travel have long been a romantic dream of people who look to the skies, but they're a relatively modern invention. The first steam-powered airship flight took place in 1852. In July 1900, the famous Zeppelin LZ1 debuted, launching a series of ships that became incredibly successful thanks to their designs, which featured multiplane tails for improved stability and separate gas cells.

Various militaries used airships for scouting and bombing during World War I, and after the war they were used extensively for military and leisure purposes – that is until the 1937 Hindenburg disaster destroyed their popularity and saw usage switch towards planes. Today, they're mostly used for advertising, surveillance and research.

Modern hybrid airships began to emerge in the 1970s, combining the advantages of gas-filled airships with improvements to stability, safety, speed, capacity and efficiency.



Airships were frequently used by militaries until planes took over

**DID YOU KNOW?** Airlander 10 weighs 20,000 kilograms before any cargo

## RISING TO THE OCCASION

The Airlander 10 has two hulls – hence the Flying Bum shape – and they're made from composite materials designed for strength and helium retention. The hull uses three layers of materials: Tedlar for weather protection, Mylar to keep helium inside and Vectran for structural strength.

On the inside, it's not just helium: smaller, malleable compartments called ballonets

are filled with oxygen and maintain the craft's pressure as the helium expands and contracts due to temperature and altitude changes. The pilots can adjust those ballonets as necessary, and if the hull is damaged there's an automatic pressure management system that gives the pilots enough time to fly the Airlander to an airfield for repairs.

The hull withstands small weapons fire, and it can even survive a missile strike.



## INSPECT THE TECH

Airlander is packed with revolutionary tech



### LIFTING UP

Airlander has a curved top and flatter underside. The pressure differences help the craft generate 40 per cent of its lift.



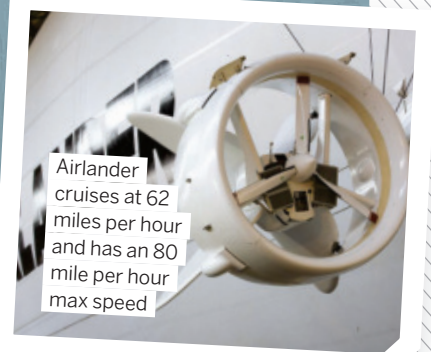
### ENGINES

Changing directions using engine power is called vectored thrust. The two side-mounted engines do this with 20-degree pivoting.



### LIGHTER THAN AIR

Helium is lighter than air, and it offsets the weight of the entire airship. This provides most of Airlander's lift.



Airlander cruises at 62 miles per hour and has an 80 mile per hour max speed

### 5 OFF THE GROUND

The side engines, which help steer, are vital during takeoff and landing, but they're typically turned off during flight.

5

1

2

4

7

3

6

### 1 A FULL VIEW

Four floor-to-ceiling windows provide visibility for two crew members, and CCTV helps them keep an eye on all the engines.

### 2 CARGO HOLD

There's space for ten tonnes of cargo in the adjustable payload module, and the weight is distributed using weight-bearing cables.

### 7 SOFT LANDINGS

Airlander lands using six 'cushions'. They retract during flight, improving efficiency, and Airlander can land without runways and on water.

### 4 EFFICIENT MOVEMENT

Strakes – long fins down Airlander's hull – improve stability. They also keep movement more efficient, which reduces carbon footprint.

### 3 STEERING CLEAR

The tailfins are made of fibreglass for rigidity, ensuring smoother steering. Vanes also direct air over the fins more efficiently.

### 6 ELECTRIFYING ENGINES

The two rear engines provide forward movement during flight. Two of the craft's engines will be electric by 2028.

# Win!

## A BOARD GAME BUNDLE

This month you have the chance to win a board game bundle from NorthStar Games. The bundle includes some of NorthStar's most popular titles: *Biomos*, *Evolution Climate*, *Oceans Deluxe Edition* and the *Oceans: Legends of the Deep* expansion



For your chance to win, answer the following question:

In which ocean can you find the Bermuda Triangle?

**A: Indian Ocean B: Pacific Ocean C: Atlantic Ocean**

Enter online at [howitworksdaily.com](http://howitworksdaily.com) and one lucky entrant will win!

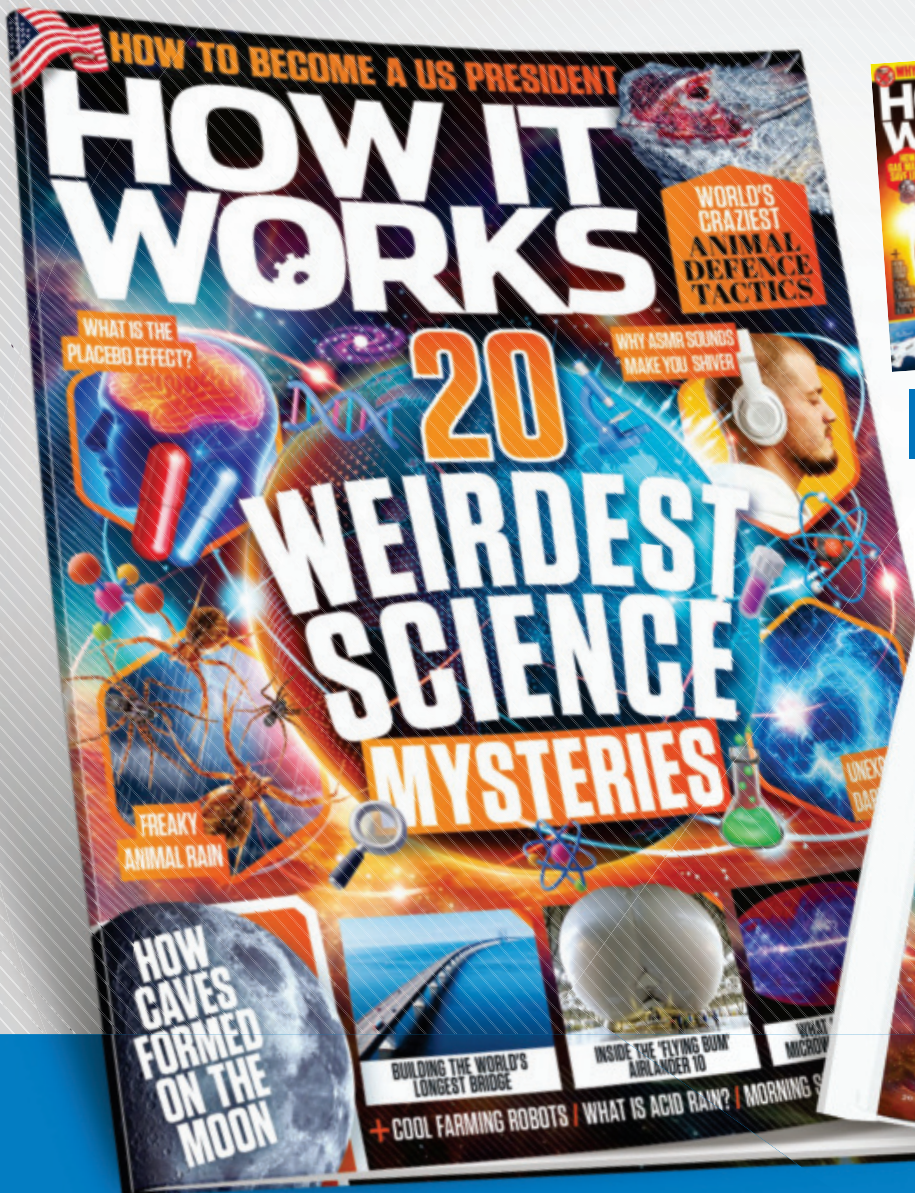
**Terms and conditions:** Competition closes at 00:00 GMT on 7 November 2024. By taking part in this competition you agree to be bound by these terms and conditions and the competition rules: [www.futuretcs.com](http://www.futuretcs.com). Entries must be received by 00:00 GMT on 7/11/2024. Open to all UK residents aged 18 years or over. The winner will be drawn at random from all valid entries received, and shall be notified by email or telephone. The prize is non-transferable and non-refundable. There is no cash alternative.



