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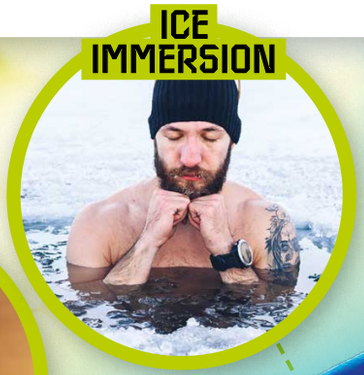
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WELLNESS

HEALTH OR HYPE?

THE SCIENCE BEHIND THERAPIES THAT CLAIM TO IMPROVE YOUR LIFE



WHY PENGUINS AREN'T REALLY PENGUINS



WHAT IF HUMANS NEVER HARNESSED FIRE?



DISCOVER THE BACTERIA THAT FILL YOUR HOME



HOW HEART-LUNG MACHINES SAVE LIVES

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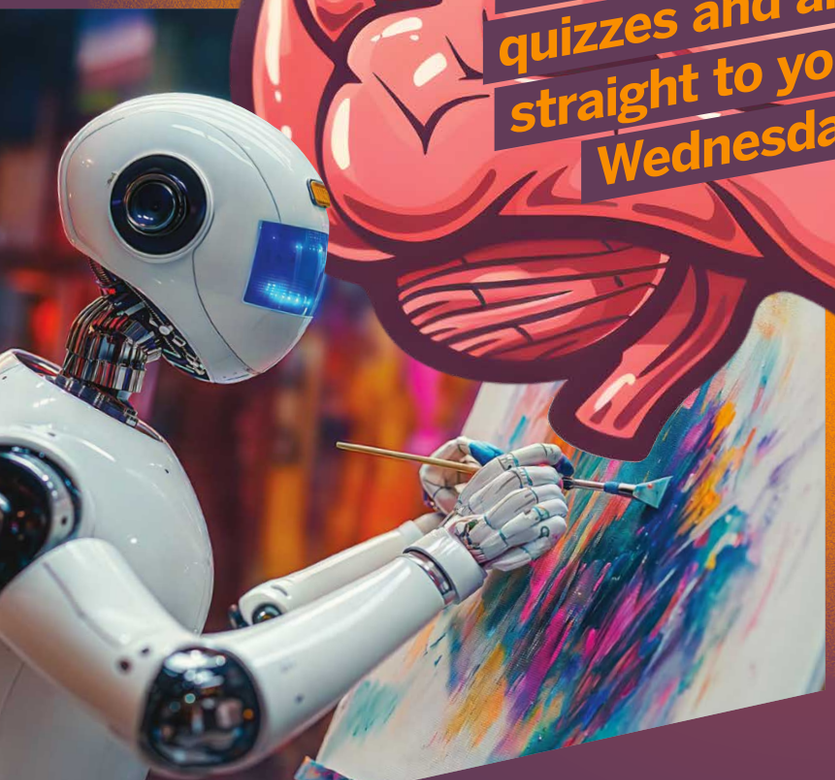
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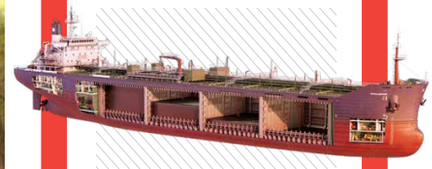


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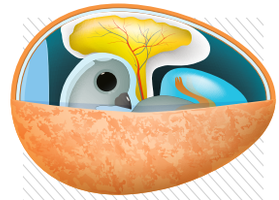
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With all the diets, physical and mental exercises, spirituality and mindfulness regimens available to many of us today, it can be quite confusing for anyone looking to make an informed lifestyle change. Especially when there are so many gimmicky fads that are at best a waste of time, and at worst harmful to your health. How do you sort the wheat from the chaff to find the right wellness routine for you? While we can't provide lifestyle advice, this issue we've picked ten of the more popular wellness devices and routines today, such as forest bathing, red-light therapy and ice water immersion, to explore the science and the technology behind them and decide whether they're good for your health, or if they're pure hype. Enjoy!



Ben Biggs
EDITOR

WHAT WE'RE ANTICIPATING



NIKOLE
PRODUCTION EDITOR



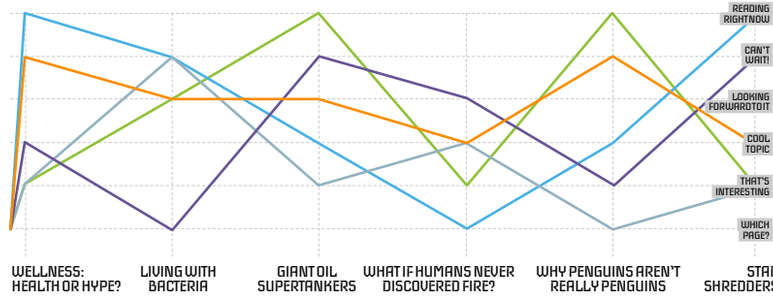
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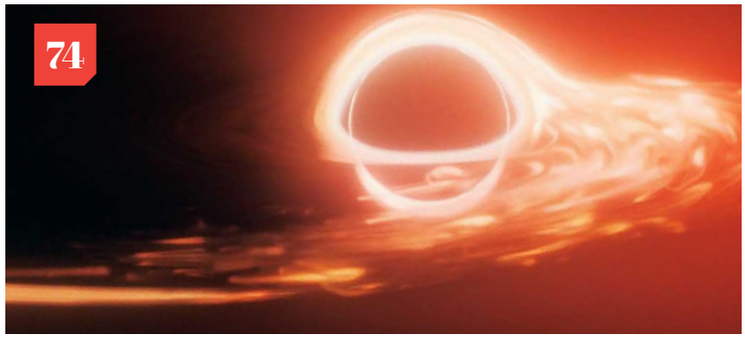
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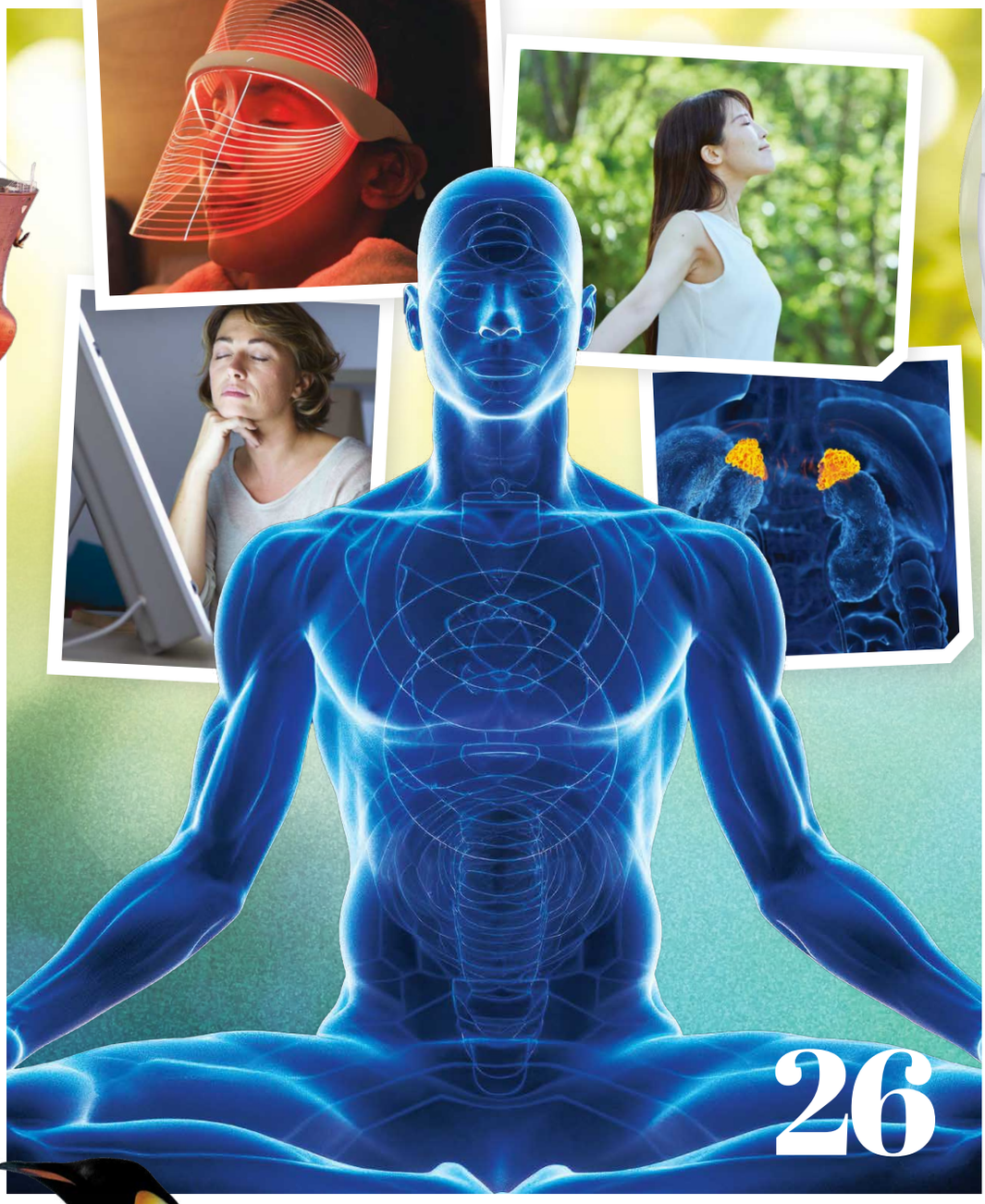
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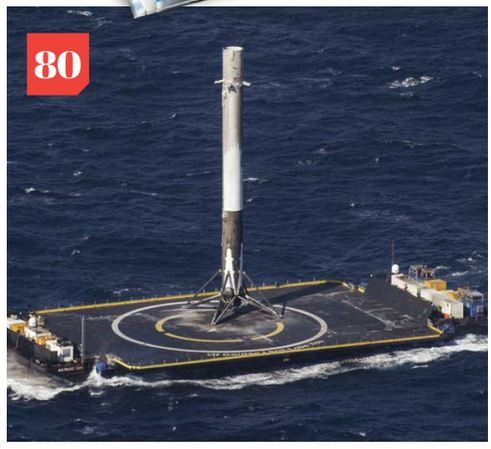
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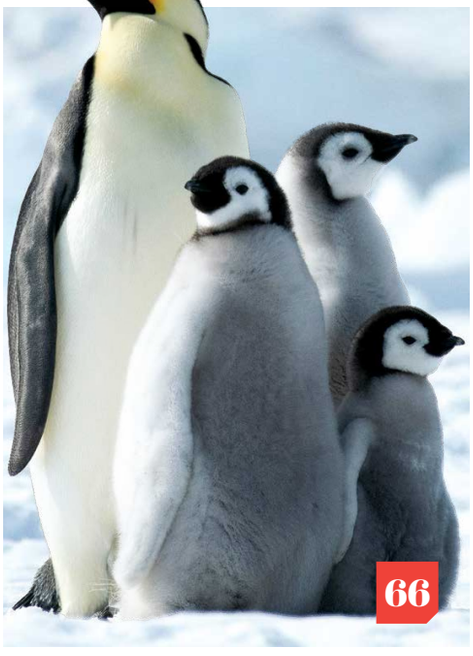


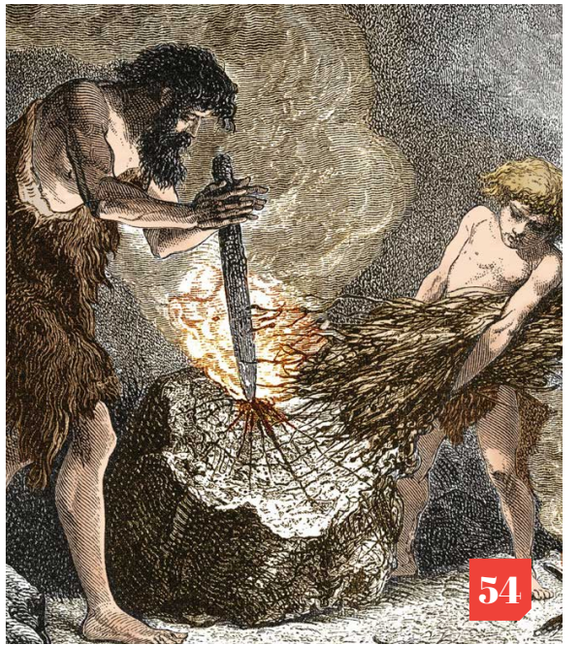


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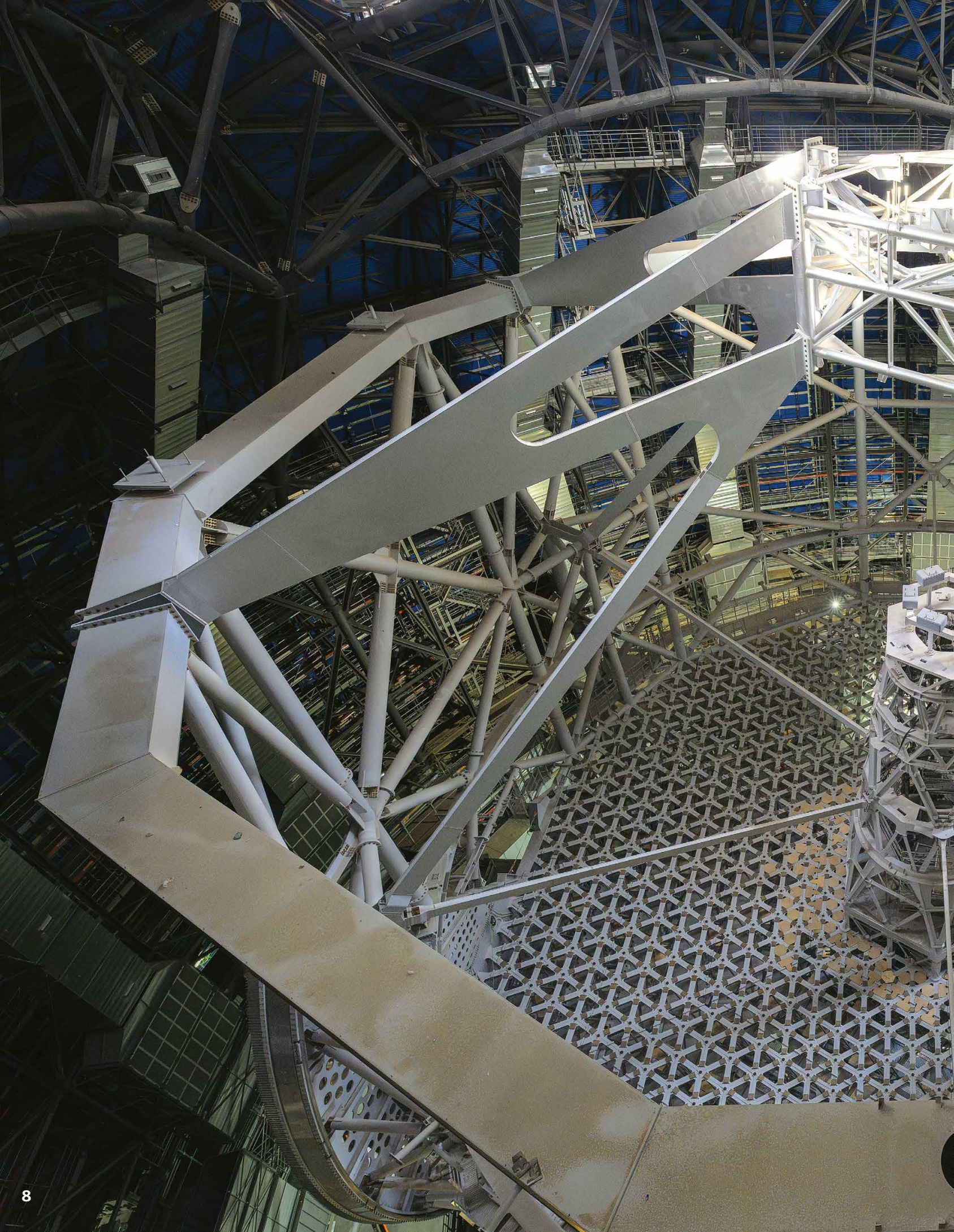




SEAL SYMPHONY

It looks like this young elephant seal is unimpressed by its cousin's crying. Found in Antarctica in spring, elephant seal pups are born weighing around 40 kilograms and are weaned from their mother after 24 days. After their mothers have gone off to sea, the pups stay on shore in groups called pods, fasting for up to ten weeks. Once most of the adults have left the rocky shore, they start to explore shallow water and eventually make deep dives in search of food.

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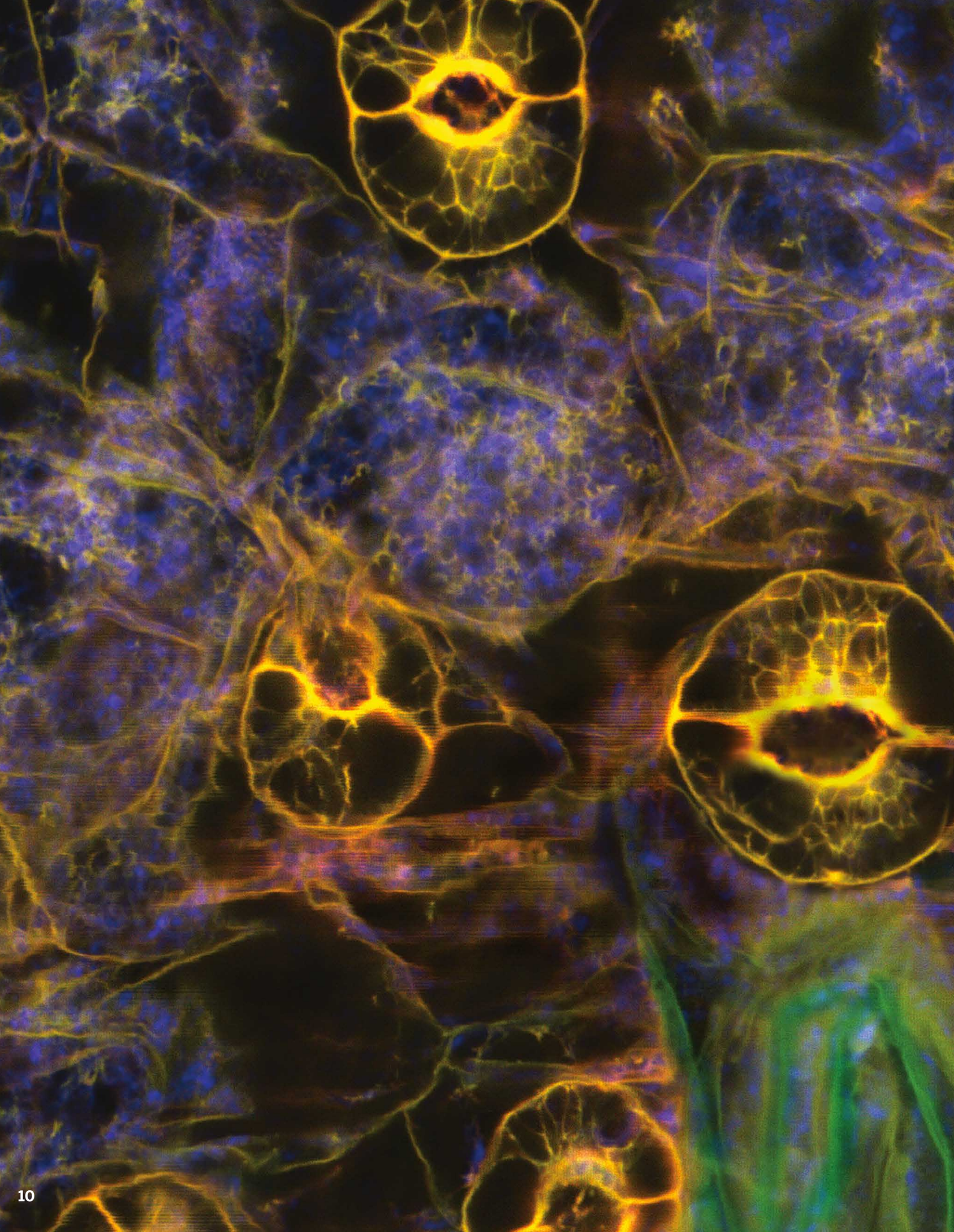


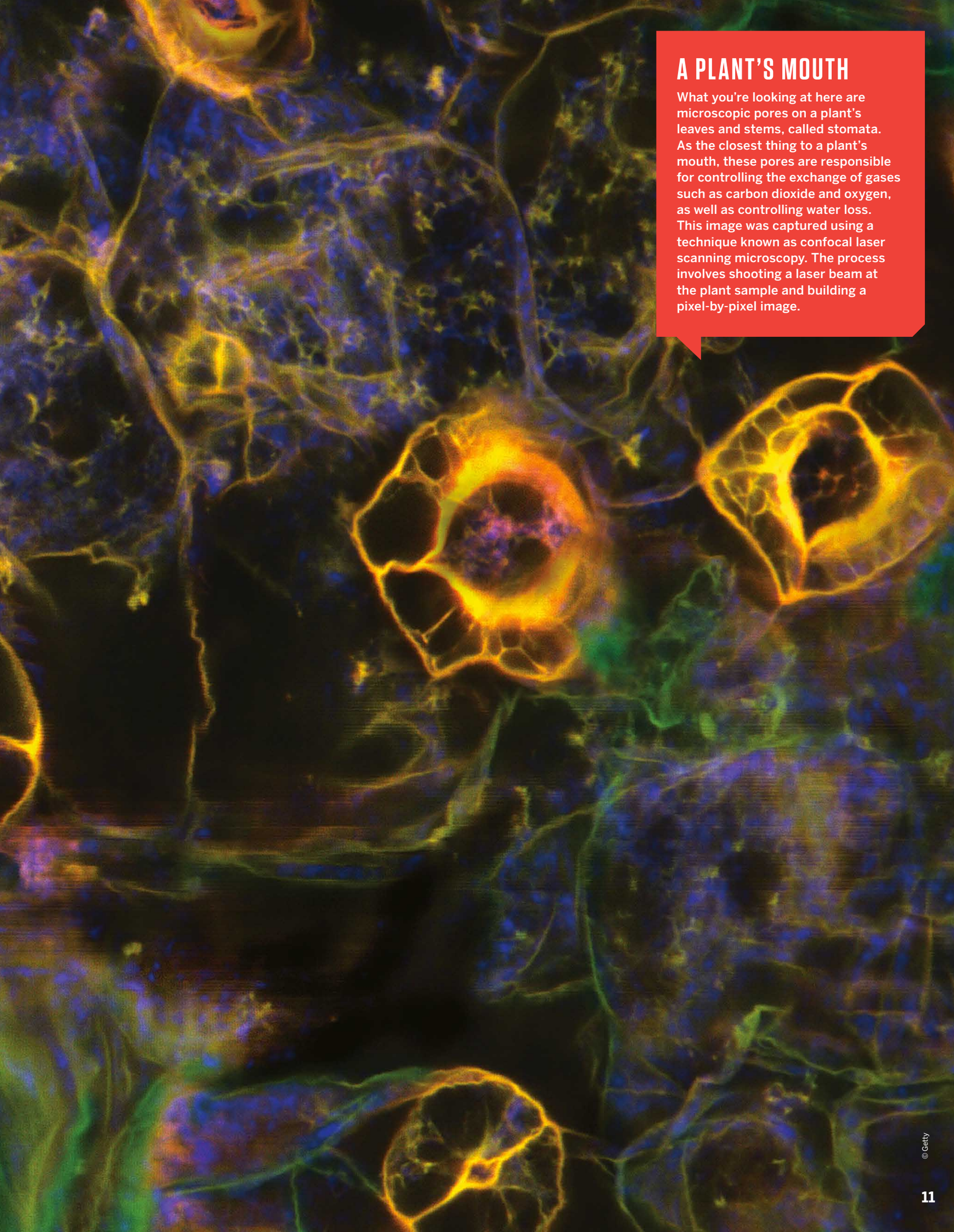


THE HEART OF A TELESCOPE

At the centre of the European Southern Observatory's Extremely Large Telescope (ELT) lies this massive structure. The frame will hold its five mirrors and instruments that will let the ELT peer deep into the universe. In this image, taken in June 2026, you can see a large hexagonal cell at the bottom that will hold the main mirror (M1). The M3, M4 and M5 mirrors will be placed inside the structure near the vertical tower. The secondary mirror (M2) will be suspended from the web-like structures at the top of the image.

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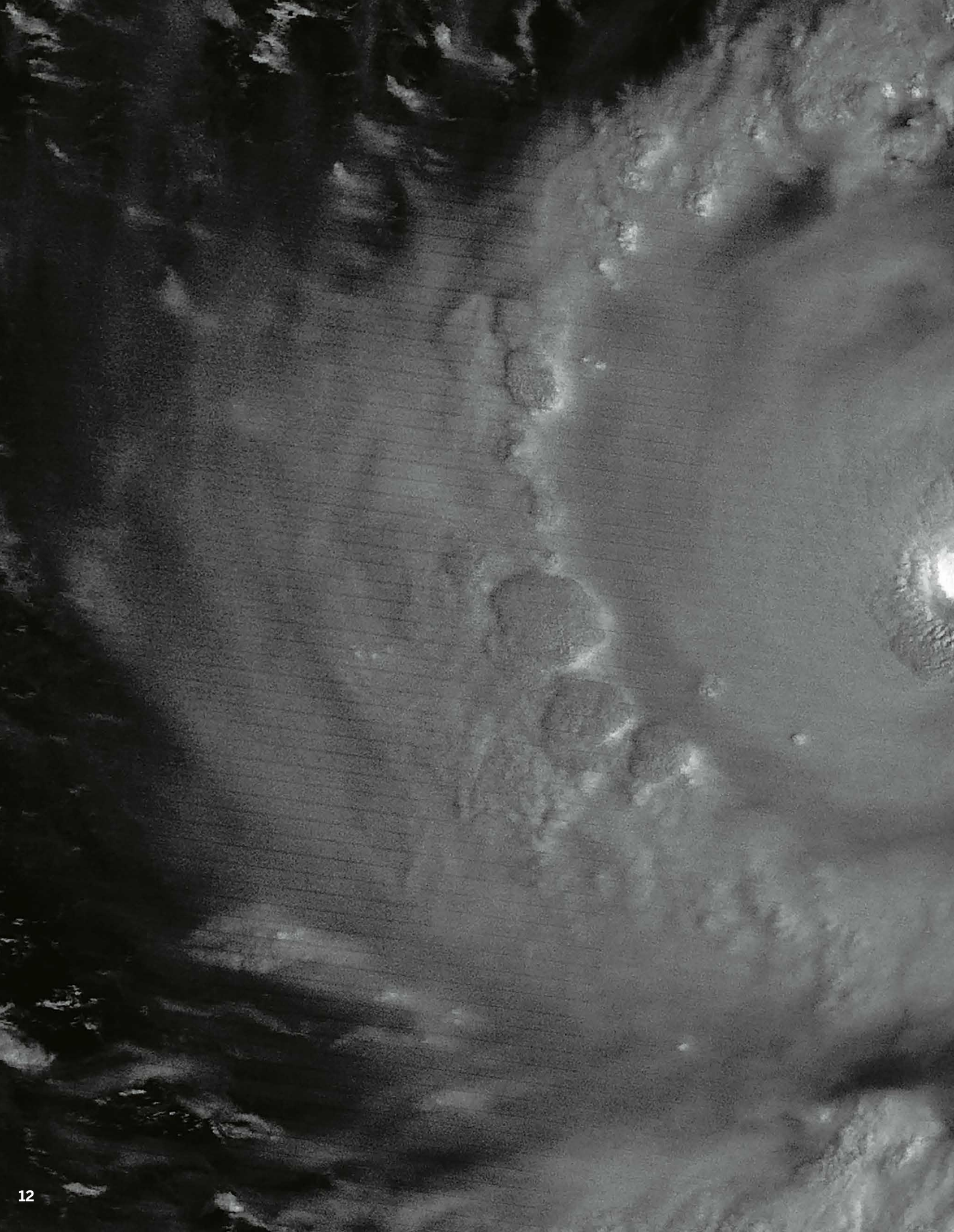