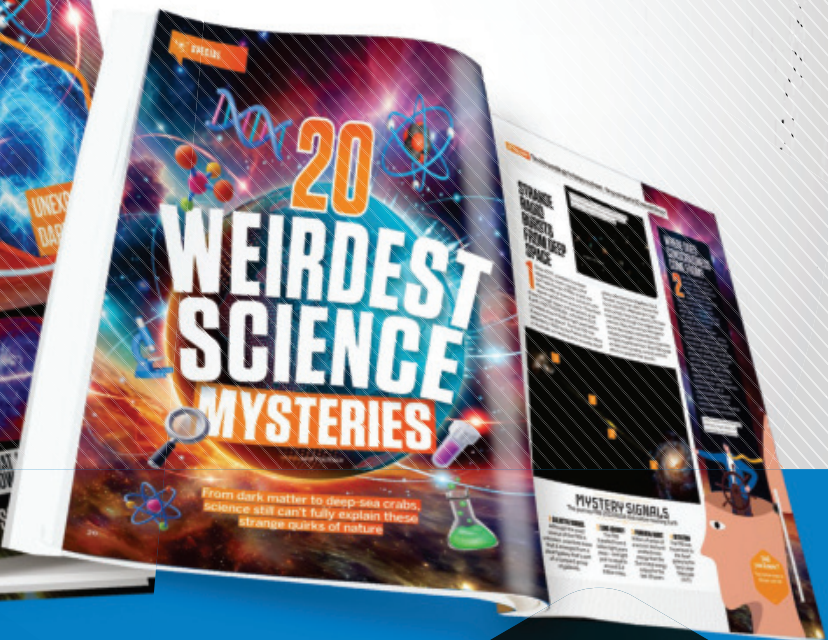
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# BRAINDUMP

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## Could a solar flare cause mayhem for electronics here on Earth today?

Definitely. When a coronal mass ejection (CME) from a solar flare reaches Earth, the fluctuating magnetic fields induce electrical currents in any long conductor. In oil and gas pipelines this can cause sparks that trigger fires and explosions at terminals and in power lines the surge can overload transformers. In 1989, a powerful flare

knocked out the electricity grid for 6 million people in Québec, Canada. The largest flare ever recorded in 1859 gave telegraph operators electric shocks from the telegraph wires. If a similar flare occurred today – with our much more sensitive equipment – the damage could easily run into the billions.



## WHICH CULTURE BEGAN THE PRACTICE OF DRINKING TEA?

According to legend, Chinese emperor Shennong enjoyed the first cup of tea back in 2737 BCE. Allegedly, while the emperor was sitting in his garden, leaves from his *Camellia sinensis* plant drifted into drinking water that he was boiling. Shennong loved the result, and tea was born.

There's no proof that the above scenario actually happened, but the evidence does point to tea originating in China's Yunnan province sometime before 1000 BCE. Historical references indicate that it was originally considered a medicinal drink. Only during the Tang dynasty, beginning in 618 CE, did it become thought of as a tasty hot beverage.

Dutch traders brought tea to Europe around 1606, and it steadily gained popularity. It hit big in Britain after 1662, when King Charles II married the Portuguese princess and avid tea fan Catherine of Braganza.

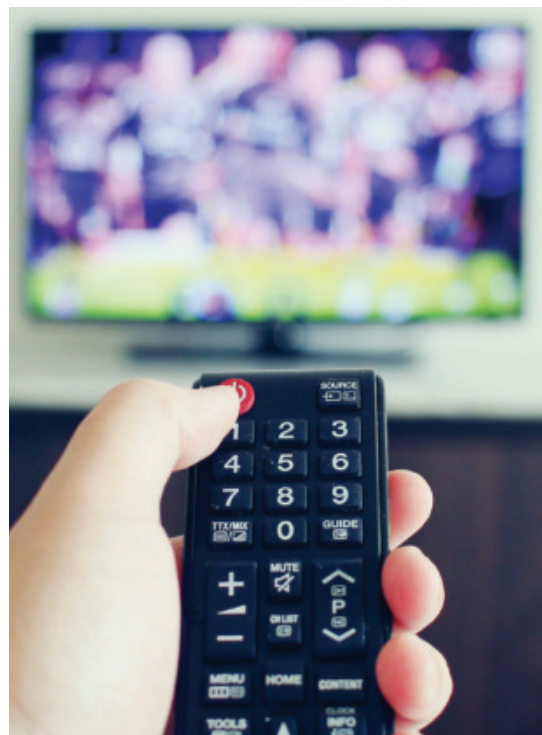
## DID AMERICAN FOOTBALL DERIVE FROM RUGBY?

Yes. In the 1860s, 'football' referred to all sorts of variations on a theme: two teams moving a ball to the opposing goal, on foot rather than on horseback. Different cities and schools adapted the idea with their own ever-evolving rules. In the 1870s, England's Rugby School variation took hold with US players, largely thanks to two prominent matches between Harvard and Canada's rugby-loving McGill University. At Yale, a student named Walter Camp led the charge in re-imagining rugby with new additions like the quarterback, line of scrimmage, plus the down-and-distance system. In American universities, this new form of football became the standard.



## IF I ALLOW COOKIES ON MY PC, WILL IT BE HACKED?

No, they don't make it easier for you to be hacked. Cookies are just small text files used as temporary storage on your computer. Websites use them to remember who you are – just like a store card for a shop. Cookies don't contain your credit card number or your computer's password, and they are only ever sent back to the website that created them in the first place. Turning off cookies just means that websites won't remember that you are already logged in and they might keep showing you the same advert because they won't know that you've already seen it.



## Do appliances use more power on standby?

The average 32-inch TV uses 123 watts when on – rising to 235 watts for a 42-inch screen – but even when switched 'off' with the remote, it's still using five watts. An Xbox Series X uses about 133 watts when on and around 15 watts on standby. However, some set-top boxes can use almost as much power on standby as normal running. A 2013 study at the Lawrence Berkeley Laboratory in California found that satellite decoders used 16.15 watts on average when they were on and 15.66 watts when they were off at the remote – that's 97 per cent of full power. Even just five watts per appliance can quickly add up. The average UK household spends £250 (around \$328) annually on electricity to power devices that are supposed to be off.



# How many types of Greek temple are there?

There are three different types of Greek temples, representing the three 'orders' of ancient Greek architecture: Doric, Ionic and Corinthian. All three orders employ similar architectural elements, most notably columns. Doric – the oldest order – uses relatively short, thick columns, while the columns of later orders are longer and more slender with concave vertical grooves called fluting. Resting atop each column is a 'capital' of varying complexity. The Doric capital is simple and understated,

while the Ionic version has swirling volutes that resemble ram's horns. The Corinthian order boasts ornate leaves and scrolls. Ancient Greek architecture is founded upon principles of order and symmetry, and the Greek temples of the Classical period provide some of its finest examples. Famous Greek temples like the Parthenon (Doric) and the Temple of Athena Nike (Ionic) – both in Athens – have inspired architects from the Renaissance right through to modern times.

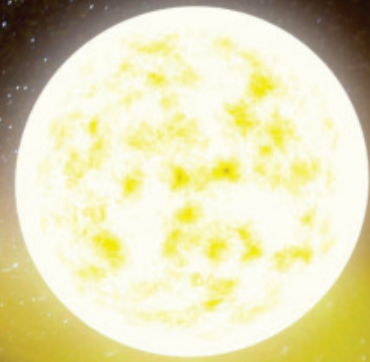


## WHAT CAUSES SNOW BLINDNESS?

The medical term for this condition is photokeratitis – sunburn of your cornea. At high altitudes, light reflected off snow contains dangerous levels of ultraviolet radiation. Like sunburn, the effects are delayed. Climbers report painful burning, blurred vision and a sandy sensation on the eye starting 6 to 12 hours after exposure. It

turns out that the best protection against snow blindness is a good pair of UVB-rated sunglasses with side shields. The best cure is to patch the eyes and let them heal themselves, which can happen as quickly as 24 hours. Interestingly, hand-carved Inuit snow goggles are equally as effective as a pricey pair of sunglasses.





## What are binary stars?

A binary star system is a pair of stars that orbit each other. They are very widespread – the majority of stars in the Milky Way are members of binary or multiple systems. Loners like our Sun are in the minority. The distance between stars in a binary system can vary hugely – some take millions of years to orbit each other, while others do it in just a few days. Astronomers find binaries very useful – the stars in these systems have spent their entire lives together, and were born at the same time from a shared cloud of gas and dust. What's more, the way in which each star orbits can give away its relative mass, so it's easy to compare how factors such as the mass of each star have affected their evolution and appearance as we see them today.

### WHY DO TONGUE-TWISTERS TRIP US UP?

A recent study of three epilepsy patients has shed new light on this linguistic phenomenon. Electrodes implanted in the subjects' brains in preparation for surgery allowed a team from the University of California, San Francisco, to record neural activity from the brain surface. The scans showed that sites in a region called the ventral sensory-motor cortex (vSMC) control different parts of the vocal tract to form each syllable. Stringing syllables

together appears to require co-ordinating complex sequences of activity across vSMC sites, timed down to tens of milliseconds. Sounds that require similar vocal tract movements, such as 'Sss' and 'Shh', are especially tricky as their representations in the brain overlap. Tongue-twisters are likely tricky because they require a rapid sequence of overlapping neural patterns that simply overwhelms the brain.



# Which planet moves the fastest?

In our Solar System, the fastest mover is Mercury. It zips along its orbit at nearly 31 miles per second and completes an orbit of the Sun every 88 days – that's why early stargazers named it after the fleet-footed messenger of the gods. Outside the Solar System, however, there are planets that would leave Mercury in their dust. New ones are being found all the time, but one of the most impressive examples so far is probably WASP-12 b, discovered in 2008. This world, some 871 light years from Earth in the constellation of Auriga, takes just 26 hours and 12 minutes to orbit its star. It's a famous example of a 'hot Jupiter' – a gas giant like our own Jupiter, but with an atmosphere that's heated to a scalding 2,200 degrees Celsius.



## CAN EM PULSES KNOCK PLANES OUT OF THE SKY?

If an aeroplane were caught in an EMP strike, it could destroy all its guidance, navigation and communication systems, making it virtually impossible to fly. An electromagnetic pulse (EMP) is a burst of high-energy photons. A flash of light is also a burst of photons, but visible-light photons have much lower frequency and energy than the photons found in an EMP. When you detonate a nuclear bomb in the atmosphere, the high-energy gamma rays ionise the air molecules and essentially cause a massive EMP. The US has developed specialised weapons designed to create a more focused pulse over a smaller area.



## DOES A COMPASS WORK UNDERGROUND?

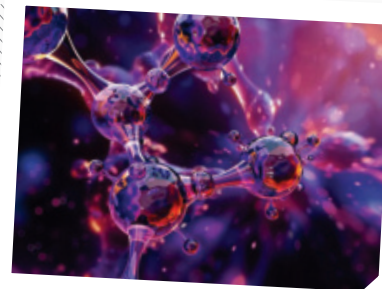
The computerised compass app you have on your phone probably won't work because it relies on radio signals that are easily blocked by rock or water, but for a traditional compass with a wobbly needle, it just depends on how far underground. This kind of compass works because its magnetised needle lines up with the magnetic field that runs between Earth's north and south poles, and that field is just as powerful if you go down a mineshaft or into the depths of the ocean. But the field is created by swirling molten iron in Earth's core, and if you could drill that far down, you'd find your magnetic needle going haywire.