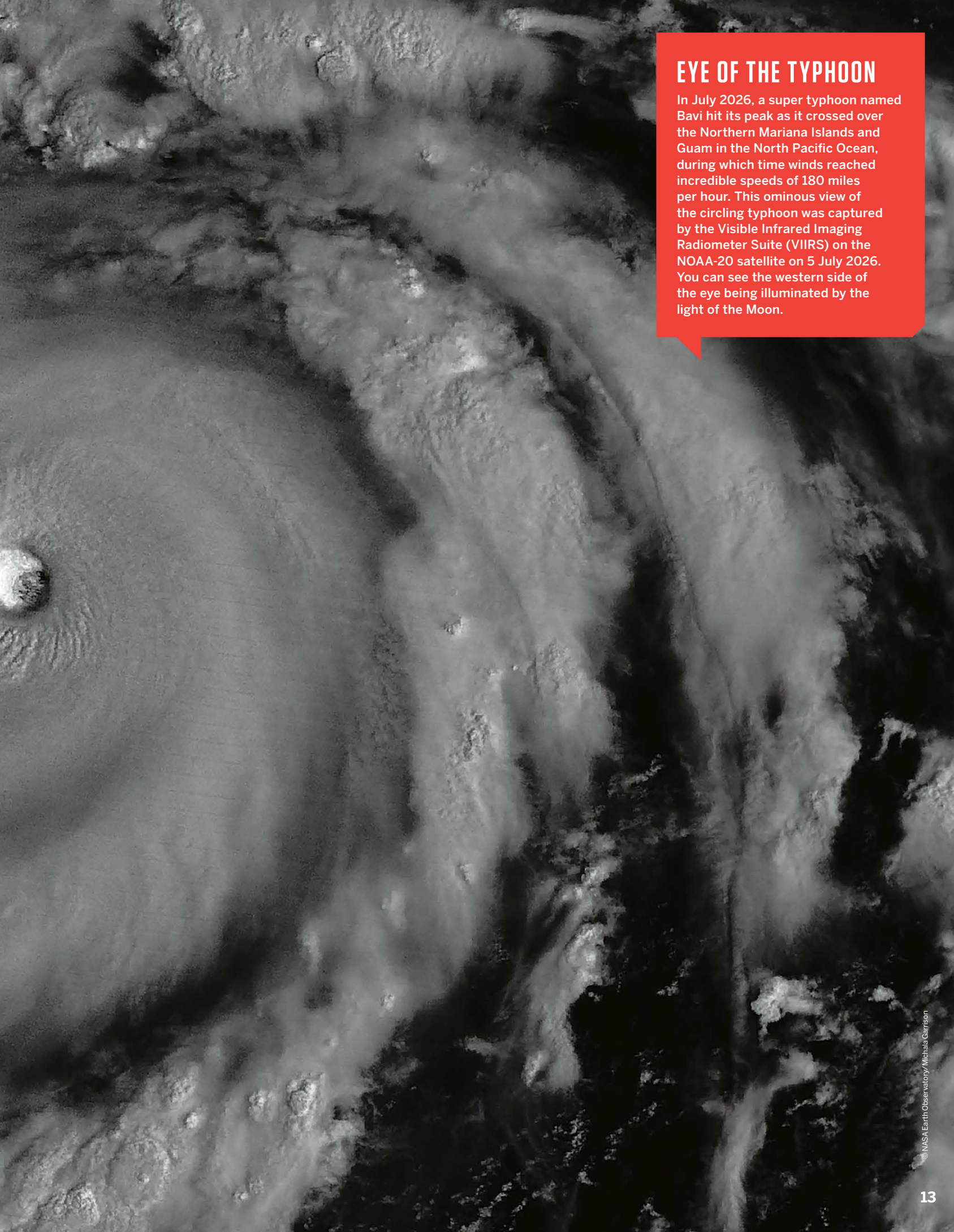


A PLANT'S MOUTH

What you're looking at here are microscopic pores on a plant's leaves and stems, called stomata. As the closest thing to a plant's mouth, these pores are responsible for controlling the exchange of gases such as carbon dioxide and oxygen, as well as controlling water loss. This image was captured using a technique known as confocal laser scanning microscopy. The process involves shooting a laser beam at the plant sample and building a pixel-by-pixel image.

© Getty





EYE OF THE TYPHOON

In July 2026, a super typhoon named Bavi hit its peak as it crossed over the Northern Mariana Islands and Guam in the North Pacific Ocean, during which time winds reached incredible speeds of 180 miles per hour. This ominous view of the circling typhoon was captured by the Visible Infrared Imaging Radiometer Suite (VIIRS) on the NOAA-20 satellite on 5 July 2026. You can see the western side of the eye being illuminated by the light of the Moon.

© NASA Earth Observatory/Michala Garrison

GLOBAL EYE

Showcasing the incredible world we live in



The katipō spider of New Zealand does not engage in cannibalistic behaviour like its cousin, the redback spider of Australia

DID YOU KNOW?

The black widow is the most venomous spider in North America

ANIMALS

Genetics triggers male black widows to backflip into death

WORDS STEPHANIE PAPPAS

Wild widow spider behaviour involving a backflip into death during mating has a simple genetic explanation. Male redback spiders, Australia's version of the black widow, flip into females' fangs while mating in order to make the act last longer. They also constrict their abdomens, a manoeuvre that seems to help them survive the experience of being eaten alive long enough to finish transferring sperm. Then they break off their sperm-transferring organs, known as pedipalps, into the females like a cork on a bottle, which prevents other males from inseminating them.

Intriguingly, a close New Zealand cousin of the redback, the katipō, doesn't do any of this. There are no backflips and no cannibalism, just a respectful courtship dance and a polite parting of ways afterward. That difference offered researchers an opportunity to understand the genetics of the more gymnastic mating behaviour. "What makes this system so intriguing is the fact that we are dealing with two species here, which are very closely related," said Kardelen Özgün Uludağ, a doctoral student at the University of Hamburg in Germany. These species may have separated less than 100,000 years ago, but they still show entirely different behaviour and traits. "This is very uncommon in animals," she said.

To figure out the genetic basis of this behavioural schism, Uludağ and her colleagues first exposed katipō females to redback males so that they would mate. The two are closely related enough to yield hybrid offspring. The researchers then crossbred hybrid females with either male redbacks or male katipō spiders. This led to mixed-genetic males. The researchers couldn't mate katipō males with redback females in the first place because redback females will eat katipōs instead of mating with them. The researchers took these hybrid males and paired them with katipō females so they could watch their mating behaviour without any of them getting eaten. Then they tracked how often the hybrid males backflipped and/or constricted their abdomens at the (presumably baffled) non-cannibalistic females.

To their surprise, the researchers found that the behaviours did not have close genetic links. Hybrid males combined backflips and life-extending abdominal constrictions only about half the time, otherwise doing just one or the other. The researchers also saw patterns of inheritance that suggested that the somersaulting was linked to the spiders' sex chromosome, the X chromosome. Male and female spiders both have two X chromosomes, but females' X chromosomes carry two full sets of chromosomes, while males' carry only one. What's more, the somersaulting behaviour had a surprisingly simple dominant-recessive pattern of being passed to offspring.

The abdominal constriction, on the other hand, was a more complex genetic trait, the researchers reported in the journal *Biology Letters*. That behaviour may be controlled by multiple genes or strongly influenced by female behaviour, the researchers concluded. Although widow spiders are famed for eating their mates, only a couple of black widow species do this. The Australian redback is one, and the US-based southern black widow is another. The researchers would like to get to the bottom of what drives this behaviour. "It would be nice to investigate more species of the genus *Latrodectus* to allow comparative studies," Uludağ said.

TECHNOLOGY

Physicists find a way to control heat in a way once thought impossible

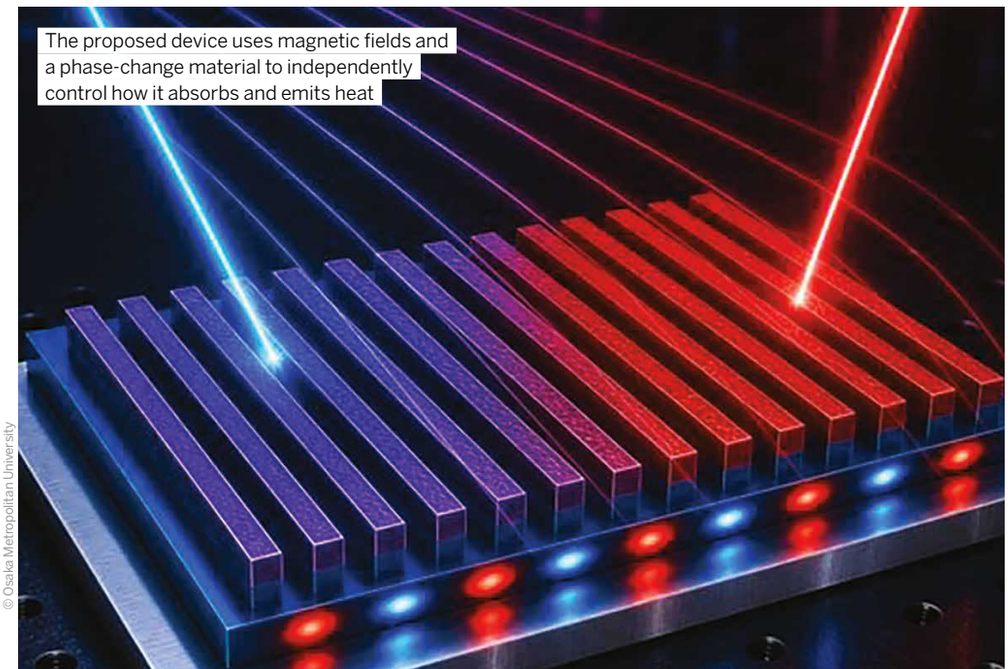
WORDS **OLIVIA MAULE**

Researchers have designed a material that can 'program' the way it releases heat, paving the way for more efficient energy systems and potentially devices that store information using heat instead of electricity. The design, described in the journal *Laser & Photonics Reviews*, sidesteps a nearly 160-year-old rule of physics linking how materials absorb and emit heat. Under ordinary conditions, a material that's good at absorbing heat from one direction is equally good at emitting heat in that direction. This rule of reciprocity, first described by physicist Gustav Kirchhoff in the 19th century, has limited engineers' ability to control incoming heat independently from outgoing heat. The researchers designed a theoretical device that could direct heat radiation in different directions and remember that setting even after the power was switched off.

The new device pairs two materials that don't normally work together. Using a magnetic field, the team broke the natural symmetry in a layer of indium arsenide, a material that absorbs and emits infrared light, so that radiation travelling in one direction behaves differently than radiation travelling the other way. On top of that layer sits a grating made of germanium-antimony-tellurium (GST), a phase-changing substance that can switch between two distinct physical structures and stay in whichever it's set to until it's deliberately switched again. Once the GST is set into position, it locks the directional difference of radiation in place and holds it there without needing continuous power, which is what lets the device's heat-directing behaviour be 'programmed'.

"I was impressed by the elegant combination of magneto-optical non-reciprocity with a non-volatile phase-change material," said Juejun Hu, a professor of materials science and engineering at the Massachusetts Institute of Technology. That's significant because earlier attempts at this kind of directional control typically worked only at steep angles, which made them impractical. It's "particularly noteworthy" that this device functions when radiation arrives just three degrees off an otherwise straight line, making it far easier to fit into real-world optical systems, Hu said.

The researchers compared their design to computer memory, since it holds onto its programmed state after the power is cut. However, the device stores a material state rather than heat itself, Hu said. GST simply keeps its amorphous or crystalline structure without power, which preserves the programmed response. For now, the device exists only on paper – it hasn't been built or tested. Still, Hu thinks it's realistic, since it relies on well-established materials and manufacturing methods. However, the GST layer is thick enough that switching it back and forth repeatedly would be difficult, though other materials could fix this problem. Once that hurdle is surpassed, Hu expects the first real-world use to be infrared sensing, where compact, direction-selective heat absorption is most directly useful.



The proposed device uses magnetic fields and a phase-change material to independently control how it absorbs and emits heat

© Oseka Metropolitan University



A close-up look at the silver coins and human remains recently excavated in Aspendos, southern Turkey

© Ministry of Culture and Tourism of the Republic of Turkey

ARCHAEOLOGY

2,400-YEAR-OLD GRAVE OF ANCIENT WRESTLER DISCOVERED

WORDS **KRISTINA KILLGROVE**

Archaeologists excavating near the ancient town of Aspendos in Turkey have discovered the grave of a person who may have been a pro athlete over two millennia ago. "Coins with depictions of wrestlers and other artefacts found in the tomb indicate that the person buried here may have been involved in sports, perhaps even a wrestler," said Mehmet Nuri Ersoy, Turkey's minister of culture and tourism. The archaeologists found the skeleton and artefacts while digging in a cemetery outside Aspendos. The tomb likely dates to 475 to 300 BCE, during the city's Classical period.

These coins, called staters, were minted for well over a century, which suggests that wrestling held civic significance for Aspendos, Oğuz Tekin, an archaeologist at Koç University in Turkey, suggested in a 2000 study. Although wrestler-type Aspendos coins were discovered in the newly excavated grave, it's unclear whether the deceased was a wrestler. "There will need to be much more analysis before a positive identification of the body as a wrestler can be determined," said Sarah E. Bond, a historian at the University of Iowa who was not involved in the discovery. "Coins alone cannot indicate this was a Classical-era Greek wrestler."

© Alamy

GLOBAL EYE



Bird figurines carved from ivory from the famous prehistoric cave site of Hohle Fels in Germany

© Ralf Ehmann / University of Tübingen

ARCHAEOLOGY

40,000-year-old bird figurines the size of a thumbnail discovered in a cave

WORDS **KRISTINA KILLGROVE**

Archaeologists excavating in the prehistoric Hohle Fels cave in Germany have uncovered two bird figurines carved from mammoth ivory. The thumbnail-size carvings add to the existing evidence that ice age humans had a sophisticated artistic sense 40,000 years ago. "The figurines demonstrate that the earliest artists were skilled ivory carvers who could depict delicate motifs in miniature form," said Nicholas Conard, an archaeologist at the University of Tübingen in Germany.

When the birds were found in 2025, they were lying just 1.5 metres from each other in a layer dating back 40,000 years. They bring the number of bird figurines from Hohle Fels up to three, as a small water bird was found there in 2001. Hohle Fels was occupied by early *Homo sapiens* during the Aurignacian period of prehistory, after the decline and disappearance of Neanderthals from Europe. At that time, humans launched a creative explosion, creating the world's first musical instruments, jewellery and small sculptures. The Venus of Hohle Fels, a 41,000-year-old statuette of a woman discovered in the cave in 2008, is generally considered to be the oldest figurative sculpture in Europe. Archaeologists have also found figurines of animals and an ivory rope-making tool at Hohle Fels, a German name that means 'hollow rock' in English.

At roughly thumbnail size, the two new bird carvings are significantly smaller than the figurines previously found at Hohle Fels. Despite their tiny dimensions, "the carvings are not highly stylised but instead include many specific and unique features," Conard said. "The artist has recorded detailed observations that allow us to consider which kind of bird is represented and what the bird could be doing." One bird appears to be lying on the ground, possibly brooding over its eggs. This position suggests the bird is a ptarmigan, a game bird that is related to chickens and grouse and whose bones have been discovered in the prehistoric layers at Hohle Fels. The second bird has spread wings that are suggestive of flight or posturing in courtship, according to the archaeologists. This bird may also be a ptarmigan, or possibly a bird of prey.

The two tiny ptarmigans raise many new questions about early humans in Europe, Conard said. They are among the earliest evidence of modern humans in Europe, suggesting art was a major feature of early human life. Archaeologists do not know what meaning the carvings held for the Aurignacian people who lived at Hohle Fels, but the objects may have been personal talismans or a symbol of a specific group of people. Hohle Fels is unique among ice age cave sites because, to date, it's the only one with bird figurines. This may reflect people's keen observations of the natural world around them.

SPACE

DETAILED VIEW OF THE SUN'S SURFACE IS REVEALED

WORDS **OLIVIA MAULE**

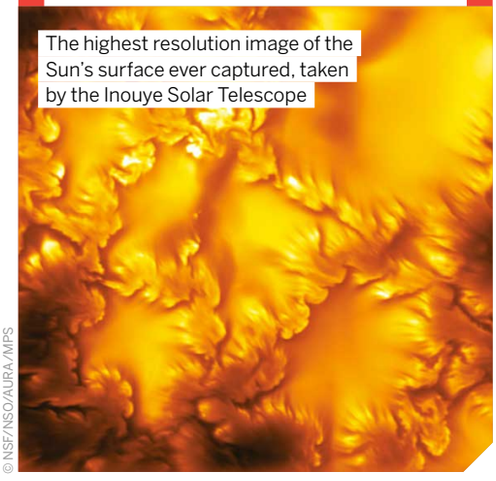
New images captured by the world's most powerful solar telescope have revealed something that was hiding in plain sight on the Sun for 150 years: thousands of tiny whirlpools twisting across its surface. The ultra-detailed observations could help explain some of the Sun's most violent behaviour, as well as hint at the answer to a long-standing solar mystery.