## How many atoms does an object need for the human eye to see it?

The best we can do is calculate a very rough approximation. Humans can see objects as small as 100 micrometres with the naked eye. A human egg cell, for example, is 130 micrometres in diameter, and its volume – assuming it's a perfect sphere – is 1.15 million cubic micrometres. One of the most common molecules in the

human body is glucose, containing 24 atoms: 12 of hydrogen, 6 of oxygen and 6 of carbon. Let's pretend, for the purpose of this example, that a human egg is entirely composed of glucose molecules. The diameter of a glucose molecule is roughly one nanometre, and there are 1,000 nanometres in a micrometre.

So, for example, if you know that there are 1.15 billion glucose molecules in a human egg cell, and each molecule contains 24 atoms, that gives us 27.6 billion atoms in a single human egg cell, one of the smallest objects that can be seen by the naked eye. This is theoretical, of course, but gives a good idea of the scale of atoms.



# THE LIBRARY

The latest book releases for curious minds

## WHAT IS TECHNOLOGY?

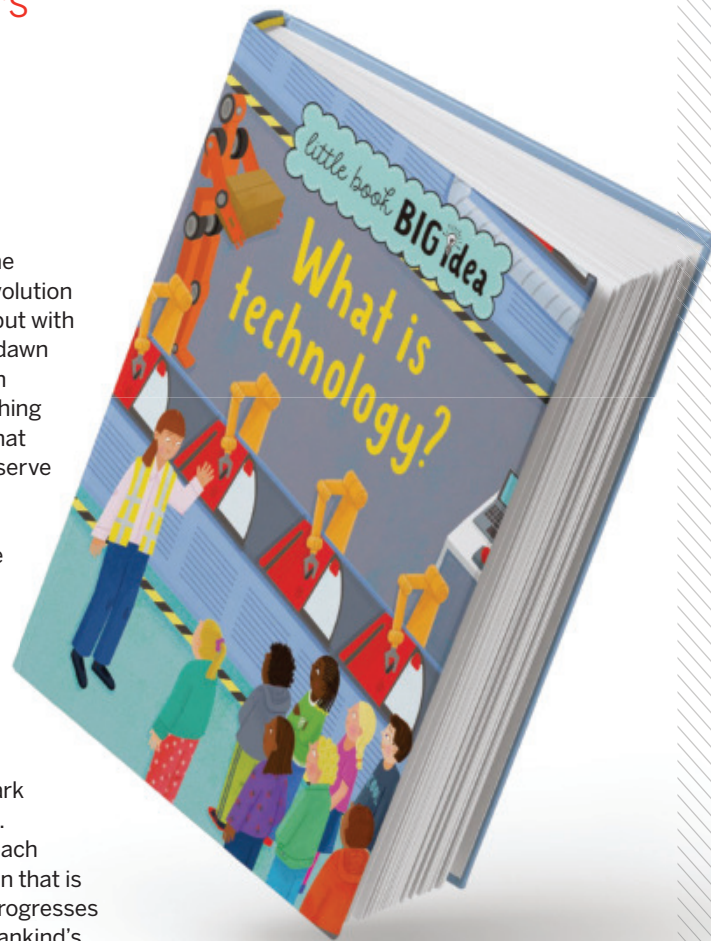
A GOOD QUESTION THAT'S WELL ANSWERED

**AUTHOR** SARAH WALDEN  
**ILLUSTRATOR** KATIE REWSE  
**PUBLISHER** NOODLE JUICE  
**PRICE** £9.99 (APPROX. \$13)  
**RELEASE** OUT NOW

**T**echnology has been in the background of human evolution since prehistoric times, but with the modern era and the dawn of the internet, the concept has been catapulted to the forefront of everything we do. So it's easy to lose sight of what technology is exactly, how it should serve us and how we might avoid being slaves to our own ingenuity. *What is Technology?* is the latest in the Little Book Big Idea series from publisher Noodle Juice, which aims to define a subject using straightforward terms and lots of examples. With the opening page, technology is given a pithy, dictionary-style definition by author Sarah Walden, and then it's into the series' trademark question-and-answer style narrative.

Beginning far back in prehistory, each double-page spread poses a question that is succinctly answered as the reader progresses through historical waypoints in humankind's use of technology. Walden has made extensive use of examples of what technologies were important to each era, so stone tools to the Neanderthals 200,000 years ago, the invention of paper in China in the 2nd century CE and Charles Babbage's mechanical computer in 1835.

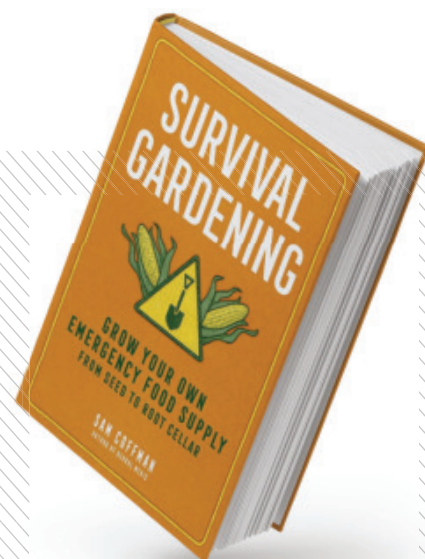
Between this detailed timeline are questions that you might expect a primary school student to ask if the subject ever cropped up. Questions such as 'who creates technology?' and 'what does an engineer do?'. The answers to these are wonderfully simple, yet comprehensive enough to satisfy the curiosity of a young mind – or an adult's mind, for that matter. Walden brings it into the modern era by explaining what robots and computers do, with all the references to modern technology that children would understand, before looking to the future



of technology with inventions that could solve many of today's world problems.

Coupled with illustrations that do an equal share of the storytelling, *What is Technology?* is a small yet especially effective book in communicating this single sophisticated concept. And in the sometimes overwhelmingly technological world that we live in today, it's nice for curious school-age children to have a reference book so concise and easily understood to turn to.

**“A small yet especially effective book in communicating this single sophisticated concept”**



## SURVIVAL GARDENING

GROW YOUR OWN EMERGENCY FOOD SUPPLY

**AUTHOR** SAM COFFMAN  
**PUBLISHER** WORKMAN PUBLISHING  
**PRICE** £22 / \$24.99  
**RELEASE** 6 FEBRUARY

During a time when people are more aware than ever of the importance of food sustainability, this gardening guide is a must-read for anyone looking to grow their own food. From fast five-week grows to establishing gardens for the long haul, this complete guide to at-home agriculture is overflowing with helpful information and instructions. There are also DIY projects that tackle some of the equipment you'll need to create your survival garden, such as water filtration systems, compost and 'humanure' making.

Along with seemingly infinite advice on the practicalities of growing your food, there is also a great deal of nutritional insight to discover, such as fat-rich seeds and protein-loaded chickpeas. One of the most important aspects of this survival guide is that it teaches how to preserve and store the fruits of your labour, including how to dehydrate and how to build a root cellar in your garden. Whether you're a nature novice or a green-thumbed gardener, there's heaps of knowledge to harvest from *Survival Gardening*.

## UNLOCKING THE UNIVERSE

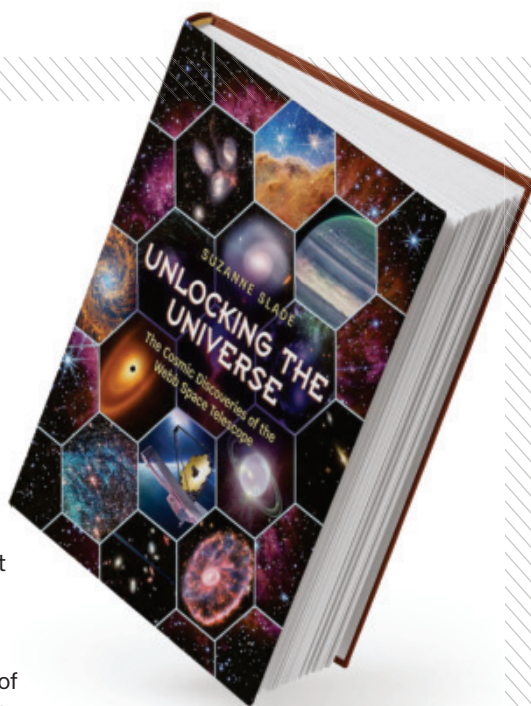
THE COSMIC DISCOVERIES OF THE WEBB SPACE TELESCOPE

**AUTHOR** SUZANNE SLADE  
**PUBLISHER** CHARLESBRIDGE PUBLISHING  
**PRICE** £16.99 / \$17.99  
**RELEASE** OUT NOW

The James Webb Space Telescope is one of the most advanced space telescopes ever created. Since 2022 it has been orbiting the Sun, capturing distant celestial objects and peering deep into the darkness of space.

*Unlocking the Universe* reveals some of Webb's most mesmerising discoveries and the awe-inspiring imagery that the telescope has captured so far.

The road to Webb's launch was long, and not without its hurdles. Within this insightful book, you'll discover the telescope's journey to space, the vast amount of technology that made its launch possible and the scientists who worked tirelessly to construct it. Webb is also packed with technology and



scientific instruments that are revealed in the book as brilliantly annotated illustrations. There's no doubt Webb will have uncovered much more about the universe by the time you've read this book. However, *Unlocking the Universe* acts as a written time capsule of its early achievements.

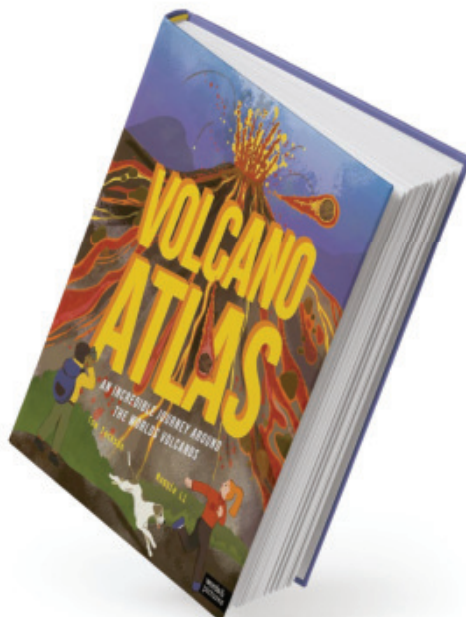
## VOLCANO ATLAS

AN EPIC JOURNEY AROUND THE WORLD'S MOST INCREDIBLE VOLCANOES

**AUTHOR** TOM JACKSON  
**ILLUSTRATOR** MAGGIE LI  
**PUBLISHER** QUARTO PUBLISHING  
**PRICE** £12.99 / \$16.99  
**RELEASE** OUT NOW

This engaging and varied tour of the world's volcanoes introduces young readers to the mightiest mounds and the geological events that cause volcanic eruptions. Beginning with the basics, the clear illustrations transport you underground to observe the magma flowing beneath us and the route it takes to emerge above the ground. Each page is bustling with enticing information while sporting a simplistic layout that doesn't overwhelm, exploring volcano types, unique features, record breakers and the mesmerising patterns of mudpots.

For each noteworthy volcano around the world, the reader is provided with a map and fact file to compare key statistics, historic



stories such as the infamous Roman-era eruption of Vesuvius and information about surrounding sites and communities. For example, did you know the active Ruapehu volcano in New Zealand hosts three ski resorts on its slopes? From the dormant to the most active and feared, this book is here to show you that no two volcanoes are the same.

## AKEEM KEEPS BEES!

A CLOSE-UP OF THE HONEY MAKERS AND POLLINATORS OF SANKOFA FARMS

**AUTHOR** KAMAL E. BELL  
**ILLUSTRATOR** DARNELL JOHNSON  
**PUBLISHER** WORKMAN PUBLISHING  
**PRICE** £16.99 / \$18.99  
**RELEASE** 4 FEBRUARY

Akeem invites you onto his family's farm to teach you all about bees and how he looks after them. The story is written by Akeem's father, but is presented from the boy's point of view, helping young readers understand and relate to the content. Akeem gives you a tour of Sankofa Farms, with expressive and detailed illustrations immersing the reader every step of the way.

Akeem helps out with a lot of activities on the farm, but his firm favourite is raising the bees. With a combination of comic-style imagery and factual diagrams, this book is an ideal blend of entertaining and informative. Akeem's enthusiasm accompanies his father's words of wisdom to guide the reader through the bees' life cycle while creating a space for young readers to share in Akeem's passion. At the end you meet the real characters in a gallery of photographs of the family farm.