The new time-lapse footage offers the first direct proof of a predicted phenomenon called Kelvin-Helmholtz instability. Whenever two fluids slide past each other at different speeds, the friction between them, or shear, rolls into spiralling patterns. However, this is the first time this effect has been seen on the Sun, where it plays out between neighbouring streams of solar plasma.

Researchers captured the swirls using the US National Science Foundation's Daniel K. Inouye Solar Telescope in Hawaii and compared them against computer simulations of the Sun's visible surface, called the photosphere. The resulting time-lapse footage from the telescope is unlike anything solar physicists have captured before. It shows dozens of tiny vortices clustering along the edges of magnetic regions, some accompanied by delicate dark stripes known as striations.

DID YOU KNOW?

The Sun is 4.6 billion years old



The highest resolution image of the Sun's surface ever captured, taken by the Inouye Solar Telescope

© NSF/NSO/AURA/MPS

SPACE

JWST has spotted the oldest and closest pair of black holes in the early universe

WORDS SHREEJAYA KARANTHA



A photo of the core region of Messier 87. The central dark area is a supermassive black hole

Astronomers have discovered a close pair of actively feeding supermassive black holes, seen when the universe was just 1.3 billion years old. Collectively known as LID-1166, the two monsters are separated by only about 4,900 light years inside a merging galaxy, offering the first clear view of a phase that's critical for understanding the growth of supermassive black holes. Most large galaxies we can see formed over billions of years by merging with other galaxies. Most galaxies also have central black holes, so a merger between them would produce a system with two black holes. These 'dual black hole' systems are thought to be common in the early universe. However, given that they're buried in dense gas and dust, these black holes are too close to be observed separately.

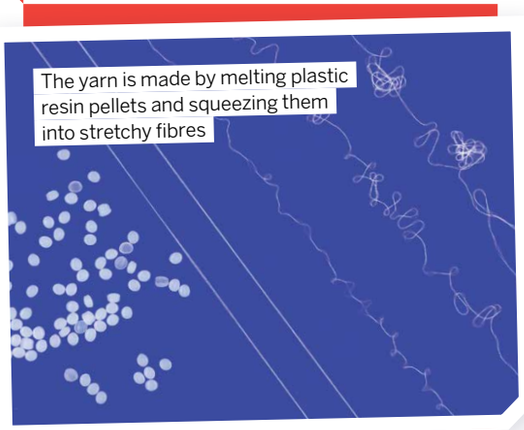
Hyewon Suh, an astronomer at the International Gemini Observatory, and her colleagues reported the discovery of the closest together dual black hole system ever confirmed this early in the universe's history. The team used the James Webb Space Telescope (JWST) and the Atacama Large Millimeter/submillimeter Array (ALMA), a collection of radio telescopes in Chile, to study this system. Their paper has been accepted for publication in the journal *Nature Astronomy*. "What makes that discovery special is that we may be seeing these two black holes growing and interacting in a system that is only about 1.3 billion years after the Big Bang," said Anna Trindade Falcão, an astrophysicist at NASA's Goddard Space Flight Center.

"Known as LID-1166, the two monsters are separated by only about 4,900 light years"

LID-1166 first caught the astronomers' eyes as an X-ray source in the Chandra COSMOS-Legacy Survey, but it remained completely undetected in even the deepest Hubble Space Telescope images. The strong X-ray signal hinted at the powerful feeding activity. To understand what was producing these strong emissions, the team turned to JWST's Near-Infrared Spectrograph (NIRSpec) instrument, which revealed two compact glowing sources sitting 4,900 light years apart. Although astronomers have spotted other dual black hole candidates even earlier in the history of the cosmos, those pairs were separated by tens of thousands of light years or more. LID-1166 is the first confirmed case of two black holes existing this close together.

"This step of the discovery could happen only thanks to the exquisite imaging and spectroscopic capabilities of JWST, and in particular its instrument NIRSpec," said Roberto Decarli, an astronomer at the Italian National Institute for Astrophysics in Bologna. "Similar observations from the ground would be extremely challenging due to the poor transparency of the atmosphere at these wavelengths." Both objects showed spectral signatures of gas swirling at high speeds, indicative of actively feeding black holes, also known as active galactic nuclei, powering the merging system. Trindade Falcão said that the researchers tested several methods for subtracting the main galaxy's light, and the signal at the second object's position stayed there every time, which is "meaningful evidence" that the signal is real. Even so, she says it would be worth double-checking, with a more detailed follow-up analysis, that the data truly shows two separate black holes, rather than one black hole plus some leftover glow being mistaken for a second one.

© NASA



The yarn is made by melting plastic resin pellets and squeezing them into stretchy fibres

© Felice Frankel, MIT

TECHNOLOGY

FASHION'S PLASTIC WASTE IS TACKLED USING A NEW YARN

WORDS **OLIVIA MAULE**

Your favourite gym clothes may be much easier to recycle one day thanks to a new type of elastic yarn that's as strong and stretchy as spandex-containing fabrics. The yarn is built entirely from polyethylene, the plastic used in milk jugs. Most of today's stretchy fabrics blend spandex, a bouncy but weak polyurethane fibre, with a tougher fibre like polyester or nylon. That combination gives clothes their stretch and durability. But because the fibres are chemically different, it's difficult and costly to separate them for recycling, and chemicals used to break down the fabrics are toxic. An estimated 80 per cent of textiles sold in the US contain spandex, and most end up incinerated or in a landfill.

For the polyethylene yarn's stretchy core, researchers created a soft, springy version of polyethylene akin to a rubber band. Around that core, they wound a second stiffer polyethylene fibre, more like a fishing line, coiling it tightly the way a spring is coiled. Because both come from the same plastic family, they don't need to be separated before they're recycled. In lab tests, researchers melted a spool of the yarn and respun it into new yarn ten separate times. Each time, they tested its strength, and the recycled yarn performed just as well in every case. The new yarn also outperformed spandex-polyester yarn by bearing more force before breaking.

TECHNOLOGY

A new tent generates electricity from the wind

WORDS **ALAN BRADLEY**

Researchers have developed a tent that harvests energy from its own motion, a process that could one day power small devices in shelters, disaster zones and off-grid camps. The key lies in a material property known as 'magnetoelasticity', which turns bending and stretching motions into electrical energy. Magnetoelasticity, first described in 1865 by physicist Emilio Villari, is the change in a material's magnetic flux density when mechanical stress is applied in the presence of an external magnetic field.

The design uses smart textile layers that respond to everyday movement in and around the tent, harvesting both environmental and biomechanical motions. Wind, a person shifting inside or the fabric flexing during setup can all contribute to the energy output, making the shelter itself part of the power system. The tent fabric acts as an energy harvester. When the material bends, stretches or flexes, its magnetic state changes, and that shift is converted into electrical energy through induction. The tent's floor incorporates magnetoelastic ribbons, while its roof is constructed as a layered architecture that integrates conductive fibres and magnetoelastic film.

Researchers reported that tapping a small sample of the magnetoelastic textile unit hand-charged a 0.22-microfarad capacitor to 5.8 volts within 1.5 seconds. This is equivalent to the kind of charge you might see in a tiny timing or filter cap on a low-power sensor node. While that's too little to power something like a smartphone, it demonstrates that even a small piece of the material can harvest energy. Primarily, the scientists envision it being used in places where electricity is limited, unreliable or unavailable, where even modest power generation can make a difference by powering LED lights, charging a phone or running a small heater. The researchers also framed the design as a response to the impracticalities of existing portable shelters; they often need power, but generators require fuel, batteries add weight and maintenance and solar panels depend on sunlight.

Unlike a solar setup, the tent does not need bright sunlight to function. Wind, handling and ordinary movement can contribute to the energy output, which means the system could keep collecting electricity even in shaded conditions or after dark, as long as the fabric continues to flex. The scientists said this technology is not meant to run high-drain appliances. Instead, it targets low-power electronics, like microwaves or power tools. In that sense, in its current guise, the tent is a supplemental power source, not a replacement for grid electricity or a high-capacity battery pack. Plenty of questions about the tent's durability remain unanswered. In future research, the scientists will need to prove how much electricity the tent can produce in real-world conditions, how durable the textile remains after repeated folding and weather exposure and whether the design can be manufactured affordably at scale.



A future camping tent could be powered by the movement of wind (not pictured here)



A group of galaxies named the Copeland Septet, just one detail among billions captured in the largest ever 2D map of the universe

DID YOU KNOW?

The first evidence for dark energy was discovered in 1998

SPACE

Astronomers release one of the largest ever maps of the universe

WORDS **ELIZABETH HOWELL**

The largest 2D map of the universe just dropped, and it's a stunner. Compiled from more than a decade of observations, the new map charts 4 billion stars, galaxies, black holes, asteroids and other objects of interest throughout the cosmos. The map reveals about three-quarters of the night sky in high resolution, spanning both visible and near-infrared light wavelengths and charting the areas of the universe not blocked by dust or gas. The map is so big, in fact, that it's impossible to reproduce as a single image here. Instead, astronomers invite you to explore their vision of the universe using the free Legacy Survey Sky Browser.

It took 13 years and three ground-based sky surveys using telescopes from the National Science Foundation (NSF) and the University of Arizona to gather the information for the map. The results are available for other scientific investigators to use and will likely help other telescopes search the cosmos. "Astronomers and citizen scientists can combine the map with their own observations to better understand our universe," NSF officials from NOIRLab said in a statement. "Researchers can search for rare phenomena like gravitational lenses, observe fleeting events like supernovae and investigate two of physics' biggest mysteries: dark matter, the invisible substance that accounts for most of the mass in our universe, and dark energy, the force driving our universe's accelerating expansion."

Past versions of the map have generated at least 1,800 science papers. The latest map is expected to inform newer observing projects, such as the Vera C. Rubin Observatory and the Nancy Grace Roman Space Telescope. Additionally, these maps laid the groundwork for the Dark Energy Spectroscopic Instrument (DESI) survey, which is creating a 3D map of the cosmos by measuring the light of celestial objects to figure out their distances.

DESI's first five-year survey wrapped up in April this year, and the early results suggest that dark energy may be getting weaker with time. As physicists grapple with the implications – including how the universe may end – more data from DESI is coming shortly, with improved results from the first five years expected next year. DESI's work will continue into 2028, so even more is still to come.

The three telescopes behind the map are the Dark Energy Camera mounted on the Victor M. Blanco Telescope in Chile, the Nicholas U. Mayall Telescope at Kitt Peak National Observatory in Arizona and the UA Bok Telescope, also at Kitt Peak. The observations were supplemented by years of data from NASA's Wide-field Infrared Survey Explorer (WISE) satellite mission, which launched in 2009.

© Shutterstock / DESI Legacy Imaging Surveys/LBNL/DOE & KPNO/CTIO/NOIRLab/NSF/AURA

HEALTH

The FDA approves the first mRNA vaccine for seasonal flu

WORDS **NICOLETTA LANESE**

The US Food and Drug Administration (FDA) has approved a new seasonal flu vaccine that uses mRNA as its base. Moderna, the vaccine's maker, announced that a vaccine advisory committee to the FDA unanimously agreed that the shot is safe and effective for preventing illness from seasonal influenza. The shot, called mFlusiva or mRNA-1010, has been approved for people aged 50 and older. Similar to mRNA vaccines against COVID-19, the vaccine uses the genetic molecule mRNA to encode instructions for cells in the body. In this case, it prompts the cells to build hemagglutinin (HA), a protein found on the surface of influenza viruses. Flu viruses use this protein to infiltrate human cells, and it's the same protein targeted by conventional flu vaccines. Following vaccination with mFlusiva, the immune system learns to recognise the HA protein on targeted flu strains, thereby improving its ability to block the viruses from infecting cells.

The HA protein poses a major challenge for conventional flu vaccines because it mutates very rapidly as the viruses multiply and spread, and these existing vaccines take months to manufacture. That's one reason the resulting shots aren't always a great match for the flu viruses that end up circulating in any given year. A benefit of the mRNA platform is that vaccines can be produced very quickly, and can be made to better match the season's dominant strains. mFlusiva's approval was based in part on a late-stage clinical trial involving over 40,000 people aged 50 and up who were vaccinated for the 2024 to 2025 Northern Hemisphere flu season. Half received the mRNA-based shot, and half received a standard dose of a conventional flu vaccine, as opposed to the higher-dose option available to older adults in the US.

Of the 40,000 participants, about 970 got sick with flu, including two per cent of the mRNA group and 2.8 per cent of the standard group. That means the mRNA vaccine was 26.6 per cent more protective than the conventional vaccine against illness from flu in this trial. mFlusiva also offered superior protection against each of the three flu subtypes included in the vaccine. And in participants aged 65 and up, the vaccine was 27.4 per cent more protective overall. More people in the mRNA group experienced side effects like injection-site pain, headaches, fatigue and achiness compared with the standard group, but these effects were mostly short-lived and mild to moderate in severity. These side effects were consistent with what was seen in earlier trials of the vaccine.

An additional trial involved a group of adults aged 65 and older and directly compared mFlusiva to an existing high-dose flu vaccine, which is approved only for older adults in the US. These findings suggested that the mRNA vaccine generated superior immune protection than the conventional option, based on antibody levels. These results led the FDA advisory committee to decide that the vaccine's benefits outweigh its risks, and the agency ultimately approved it. For adults aged 50 to 64, the vaccine earned standard approval, and for adults 65 and up, it earned 'accelerated approval', meaning further trials will be conducted to confirm the benefit of the shot over the high-dose option for this population.



Moderna's flu vaccine mFlusiva has been approved for use in adults aged 50 and older

DID YOU KNOW?

Up to 30 per cent of people with the flu have no symptoms



An artist's concept of a Voyager probe

© NASA/JPL-Caltech

SPACE

NASA grants the Voyager 2 probe another year of power

WORDS **ELIZABETH HOWELL**

Scientists are preparing for an interstellar rescue of humanity's most distant spacecraft, Voyager 1, after fixing up its twin from billions of miles away. According to NASA, a clever power-saving manoeuvre known as the 'Big Bang' helped the agency avoid having to shut off another one of the Voyager 2 probe's three remaining science instruments later this year. The Big Bang procedure involves selectively shutting off some high-power instruments on the Voyager probes while switching on lower-power alternatives, all while keeping the spacecraft warm enough to operate in the frigid environment of interstellar space. "The idea is to swap out a group of powered devices all at once, hence the nickname, turning some things off and replacing them with lower-power alternatives to keep the spacecraft warm enough to continue gathering science data," representatives from NASA's Jet Propulsion Laboratory wrote in an April blog post.