# BRAIN GYM

Give your brain a puzzle workout

## Sudoku

Complete the grid so that each row, column and 3x3 box contains the numbers 1 to 9

### EASY

6	5		9	1		3		
				6	9		1	
4	9				5	7		
8	3	6		7	5	4		
		1	4	2			8	3
			6	3	8		5	
1	4		8			2	6	
		5					1	8
	6	8		1	3			4

### MEDIUM

	5			1	2	6		
	7	4				5		
6	8	7						
		6	4					
7				8		2		3
				5	7			
1	9	5	3				2	
4	2			7		3	8	9
		7	2	9			4	

### HARD

					3			
8				5				
	4		9				8	1
5				1			7	
				9	8			6
9			4					
4	1			7		6		
6	8							7
	7		5	6		9		



## Word search

Find the following words

STARS  
PRESIDENT  
COSMIC  
ACID

SKELETON  
SICK  
HYDRO  
DEFENCE

MYSTERY  
BRIDGE  
FARMING  
CAVE

S	A	L	R	T	P	N	A	L	U	P	C	M	Y	S
T	E	R	Y	S	K	E	L	E	T	O	N	B	C	A
U	E	P	R	E	Z	I	D	A	N	K	C	R	E	J
D	E	F	E	N	C	E	H	Y	B	R	O	I	L	E
A	C	L	D	G	N	I	M	R	A	F	C	D	K	S
S	T	A	R	S	I	T	S	Y	A	S	B	G	E	N
A	L	C	A	T	N	C	R	K	M	N	O	E	G	T
P	H	I	E	L	P	E	C	O	S	C	M	I	K	N
Y	E	D	N	A	T	U	D	R	O	Y	H	S	G	E
H	Y	U	J	S	M	I	C	S	K	C	I	N	R	D
F	A	R	Y	M	I	N	M	G	I	B	R	D	G	I
S	Y	M	T	E	R	I	Y	P	R	C	E	S	O	S
K	E	L	E	T	C	O	M	U	A	O	K	C	N	E
E	H	Y	D	R	O	H	G	I	C	K	S	I	O	R
A	C	Y	B	N	O	L	C	A	V	E	B	E	X	P

## What is it?

Hint:

Cane you guess it?

A



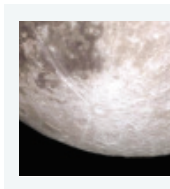
# Spot the difference

See if you can find all six changes between the images below



## Answers Find the solutions to last issue's puzzle pages

- Q1** LIVER
- Q2** BROMINE
- Q3** SOUND UNDERWATER
- Q4** ITS CORE
- Q5** PLAYSTATION 3
- Q6** CARBON DIOXIDE



**What is it?**  
TYCHO CRATER

Spot the difference



## QUICKFIRE QUESTIONS

**Q1** Which two gases is Saturn mainly composed of?

- Argon and xenon
- Chlorine and krypton
- Hydrogen and helium
- Nitrogen and neon

**Q2** On average, how far is the Moon from Earth?

- 93 million miles
- 2.7 billion miles
- 24,901 miles
- 238,855 miles

**Q3** Which of these four countries is the rainiest?

- United Kingdom
- Colombia
- Indonesia
- Ghana

**Q4** Which part of a plant produces its energy?

- Stem
- Leaf
- Root
- Flower

**Q6** What is at an atom's centre?

- Neutron
- Electron
- Nucleus
- Proton

**Q6** Which of these is also a word commonly used for junk email?

- Ham
- Beef
- Pork
- Spam

# HOW TO...

Practical projects to try at home

## KIT LIST

Four raw eggs

Four clear cups or glasses

Vinegar

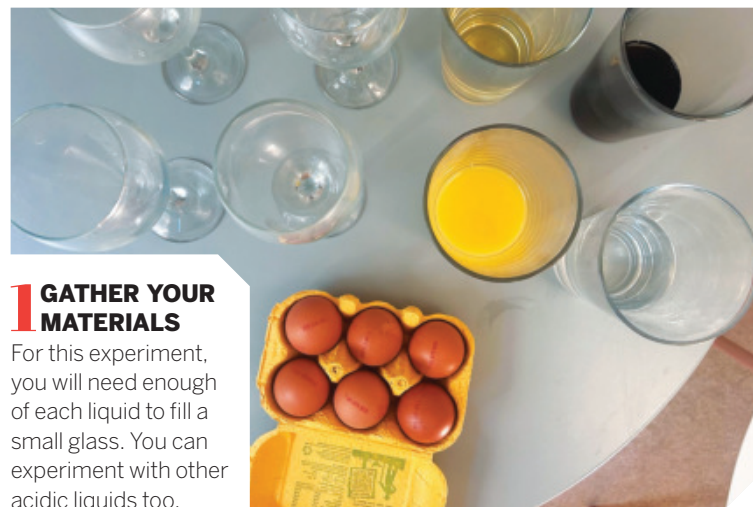
Cola

Orange juice

Water

## MAKE A BOUNCY EGG

Watch as acid dissolves the hard shell in this simple eggs-periment



### 1 GATHER YOUR MATERIALS

For this experiment, you will need enough of each liquid to fill a small glass. You can experiment with other acidic liquids too.

### 2 DISTRIBUTE THE EGGS

Place one raw egg into each of the four glasses. Take note of the appearance and texture of the eggs.



### 3 POUR THE LIQUID

In one of the glasses, cover the egg with water. Cover the next with orange juice, cola and pour vinegar into the last. Make sure the eggs are fully submerged.

### 4 OBSERVE THE REACTION

When pouring in the vinegar, you may notice an immediate reaction as the vinegar reacts with the eggshell, producing bubbles.



### 5 WAIT 24 HOURS

Cover the glasses and leave them for 24 hours. Check on the eggs before leaving them for an additional 24 hours.



### 6 REMOVE THE EGGS

After 48 hours, remove each egg. Some will be discoloured and will have changed in size.

**DON'T DO IT ALONE!**  
If you're under 16, make sure you have an adult with you

**7 RINSE THE SHELLS**

Some of the shells will feel soft. Gently rinse each of the eggs under a tap to remove loose shell.



**8 TEST BOUNCINESS**

For each egg, drop it from just above a plate. Keep increasing the height and see which liquid created the bounciest egg.

**SUMMARY**

Of the four liquids, the vinegar, orange juice and cola will have altered the eggs' appearance and texture. This is because they are acidic liquids. Vinegar contains acetic acid, cola contains phosphoric acid and orange juice holds citric acid. This reacts with the calcium carbonate in the eggshell to dissolve it. Calcium carbonate is the main component of the eggshell, and as it dissolves, carbon dioxide gas is released as bubbles. In the case of the vinegar – the most acidic liquid – all of the eggshell is dissolved, leaving behind just a semipermeable membrane. This membrane makes the egg translucent and gives it its rubbery, bouncy feel. The cola and orange juice dissolve some of the eggshell, but some of the hard exterior remains. The cola also causes some staining to the calcium carbonate shell. Although you can have fun watching the egg bounce, take care handling the eggs. Eventually, you'll find a drop height too extreme for the fragile membrane, causing the egg to splatter over the plate.