NASA carefully ran tests on Voyager 2 before implementing the procedure in May and June. Now, sharing the results of those tests, NASA reports a successful power transfer that should keep Voyager 2 running a while longer. "The savings should provide power to keep its three instruments operating for at least an extra year," NASA wrote of the Big Bang. But power is dwindling on both nuclear-powered spacecraft, and Voyager 1 is in worse shape than its twin. Mission scientists were forced to turn off one of Voyager 1's last remaining science instruments in April. Voyager 1's turn for a life-extending Big Bang will happen within a few months to keep science operating there as long as possible.

Scientists decided to do the Big Bang on Voyager 2 first because it's in better health and is closer to Earth than Voyager 1. Voyager 1 is nearly 171 astronomical units (AU, where 1 AU is the average distance between Earth and the Sun) from our planet, while Voyager 2 is about 143 AU away. Both are crucial for revealing clues about the region outside the heliopause, the sphere of influence the Sun exerts upon our Solar System, as they're the only working spacecraft at such a distance. In November, Voyager 1 will reach a milestone 'light day' from Earth, when it takes 24 hours for a radio signal to travel one way from our planet to the spacecraft. Both spacecraft will also turn 50 years old in 2027, assuming they keep working.

MATHEMATICS

HONG WANG BECOMES THE THIRD WOMAN TO WIN THE FIELDS MEDAL

WORDS **OLIVIA MAULE**

The 2026 Fields Medal, one of the world's most prestigious mathematics prizes, has just been awarded to four pioneering young researchers, including mathematician Hong Wang. The Fields Medal is presented every four years to mathematicians under the age of 40 for their outstanding discoveries. The International Mathematical Union announced on 23 July that Wang, a professor at New York University, is among the four recipients of the 2026 medal for her work on a decades-old conjecture about how needles move in 3D spaces.

Wang was recognised for her work on the Kakeya conjecture, a problem that asks how little space is needed to rotate a needle so that it points in every possible direction in three dimensions. Mathematicians had chased a solution for roughly 50 years. Working with collaborator Joshua Zahl, Wang showed that if you track every direction the needle could point as a bundle of thin tubes, there's a precise trade-off between how thin those tubes are and how much total space they must occupy. Solving the puzzle required tools from harmonic analysis, a field that studies how complex shapes and signals can be broken down into simpler pieces.



Hong Wang was awarded the 2026 Fields Medal in mathematics for her work on the Kakeya conjecture

© Shutterstock / Getty

WISH LIST

BACK TO SCHOOL



MOVINKPAD PRO 14

£749.99 / $1,099.95 WACOM.COM

For digital artists, illustrators and designers, the MovinkPad Pro 14 is a portable 14-inch OLED pad that can level up the way you work. Using the Wacom Pro Pen 3 (sold separately), art students can sketch, paint and edit their work with ease and precision. The pad's surface is crafted from textured glass for a smooth pen glide with the right amount of resistance for a natural drawing feel. It's been specially treated to reduce reflections, glare and fingerprint marks for uninterrupted working.



ZENSCREEN DUO OLED

£569 / $599 ASUS.COM

To organise your notes and research, a second, or even third computer screen is essential for some of us when it comes to studying. The ASUS ZenScreen Duo portable monitor can offer just that. The foldable dual 14-inch OLED panels create a 20-inch workspace that can be divided to display separate or identical content. The panels also operate on a 360-degree hinge and boast an integrated kickstand for face-to-face presentations and desk work.



PLAUD NOTEPIN S

£159 / $179 PLAUD.AI

For the dedicated note-taker, this wearable AI assistant could save you a lot of time. Worn as a lanyard, wristband, clip or pin, the Plaud NotePin S is an AI-powered voice recorder for hands-free note-taking. Just hold and long-press to record and short-press to highlight key moments in your lecture or meeting. It can generate recorded summaries in over 10,000 templates, visual mind maps and workflow integrations using the companion Plaud app or website. The device can also transcribe audio in 112 different languages.





BOSE QUIETCOMFORT ULTRA HEADPHONES

£349.95 / $449 BOSE.CO.UK

Bose has released the second generation of its active noise-cancelling headphones. With an updated design and the inclusion of Bose TrueSpatial technology, these headphones are a great way to block out the noise while you study, enjoy music or immerse yourself in cinema. The TrueSpatial technology enables three immersive audio settings that adjust the audio so that the listener is in the 'sweet spot' of the audio source. For example, in 'Cinema Mode', the technology expands the soundstage for a theatre-like experience.



CASA POP-UP DESK

£159.99 / $179.99 LOGITECH.COM

If you like to work or study on the go but enjoy the set-up of a permanent desk, the Casa Pop-Up Desk might be a great compromise. The book-like case neatly packs away your laptop, a wireless keyboard and a touchpad. When you're ready to work, it unfolds into a laptop stand to prop up your device. Once you're done, simply slot the three key components back into the case and away you go. There's also a handy storage space for cables or stationery.



"Even if your possessions are still too hard to find, you can sound the alarm"

TILE PRO

FROM £22.99 / $34.99

LIFE360.COM

You'll never have to worry if you've left your backpack somewhere on campus again, as long as it's got a Tile Pro attached. The handy little device is a Bluetooth tracker that helps you keep tabs on valuables within a 152-metre range. Using the accompanying app, you can track its live location using your smartphone, and even if your possessions are still too hard to find, you can sound the alarm. There's also the option to join Life360's membership program for additional features, including the tracker's seven-day location history and crash detection.

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WELL

HEALTH OR

DID YOU KNOW? Over 76 per cent of American adults see their doctor for an annual health check





NESS HYPE?

Why some popular physical and mental health trends don't deserve a place in your routine

WORDS AILSA HARVEY

© Shutterstock / AdobeStock

HEALTH

FOREST BATHING FINDINGS

Forest bathing, also called shinrin-yoku in Japan, isn't a new wellness trend. It originated in Japan in the 1980s and involves immersing yourself in nature. This means focusing all your senses on the surrounding nature – not just spending time walking through it. This includes turning off any devices, walking slower than normal or finding a spot to sit and breathe deeply. Studies show that spending time in nature lowers the levels of stress hormones in the body, reduces your heart rate and blood pressure and improves your mood. Forest bathing was also found to increase the activity of natural killer (NK) cells in the body. These are immune cells that help the body fight against viruses and cancerous cells. The long-term impact of this cellular activity still needs to be studied further, however. This benefit of forest bathing is thought to be due to reduced mental stimulation and exposure to phytoncides – antimicrobial organic compounds released by plants.



"Spending time in nature lowers the levels of stress hormones"

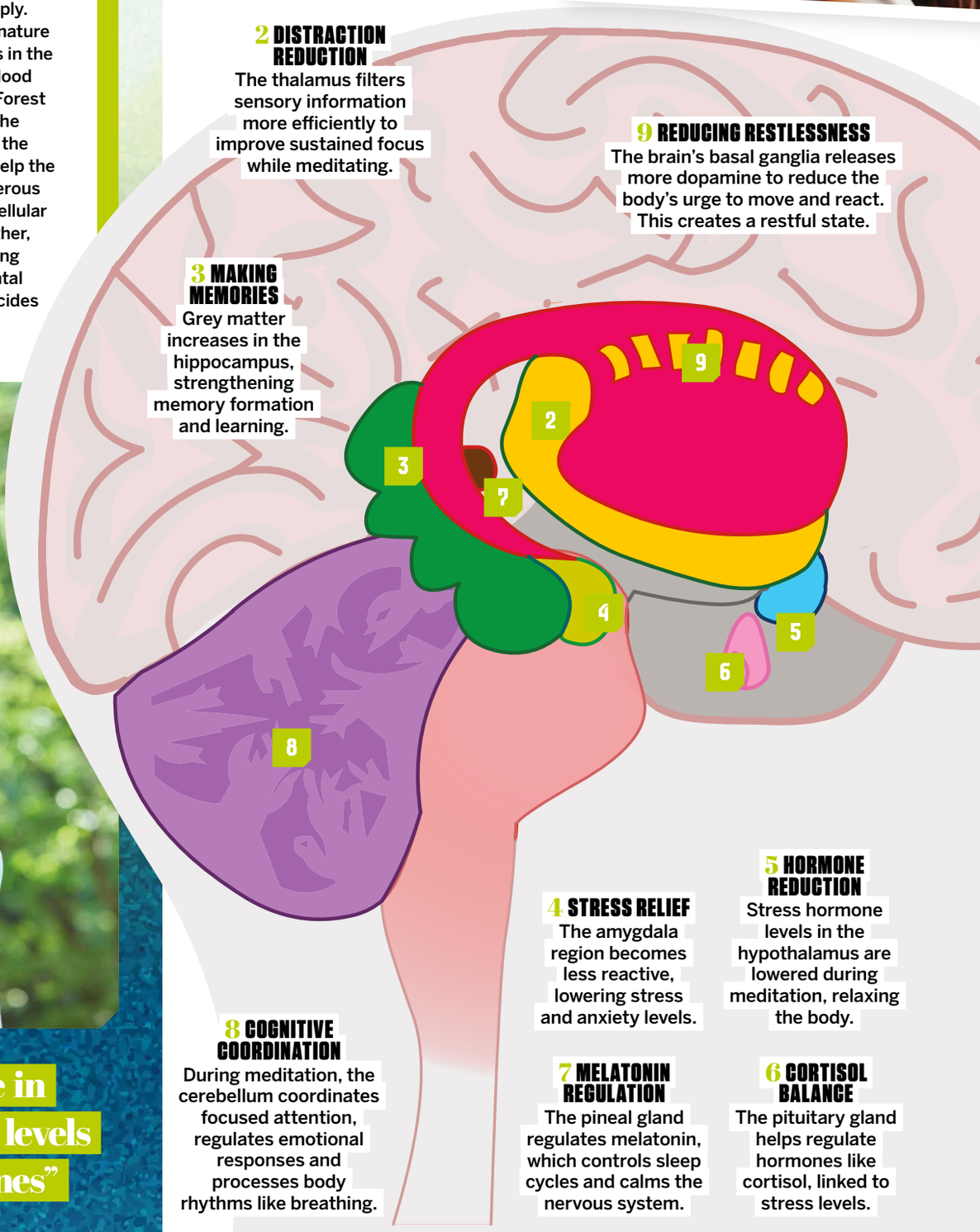
HEALTH

MEDITATION MINDFULNESS

It's more than just peaceful reflection – the inner calm and focus that come with meditation shape the brain in positive ways



Meditation can also be a group activity



2 DISTRACTION REDUCTION
The thalamus filters sensory information more efficiently to improve sustained focus while meditating.

9 REDUCING RESTLESSNESS
The brain's basal ganglia releases more dopamine to reduce the body's urge to move and react. This creates a restful state.

3 MAKING MEMORIES
Grey matter increases in the hippocampus, strengthening memory formation and learning.

4 STRESS RELIEF
The amygdala region becomes less reactive, lowering stress and anxiety levels.

5 HORMONE REDUCTION
Stress hormone levels in the hypothalamus are lowered during meditation, relaxing the body.

8 COGNITIVE COORDINATION
During meditation, the cerebellum coordinates focused attention, regulates emotional responses and processes body rhythms like breathing.

7 MELATONIN REGULATION
The pineal gland regulates melatonin, which controls sleep cycles and calms the nervous system.

6 CORTISOL BALANCE
The pituitary gland helps regulate hormones like cortisol, linked to stress levels.

DID YOU KNOW? A 2023 study found that habitual napping may help keep your brain bigger for longer

THE PERFECT POWER NAP

Are you a fan of breaking up your day with a nap? If so, you might be pleased to learn that power naps are a health-promoting, science-backed wellness habit. A power nap is different from long, daytime sleeps because they only last between 10 to 30 minutes. This enables the brain to rest without entering a deep sleep that will leave you groggy upon awakening. While napping, brain activity slows and stress hormones decrease. After waking from a short nap, a person is usually more alert, concentrated and has a better memory than before sleeping. A study carried out by NASA in 1995 found that napping for 26 minutes before a long-haul flight improved a pilot's performance by 34 per cent and increased their alertness by 54 per cent. Power naps are best taken after experiencing poor sleep the night before or when there's a natural dip in alertness levels in the middle of the day.



Napping for too long can disrupt your internal clock, making sleeping at night difficult

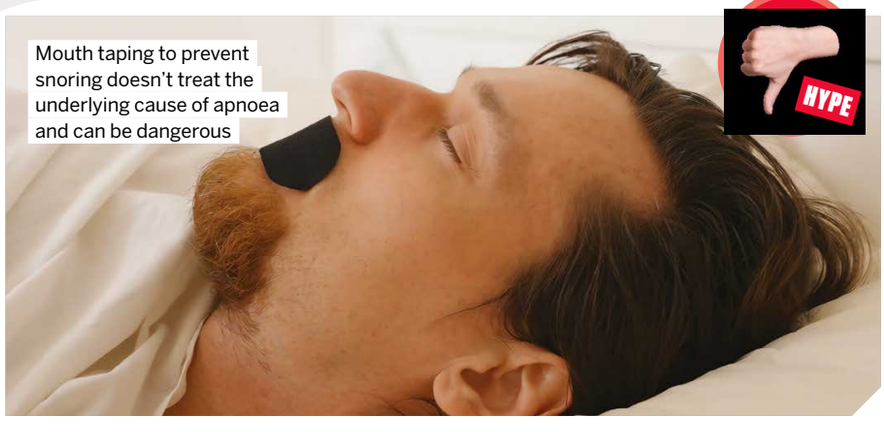
DID YOU KNOW?
It's easiest to nap between 14:00 and 16:00



1 ATTENTION SPAN
The cerebrum reinforces connections between brain regions to strengthen attention, improve self-awareness and regulate emotions.

MOUTH-TAPING TREND

Mouth-taping advocates claim that placing a strip of tape over your lips while sleeping improves sleep quality by forcing the body to breathe through the nose. The trend grew with theories that it prevents snoring and dry mouths, as well as improving your concentration during the day. The scientific evidence for these claims is limited, however. While nasal breathing does warm and humidify the incoming air, as well as serving as a filter for particles in the air, taping your mouth closed while sleeping doesn't remove the causes of mouth breathing. The result is that the body can't breathe through the mouth at night, while the nose remains congested or inflamed due to allergies. Breathing then becomes more difficult and dangerous, as airflow is restricted. Mouth taping shouldn't be viewed as a cheap 'biohack'. Instead, mouth breathers should consult a medical professional to diagnose the cause of their sleep breathing style.



Mouth taping to prevent snoring doesn't treat the underlying cause of apnoea and can be dangerous

5 FACTS BENEFITS OF A DIGITAL DETOX

1 LOWER STRESS
Reducing time on phones and social media can reduce anxiety and stress by preventing information overload and social comparison. The brain enters a calmer and less reactive state during time away from technology like tablets and smartphones.

2 ENHANCE SLEEP
It's best to avoid screen time before going to sleep. Exposure to blue light and mental stimulation can keep you awake for longer. Without screens, production of the hormone melatonin naturally rises to help the body fall asleep faster.

3 IMPROVE CONCENTRATION
Constant notifications and switching between smartphone apps break up your concentration. Without this technology, your brain can sustain longer periods of focus.

4 BOOST MOOD
When you remove yourself from online apps, you also remove social comparison and an overstimulated brain, improving your mood over time.

5 INCREASE PHYSICAL ACTIVITY
When you spend less time scrolling on your phone, you're more likely to spend time outdoors, walking or exercising.

© Shutterstock / AdobeStock

HOW RED LIGHT HELPS THE SKIN

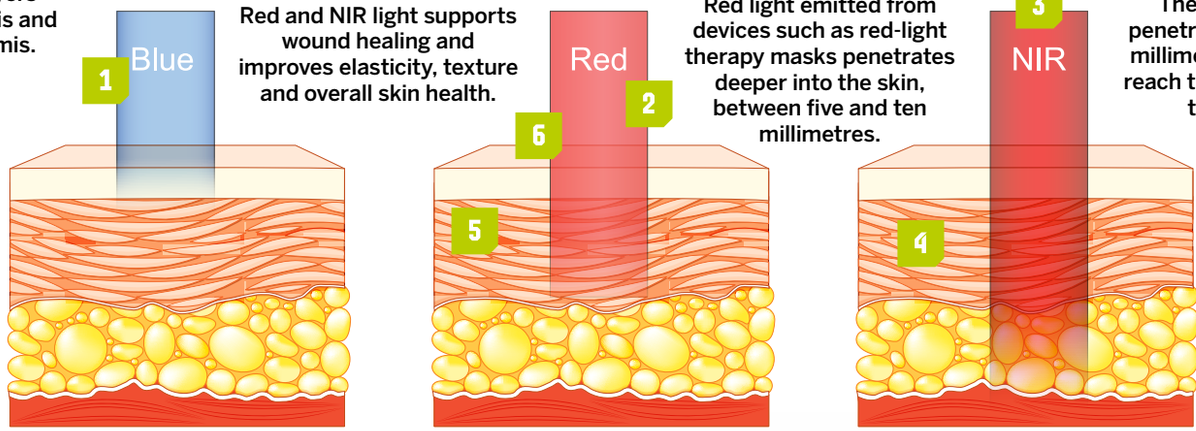
Red-light therapy exposes the body to low-level wavelengths of red and near-infrared light

1 BLUE LIGHT
Blue light only penetrates the skin superficially, reaching one to two millimetres into the skin's top layers – the epidermis and upper dermis.

6 SKIN CHANGES
Red and NIR light supports wound healing and improves elasticity, texture and overall skin health.

2 RED LIGHT
Red light emitted from devices such as red-light therapy masks penetrates deeper into the skin, between five and ten millimetres.

3 NEAR-INFRARED LIGHT
The NIR beam penetrates 20 to 50 millimetres and can reach tissue beneath the skin.



4 DERMIS
Red and NIR light stimulates collagen-making cells called fibroblasts in the dermis, leading to increased levels of collagen.

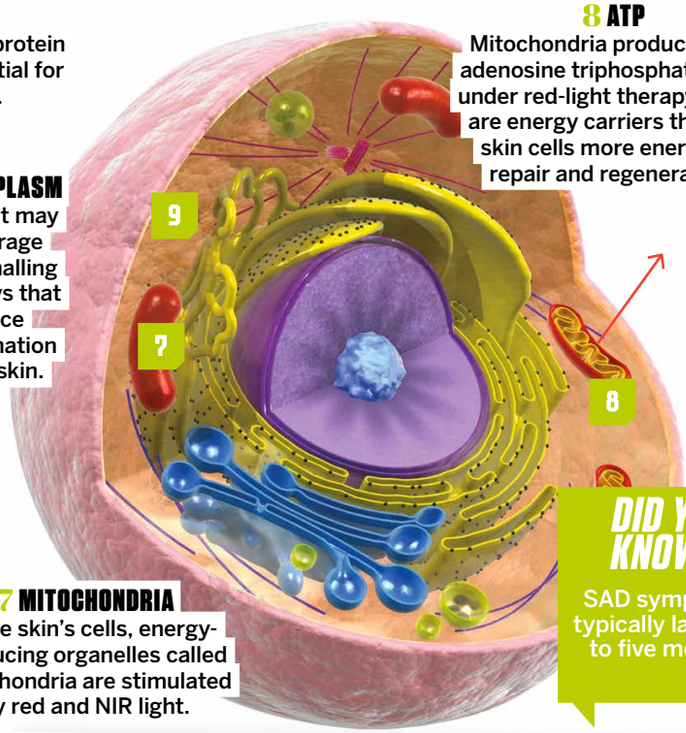
5 COLLAGEN
Collagen is the most abundant protein in the human body and is essential for supporting skin structure.

8 ATP
Mitochondria produce more adenosine triphosphate (ATP) under red-light therapy. These are energy carriers that give skin cells more energy for repair and regeneration.



Red-light therapy is good for your skin's health

9 CYTOPLASM
Red light may encourage cell signalling pathways that reduce inflammation in the skin.

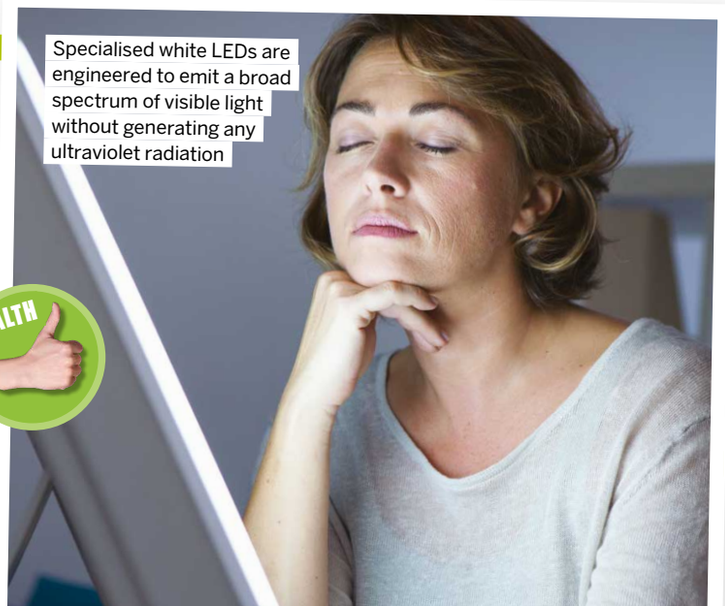


7 MITOCHONDRIA
In the skin's cells, energy-producing organelles called mitochondria are stimulated by red and NIR light.

DID YOU KNOW?
SAD symptoms typically last four to five months

WINTER WELLNESS: SAD LAMPS

Seasonal affective disorder (SAD) lamps work to prevent a type of depression triggered by the shorter days of the winter season. They emit a bright light of around 10,000 lux, which mimics natural daylight. The body's internal clock then suppresses melatonin production and regulates serotonin levels. Melatonin is released during darkness and brings about fatigue. This fatigue can be experienced during the day when the Sun sets earlier. Meanwhile, serotonin is a neurotransmitter that helps boost mood. The lamps alter the body's chemistry to lift spirits, raise energy levels and regulate sleep patterns. SAD lamps usually have the best effect when used for 20 to 30 minutes each morning.



Specialised white LEDs are engineered to emit a broad spectrum of visible light without generating any ultraviolet radiation

DID YOU KNOW? Red-light therapy originated as a NASA experiment on plant growth in space

ELECTROMAGNETIC FIELD MATS

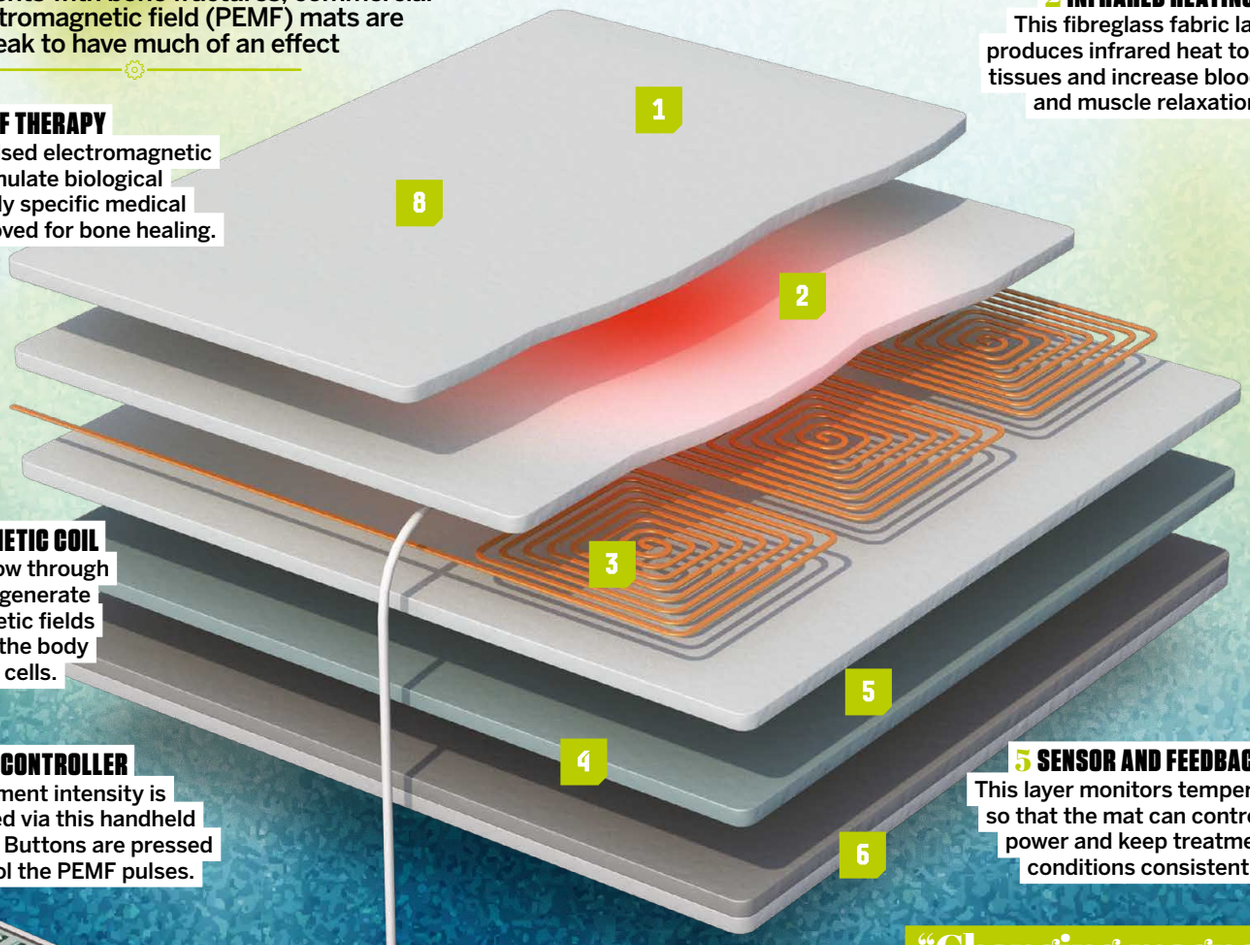


While medical-grade versions of these devices can treat patients with bone fractures, commercial pulsed electromagnetic field (PEMF) mats are too weak to have much of an effect

1 PROTECTIVE SURFACE
A cushioning fabric layer forms a comfortable, insulated surface between the user and the electronics beneath.

2 INFRARED HEATING
This fibreglass fabric layer produces infrared heat to warm tissues and increase blood flow and muscle relaxation.

8 PEMF THERAPY
The mat uses pulsed electromagnetic fields to stimulate biological processes. Only specific medical devices are approved for bone healing.



3 ELECTROMAGNETIC COIL
Electric pulses flow through copper coils to generate changing magnetic fields that penetrate the body to stimulate cells.

7 CONTROLLER
Treatment intensity is controlled via this handheld controller. Buttons are pressed to control the PEMF pulses.



4 THERMAL REGULATION
Heat-resistant foam and fabric insulate the heating and electromagnetic components to control the mat's temperature.

6 CONTROL AND POWER INTERFACE
The bottom layer supplies electrical power to the mat to enable the electromagnetic field to form.

5 SENSOR AND FEEDBACK
This layer monitors temperature so that the mat can control its power and keep treatment conditions consistent.

"Changing magnetic fields penetrate the body to stimulate cells"

BLUE-LIGHT GLASSES

Blue-light glasses are a type of eyewear marketed as a shield against eye strain and poor sleep. The lenses are meant to filter out blue wavelengths of light released from digital screens. Because of this, they've become popular among office workers who look at a computer screen all day. The theory is that blue light suppresses melatonin, the hormone that regulates sleep. Unfortunately, there's little evidence to show that blue-light glasses have much effect on sleep patterns. And those who wear them to prevent digital eye strain may only be making a difference to their appearance. Blue light is unlikely to cause eye strain, which is due to reduced blinking with prolonged screen use. No strong evidence exists to show that blue light causes eye damage. The use of blue-light glasses is unlikely to cause harm, but they may not be shielding you as much as you expect, or at all.



© Alamy / Shutterstock / Illustration by Adrian Mann

HEALTH HYPE

COLD PLUNGE THERAPY

Submerging your body in very cold water has health benefits, but comes with serious risk

1 VASOCONSTRICTION
The cold causes blood vessels near the skin to narrow, reducing heat loss and redirecting blood back to the body's core.

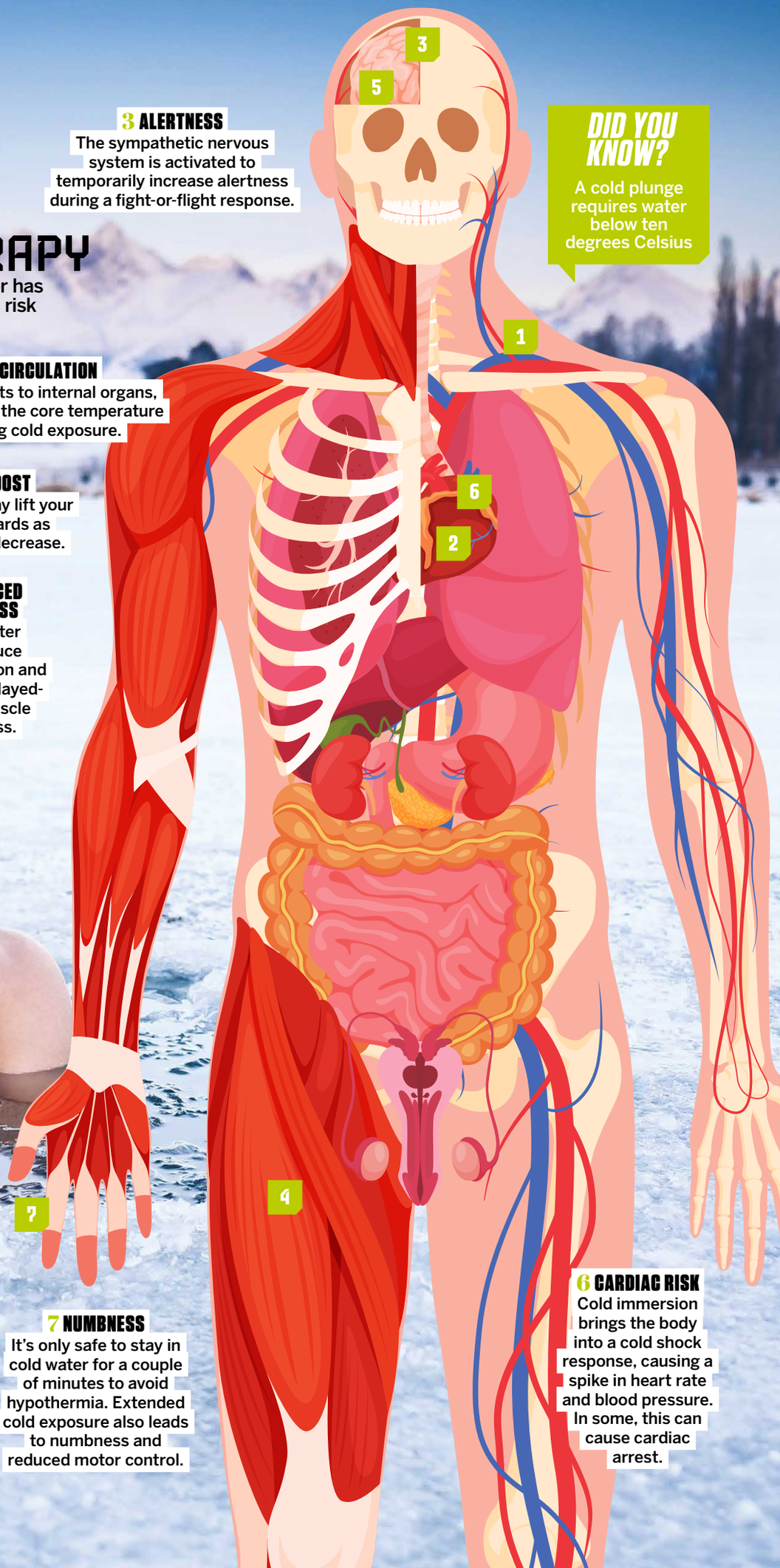
2 CIRCULATION
Blood shifts to internal organs, preserving the core temperature during cold exposure.