**Had a go? Let us know!**

If you've tried out any of our experiments – or conducted some of your own – let us know! Share your photos or videos with us on social media.

**DISCLAIMER**

Neither Future Publishing nor its employees can accept any liability for any adverse effects experienced during the course of carrying out these projects or at any time after. Always take care when handling potentially hazardous equipment or when working with electronics, and follow the manufacturer's instructions.

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Speak your mind

SEND YOUR QUESTIONS OR COMMENTS TO: **f** HOW IT WORKS MAGAZINE **@** HOWITWORKSMAG **X** @HOWITWORKSMAG **@** HOWITWORKS@FUTURENET.COM **@** HOWITWORKSMAG

## THINKING FOOD

Dear **HIW**,  
What are some of the latest nutrition findings?  
**Peter Doyle**

Scientists are always working to uncover more information about our health and the products that enter our bodies. When a new discovery is made, findings are based on the results of research, which generally needs to be followed up with further studies. Earlier this year, scientists discovered that eating more kiwi fruit can improve your mood in just a few days. It can be challenging to know which findings to trust as new discoveries are made. Although these findings weren't known previously, they usually don't change the bigger picture of foods that are deemed healthy and those that are detrimental to our health. Generally speaking, an emphasis on a wide range of balanced whole foods has been standard health advice.

The high vitamin C in kiwi fruits is thought to enhance your mood



Racing wheelchairs are made of aluminium, titanium and carbon fibre



**WIN!**  
AN AMAZING PRIZE FOR LETTER OF THE MONTH  
**WHAT IS TECHNOLOGY?**

This delightful book builds the foundations for lifelong learning by explaining big ideas using simple language

## PARALYMPIC HISTORY

Dear **HIW**,  
I've been watching the Paralympics and have been amazed at the technology that enables different bodies to participate in sports. How long have the Paralympics been an event and how much do the competitions change as technology does?  
**Jen Shaw**

The Paralympic Games is an inspiring spectacle that has been an official event since 1960. But its origins go back further. In 1948, the Stoke Mandeville Games took place in England, which invited veterans of World War II with spinal cord injuries to compete. This is thought to have sparked the Paralympics. The Paralympics has become a major event internationally, occurring alongside the Olympics every four years.

—◇—  
**LETTER**  
of the  
**MONTH**  
—◇—

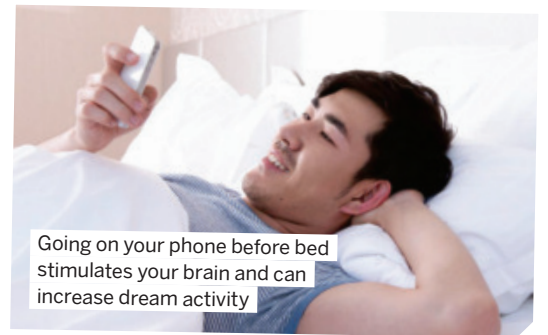
Technology has drastically shaped Paralympic events and athlete abilities. Prosthetic limbs for running and grasping equipment have seen major advances. Today's carbon-fibre running blades are lightweight and energy efficient. In early Paralympics, track events were limited to wheelchair races before the dawn of prosthetics. Running blades are able to release energy efficiently enough for athletes to compete in jumping events.

Wheelchair events have remained, but their capabilities have changed. Modern chairs are lighter, more aerodynamic and faster. Some of the latest wheelchairs are equipped with smart technology, too, so athletes are provided with real-time feedback on their speed, acceleration and turning efficiency.

## COMBATting NIGHTMARES

Dear **HIW**,  
Is there a way to stop yourself from having nightmares, or are they random and uncontrolled?  
**Graeme Broadbent**

It's perfectly natural to experience nightmares from time to time. However, their occurrence can be very unsettling. They are somewhat uncontrollable, but there are things you can do to prevent the likelihood of nightmares. Stress, anxiety, trauma, medication and diet can influence your likelihood to experience bad dreams. To manage your nightmares, you should aim to remove stress from your life.



Going on your phone before bed stimulates your brain and can increase dream activity

While you are asleep, your brain attempts to process unresolved emotions. This is why nightmares often hold links to whatever you might have been worrying about during the day. Deep breathing and mindfulness activities can benefit the brain and increase your chance of a peaceful sleep. You should also focus on making your sleeping environment relaxing and removing disturbances. A comfortable bed and dark room can prevent your sleep being disturbed and stop nightmares as a result.



The quickest time a Rubik's Cube has been completed is 3.13 seconds

## SOLVING SCIENCE

Dear HIW,

I've always wanted to solve a Rubik's cube but haven't been able to. Are some people born with a better ability to solve one?

Chris Pring

Though it's true that you can teach yourself the algorithms to solve a Rubik's Cube with time and patience, some people will be able to achieve this more easily than others. There's a specific combination of cognitive abilities needed to perfect the process. Spatial reasoning, which is the ability to visualise objects and understand how they can be manipulated, is an important ability in this task. It also requires pattern recognition and the ability to quickly recognise sequences, strong memory skills, logical thinking for problem solving and quick cognitive processing.

## FLAMINGO FACTS

Dear HIW,

Does a flamingo's pinkness change over time?

Grace Howells

There are many factors that change how pink a flamingo is. The pink colour comes from the algae, plankton and crustaceans they consume, which contain pigments called carotenoids. These pigments are taken on by the skin, feathers and beaks of these birds. Sometimes, a bird may migrate to areas where foods contain less carotenoids, and so at certain times in their migration, their colouring appears to fade. Flamingos grow pinker with age as they take on more carotenoid-rich foods.



A baby flamingo isn't pink

## HOW IT WORKS

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**Printed by** William Gibbons & Sons Limited  
26 Planetary Road, Willenhall, Wolverhampton,  
West Midlands, WV13 3XB

**Distributed by** Marketforce, 121-141 Westbourne Terrace, London  
W2 6QA [mfccommunications@futurenet.com](mailto:mfccommunications@futurenet.com)

ISSN 2041-7322

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## WE ASKED YOU

This month on social media, we asked you:

If you could take on one animal ability, what would it be?