3 ALERTNESS
The sympathetic nervous system is activated to temporarily increase alertness during a fight-or-flight response.

5 MOOD BOOST
Cold plunges may lift your mood afterwards as cortisol levels decrease.

4 REDUCED SORENESS
Cold water can reduce inflammation and prevent delayed-onset muscle soreness.





DID YOU KNOW?
A cold plunge requires water below ten degrees Celsius

> "The cold causes blood vessels near the skin to narrow, reducing heat loss"

7 NUMBNESS
It's only safe to stay in cold water for a couple of minutes to avoid hypothermia. Extended cold exposure also leads to numbness and reduced motor control.

6 CARDIAC RISK
Cold immersion brings the body into a cold shock response, causing a spike in heart rate and blood pressure. In some, this can cause cardiac arrest.

DID YOU KNOW? Sitting for eight hours a day with no physical activity has a similar death risk to obesity and smoking



MEETINGS ON THE GO

In most office jobs, people stay seated for the majority of the day as they work on a computer. Sitting all day slows your metabolism, reduces your blood flow and weakens your muscles. So some people have incorporated standing and walking as much as possible during a working day. This includes taking meetings while walking and using standing desks to reduce time seated at a desk. Walking meetings help increase physical activity, boosting mood and energy levels. Some studies also suggest that walking meetings can increase creativity and idea generation in brainstorming tasks. Group walks can be useful for small meetings, but aren't practical for large team productivity. Research suggests that standing all day isn't healthy, but alternating between sitting and standing is the best way to stay healthy at work.

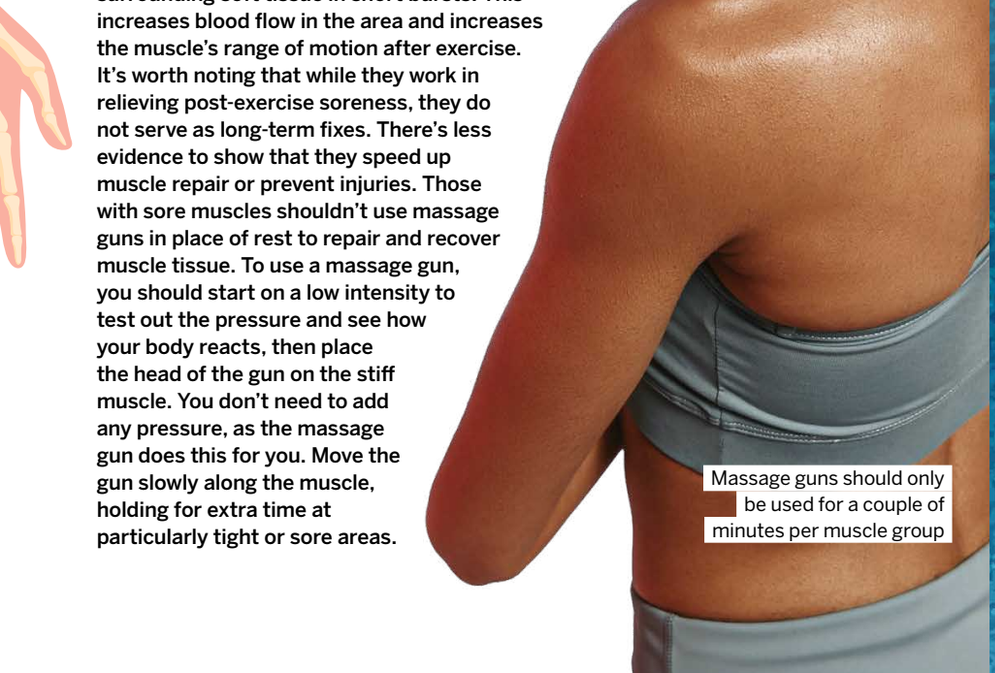


For virtual meetings, walking can take place at a desk treadmill



MUSCLE MASSAGE GUNS

Massage guns are proven to provide short-term relief and flexibility in tight muscles. The guns are handheld devices that use rapid percussive movements to apply pressure to muscles and surrounding soft tissue in short bursts. This increases blood flow in the area and increases the muscle's range of motion after exercise. It's worth noting that while they work in relieving post-exercise soreness, they do not serve as long-term fixes. There's less evidence to show that they speed up muscle repair or prevent injuries. Those with sore muscles shouldn't use massage guns in place of rest to repair and recover muscle tissue. To use a massage gun, you should start on a low intensity to test out the pressure and see how your body reacts, then place the head of the gun on the stiff muscle. You don't need to add any pressure, as the massage gun does this for you. Move the gun slowly along the muscle, holding for extra time at particularly tight or sore areas.

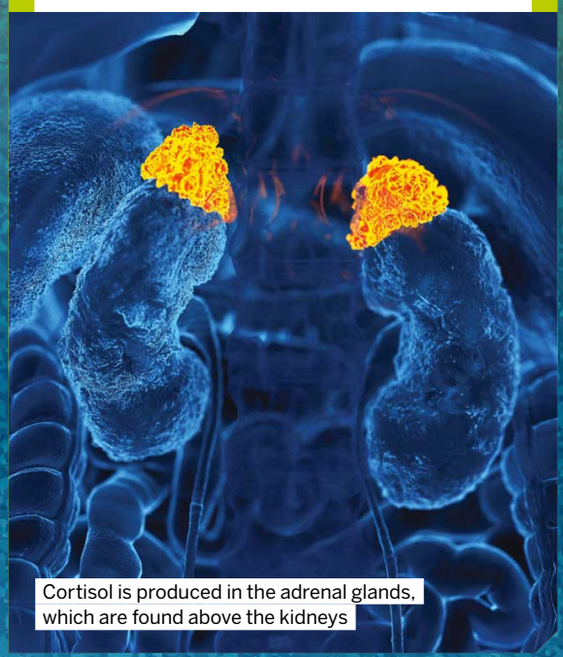


Massage guns should only be used for a couple of minutes per muscle group



BIOSYNCHING

Have you ever noticed a pattern in your daily energy levels? For example, you might feel alert in the mornings before your energy dips after lunch. Everyone has a 24-hour biological clock that helps them regulate alertness, body temperature, hormones and sleep. And some people have tapped into this natural daily rhythm to plan their exercise regimes, sleep and meal times. There's genuine science behind this health trend. Your body will have different abilities and energy levels at different times of the day. Cortisol levels, for example, are higher in the morning in most people. This is a hormone produced by the adrenal glands that makes the body more alert. Meanwhile, the hormone melatonin does the opposite and prepares the body for rest. Metabolic processes also follow a daily schedule, giving you varying energy levels throughout the day. The idea of biosynching as a wellness trend becomes less credible when specific timetables are advised. Everybody's circadian rhythm is unique to them, so you can only truly benefit when you listen to your body, and not a pre-planned schedule. If you're told to eat certain foods or exercise at specific hours of the day, this plan won't work for everyone. Your age, light exposure, sleep patterns, genetics and work schedule all influence your own personal circadian rhythm. And your natural rhythm can change depending on how well you sleep on a given night or when there's a change in your routine. So while biosynching is science-backed, you need to know your own circadian rhythm and be able to adapt with it to reap any benefit.



Cortisol is produced in the adrenal glands, which are found above the kidneys

© Shutterstock / Alamy / Getty

LIVING WITH BACTERIA

Your home is teeming with these tiny organisms, but which ones should you be wary of?

WORDS AILSA HARVEY

A typical house may look clean and spotless. But there are actually trillions of bacterial cells lining its surfaces, making up an invisible microbial community. Just by being present in a room, you add about 37 million bacteria to the air every hour. Bacteria spread around your home from your hands and breath, float through the air, live in the dust, lurk in the drains and cover every surface of your home. Bacteria are single-celled organisms and are the simplest forms of life on Earth. Yet they're some of the most significant. They're found almost everywhere on the planet, and around 43,000 species of bacteria have been discovered and named.

Your body consists of roughly as many bacteria cells as human cells, and as you navigate your home, you help distribute them around the rooms. Every time you touch a keyboard, sit on the sofa or open a door, you shed tiny flakes of skin, each carrying smaller microorganisms on them. Bacteria can also enter a home through open windows, on the soles of shoes and on animals. This means the bacterial composition in your home is always changing.

The majority of bacteria in the home are harmless to humans, but a small percentage can cause diseases. When you clean with antibiotic products, you remove some of the harmful cells from toilets, kitchens and other surfaces. However, it doesn't remove all bacteria. Instead, it kills some bacteria and leaves others behind, resulting in an ever-changing microbial community.

And the bacteria aren't just sitting still. Across your home, the different bacterial species are competing against each other for dominance. They battle to colonise surfaces and take up space and nutrients. So while you may think of your house as a private space for you and your family, you're far outnumbered by these tiny microbial invaders.

DID YOU KNOW? Reusable water bottles contain 40,000 times more bacteria than a toilet seat



DID YOU KNOW?

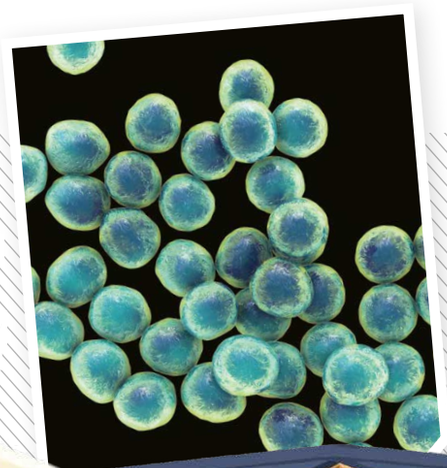
Bacteria with tails move 100 times their body length a second

© AdobeStock

HOME HOTSPOTS

Which types of bacteria lurk in the rooms of your house?

HELPFUL HARMLESS HARMFUL

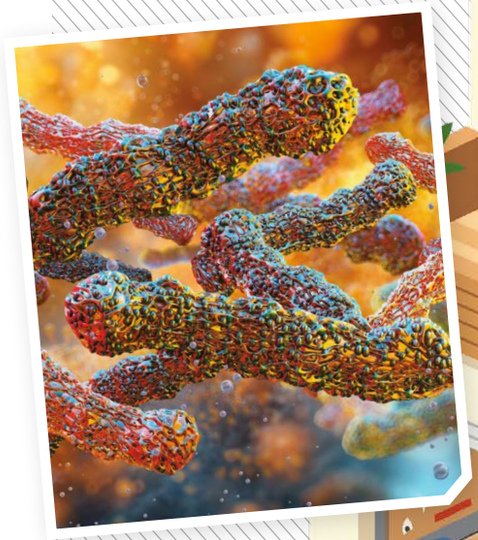


6 STAPHYLOCOCCUS

TV remotes are rarely cleaned but are regularly handled, harbouring *Staphylococcus* species. Many types live safely on your skin and in your nose.

5 BACILLUS SUBTILIS

Soil in houseplants is packed with bacteria. *B. subtilis* has spores that are extremely resistant to chemicals and harsh physical conditions. It isn't harmful to humans, however, and can improve gut health.







2 ESCHERICHIA COLI

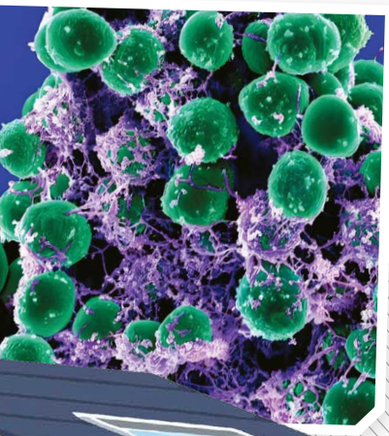
Studies show that *E. coli* is found in 15 per cent of homes, mostly in kitchen sinks. The bacterium comes from raw meat and unwashed hands.

4 LISTERIA MONOCYTOGENES

Refrigeration doesn't prevent the growth of this bacteria as it does most. Contaminated foods can spread this bacteria to other products in the fridge. It's particularly harmful to pregnant women and newborn babies.



DID YOU KNOW? 67 types of bacteria live on the drip trays of coffee machines



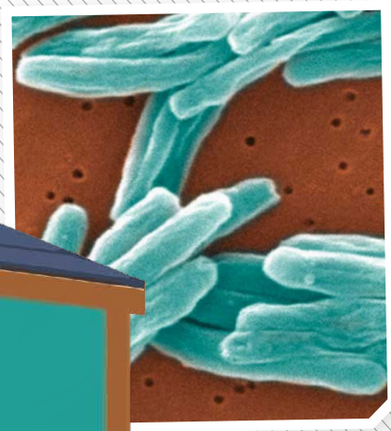
1 STAPHYLOCOCCUS EPIDERMIDIS

This common skin bacterium is continually shed in the home, including in your clothes and bedding. 10 to 25 per cent of airborne living room bacteria are *Staphylococcus epidermidis*.

DID YOU KNOW?

Bacteria are the oldest known life forms





3 MYCOBACTERIUM

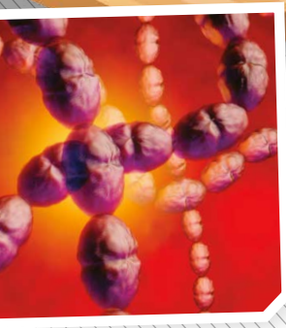
Mycobacterium are organisms that occur naturally in water systems and are resistant to some disinfectants. This bacteria can build up in shower heads, and in some people it can cause lung disease.