**@JACKLYNDEEVER**  
TO BLEND INTO MY ENVIRONMENT LIKE AN OCTOPUS. BECAUSE SOMETIMES I LIKE TO BE UNNOTICED

**@CAROLJSHELDON**  
A BIRD SO I COULD FLY AND GET PLACES QUICKER

**@MERLE.HAHA**  
SLEEPING ALL DAY

**@GRANTSHELDONCOACHING**  
CHEETAH RUNNING SPEED

**@MAIRA\_H3**  
FLYING, SO I DON'T HAVE TO SPEND SO MUCH TIME IN THE AIRPORT

**@ALIGHTYOURSENSES**  
IMMORTALITY LIKE THE IMMORTAL JELLYFISH

## NEXT ISSUE

ISSUE 196 ON SALE 7 NOV 2024

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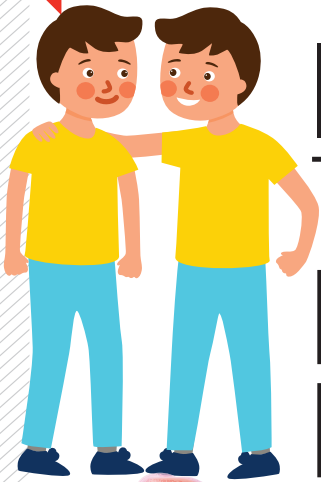
# FAST FACTS

Amazing trivia that will blow your mind



## 24 HORSEPOWER

A single horse actually has more than one horsepower

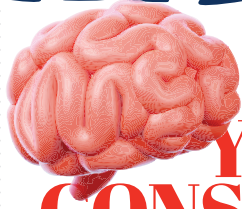


## IDENTICAL TWINS DON'T HAVE THE SAME FINGERPRINTS



## 10 BILLION LIGHT YEARS

If you stacked all the bacteria on Earth, it would stretch around our galaxy 20,000 times



## SOME CELLS IN YOUR BRAIN ARE CONSTANTLY EATING OTHER BRAIN CELLS



## 15,000 YEARS

Glass sponges are the longest living animal on Earth

## 800 KILOGRAMS

Just one of SpaceX's Starlink satellites weighs almost a tonne

## 21 HOURS

600 million years ago, a day on Earth was three hours shorter than today



## -20.35 DECIBELS

Microsoft's anechoic chamber in Redmond, Washington, is the quietest place on Earth

## Cats experience the fear of missing out too, which is why they hate closed doors

## 1 IN 2,500

A large number of women don't know they're pregnant until they give birth

# IF I HAD SOMEWHERE TO LIVE...

## I COULD GO ANYWHERE IN LIFE



When Abi's mum died, life got tough. She didn't get on with her dad and the arguments became violent. Abi felt her only choice was to leave home. With just the clothes on her back, and no idea where to go, she ended up sleeping on the streets in the freezing cold.

**Right now, you could give a homeless young person like Abi somewhere to start their future**

Abi's life changed when she was given a room at Centrepont. A safe place to sleep and recover. A place to develop the skills and confidence she needed to rebuild her life – and leave homelessness behind for good. Now, Abi believes she can go anywhere.

Thousands of homeless young people like Abi are desperately trying to find their place in the world – but first they need a place to start again. **You could help right now by sponsoring a room at Centrepont for just 40p a day.**

**We know this support changes lives. 88% of the young people we help move on positively in life. So please, help someone like Abi today. Thank you.**

**Text PLACE to 78866 to donate £3**

**Call free on 0800 472 5798**

**Visit [centrepont.org.uk/place](http://centrepont.org.uk/place)**

**Or complete and return the form below**



**SPONSOR A ROOM. HELP A HOMELESS YOUNG PERSON FIND THEIR PLACE.**

### YES, I WANT TO SPONSOR A ROOM FOR £12 A MONTH

Please collect my payment on the 1st/15th of every month (please circle preferred date).

#### Instruction to your Bank or Building Society to pay by Direct Debit

To the Manager: \_\_\_\_\_  
Name and full address of your Bank or Building Society: \_\_\_\_\_  
Originators Identification No.

Postcode \_\_\_\_\_

Name(s) of Account Holder(s) \_\_\_\_\_

Bank Sort Code:  -  -  Account Number:

Instructions to your Bank or Building Society: Please pay Centrepont Direct Debits from the account detailed in this instruction, subject to the safeguards assured by the Direct Debit Guarantee. I understand that this instruction may remain with Centrepont and, if so, details will be passed electronically to my Bank/Building Society.

Signature(s) \_\_\_\_\_ Date \_\_\_\_\_

Banks and Building Societies may not accept Direct Debit Instructions for some types of account.

#### Increase your donation by 25p for every £1 you donate with Gift Aid *giftaid it*

By ticking this box I confirm I am a UK taxpayer and want Centrepont to Gift Aid all donations I've made in the last four years and any donations I make in the future until I notify you otherwise. I understand that if I pay less Income Tax and/or Capital Gains Tax in any tax year than the amount of Gift Aid claimed on all my donations it is my responsibility to pay any difference.

Your name and address are needed to identify you as a current UK taxpayer.

Full Name: \_\_\_\_\_

Address: \_\_\_\_\_

Postcode: \_\_\_\_\_ Telephone: \_\_\_\_\_

Email: \_\_\_\_\_

**Thank you for donating to Centrepont today.**

We'd love to show the impact of your support and share how young people continue to need your help, through newsletters, fundraising appeals and information about events. Please let us know how best to stay in touch with you by adding your details above, and ticking the relevant boxes:

Please contact me by email  Please contact me by phone

Last year our supporters helped us change the lives of over 15,000 homeless young people. By letting us know we can count on you, we can continue helping young people with a home and a future.

**Your privacy is key.**

We promise never to sell or swap your details, and will always keep them secure. You can view our Privacy Notice in full at [www.centrepont.org.uk/privacy](http://www.centrepont.org.uk/privacy). You can opt out of post and change how we communicate with you at any time. Please call 0800 232320 and speak to one of our friendly team or email [supportercare@centrepont.org](mailto:supportercare@centrepont.org) to do this and ask us any questions.

**Please return this form to: Freepost Plus RTXY-LBEA-UTJJ, Angel Fulfilment Services Ltd, Communication Centre, Par Moor Road, Par PL24 2SQ.**

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Your donation will go towards funding Centrepont's vital work with young people all year round providing accommodation and support. We sometimes use models and change the names of the young people we work with to protect their identity; however all stories are true and as told by the young person.



# A SATISFYING TRIP BEFORE YOU'VE EVEN PACKED.



**GO.**  
**COMPARE**

Get more information or compare quotes  
at [go.compare/travel-insurance](https://go.compare/travel-insurance)