WHAT'S THE DIRTIEST SPOT?

It might look non-threatening, but the warm, soapy kitchen sponge could be the dirtiest thing in your home. Sponges are constantly getting warm and damp, with the porous structure making it an ideal environment for microbes to live and multiply. Additionally, the tiny food particles left in the sponge from washing dishes are an energy source for the microbes, sustaining them. Kitchen sponges can harbour billions of bacteria per square centimetre. These microbes come from food, hands and kitchen surfaces. Not all the microbes on sponges are harmful, but those such as *E.coli*, *Staphylococcus* and *Salmonella* can make you ill after you touch them and they enter your body. Another factor making sponges a bacteria hotspot is that they are difficult to clean thoroughly. Bacteria can spread deep into the sponge pores, so washing the sponge doesn't remove all of the lurking microbes.



A used sponge can contain 54 billion bacterial cells per cubic centimetre



7 STREPTOCOCCUS

Your toothbrush is teeming with hundreds of bacteria from your mouth. *Streptococcus* species are very common oral bacteria, with some fighting off germs in the mouth.



The average home collects 18 to 20 kilograms of dust in a year

LIVING DUST

Dust is a mix of solid particles from inside and outside your home, including dead skin, clothing fibres, soil and thousands of microbial species. Particles are brought into the house on people, pets, shoes and through open windows. Bacteria is abundant in dust, with common inhabitants including *Staphylococcus*, *Streptococcus* and *Corynebacterium*. These come from human skin, while other dust dwellers *Bacillus* and *Micrococcus* enter from the external environment. Bacteria are the dominant microbes in dust, but others include fungi like *Penicillium* and *Aspergillus*. Most of the microbes in dust are harmless, essential parts of the indoor microbiome. However, dust can contain allergens in the form of dust mites and fungal particles. Dusty homes therefore trigger allergic symptoms in some people, including sneezing, watery eyes and breathing difficulties.

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THE INVISIBLE PLUME

Bacteria are sprayed around your bathroom when you flush the toilet... gross

1 ESCHERICHIA COLI
E. coli is a bacterium that lives in the intestines and is shed in faeces. Some strains can cause diarrhoea and illness if ingested.

2 ENTEROCOCCUS FAECALIS
E. faecalis is found in the gut and can cause urinary tract infections. Studies show that 12 to 55 per cent of toothbrushes in bathrooms test positive for *E. faecalis*.

3 KLEBSIELLA PNEUMONIAE
K. pneumoniae is a bacterium found in some people's guts and respiratory tract without causing harm. In some cases, it can cause pneumonia when immune defences are low.

4 STAPHYLOCOCCUS AUREUS
S. aureus is carried on human skin and in noses. When touching toilet surfaces, this bacteria spreads. It can cause infection when it enters broken skin.



5 TOILET PLUME
Flushing an open toilet generates droplets of water and aerosols that carry bacteria and other microorganisms upwards into the air. These can linger in the air for many minutes.

6 AIRBORNE SPREAD
Some aerosolised particles travel beyond the toilet and land on nearby surfaces, such as the sink.

7 SURFACE SETTLEMENT
Bacteria from plumes can land on nearby surfaces within a two-metre radius of the toilet.

8 HAND TRANSFER
Touching contaminated toilet surfaces like the flush handle transfers bacteria to the hand to be spread elsewhere.

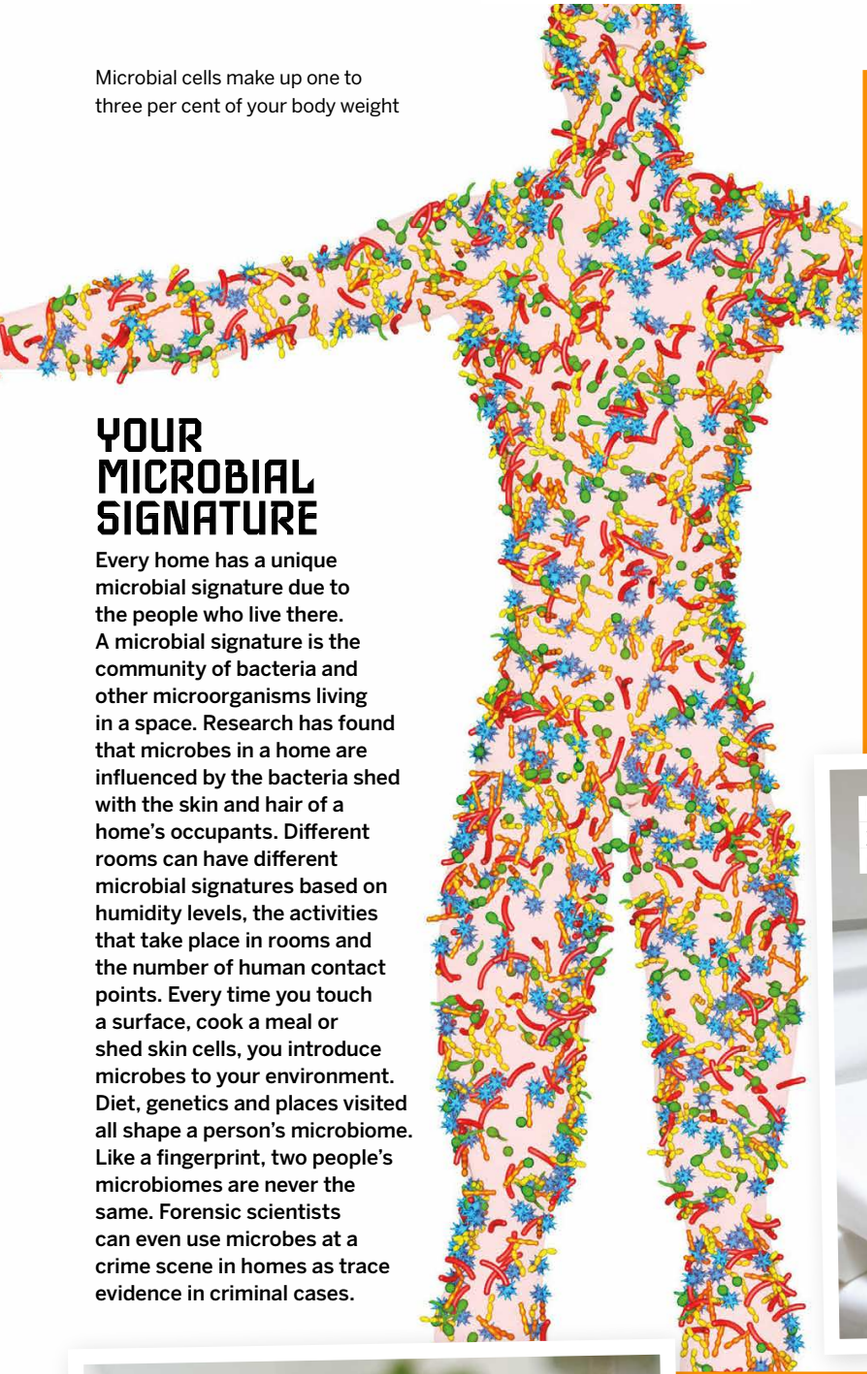
9 OPEN LID
When the lid stays open during flushing, there's a greater area for water droplets and aerosols to escape upwards and contaminate more surfaces.

10 CLOSED LID
Closing the lid of the toilet before flushing prevents the upward plume, limiting how much bacteria-containing aerosol escapes the bowl.

DID YOU KNOW?
Bacteria can reproduce within ten minutes of being 'born'

"Just by being present in a room, you add about 37 million bacteria to the air every hour"

DID YOU KNOW? Bacteria are aware of their surroundings and conserve energy when their species is low in numbers



Microbial cells make up one to three per cent of your body weight

YOUR MICROBIAL SIGNATURE

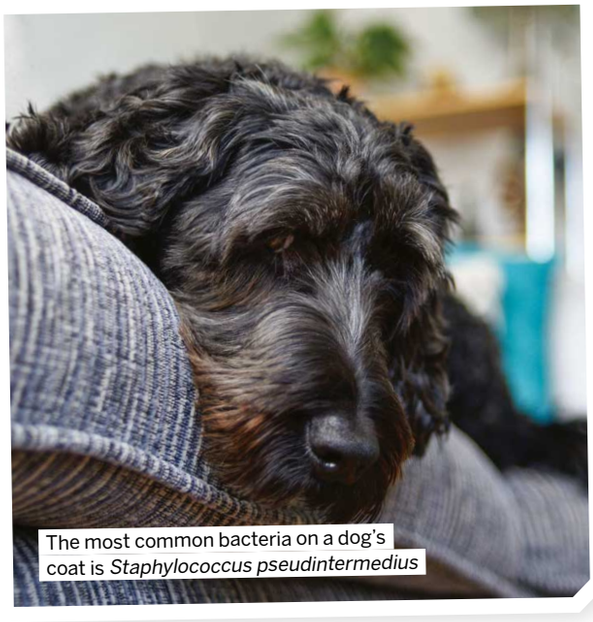
Every home has a unique microbial signature due to the people who live there. A microbial signature is the community of bacteria and other microorganisms living in a space. Research has found that microbes in a home are influenced by the bacteria shed with the skin and hair of a home's occupants. Different rooms can have different microbial signatures based on humidity levels, the activities that take place in rooms and the number of human contact points. Every time you touch a surface, cook a meal or shed skin cells, you introduce microbes to your environment. Diet, genetics and places visited all shape a person's microbiome. Like a fingerprint, two people's microbiomes are never the same. Forensic scientists can even use microbes at a crime scene in homes as trace evidence in criminal cases.

HOW TO PREVENT A HARMFUL HOME

Bacteria is meant to live in your home. But there are ways to prevent the bad types from thriving and causing you harm. The best way to do this is to reduce the harmful bacteria where they are most likely to accumulate. One of the simplest methods to protect your body from pathogens is to wash your hands with soap after using the toilet, handling raw meat and touching pets if you're about to prepare or eat food. When in the kitchen, keep raw meat separate from ready-to-eat items and regularly clean surfaces with antibacterial products. Sponges and dish cloths should frequently be replaced to prevent bacterial build-up on the damp materials. Bacteria thrive in moisture, so keeping your home's surfaces dry limits how much harmful bacteria can accumulate. Surfaces that are regularly handled, like door handles, toilet flushes and taps, should be cleaned more than other surfaces, especially when someone in the household is unwell. Devices such as air purifiers can filter out the majority of bacteria in the air, removing particles as small as 0.3 microns. Most bacteria are around 0.5 microns long, meaning these machines are effective at removing them.



It's recommended that you clean your toilet with antibacterial products at least once a week

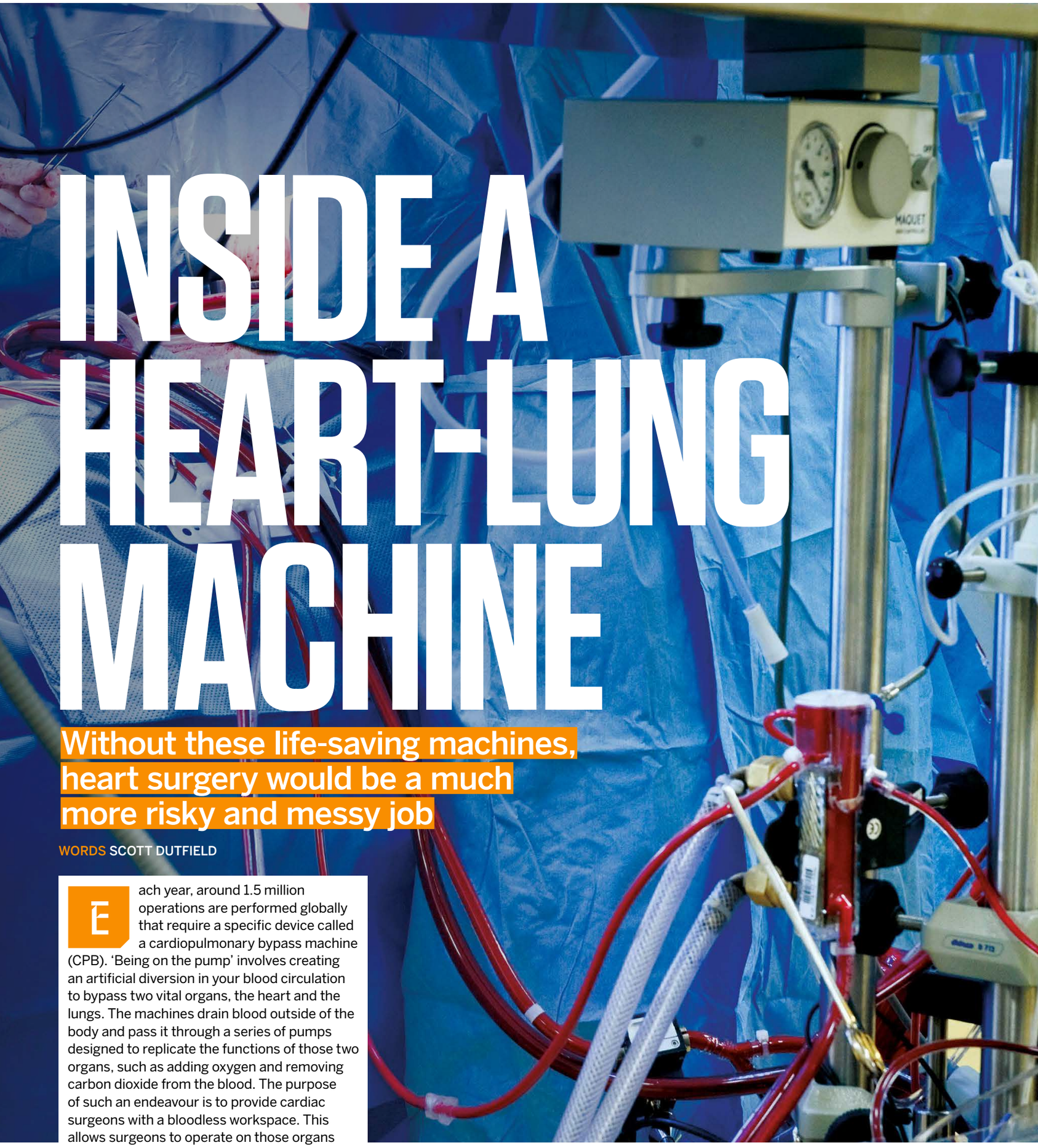


The most common bacteria on a dog's coat is *Staphylococcus pseudintermedius*

LOOK WHAT THE CAT DRAGGED IN

Pets leave more than fur and paw prints in their home. They also play a key role in influencing the types of bacteria you live with. Their fur, paws, skin and mouths carry bacteria and leave behind a changing collection of microorganisms. Dogs and cats, which spend time both outdoors and in the home, pick up microbes from soil, plants and other animals. They carry these bacteria on their fur and feet, spreading them throughout the house. Over time, this exchange of microbes reaches owners too, as they make contact with their pets and their home's surfaces. As a result, studies show that pet owners begin to share a gut microbiome with their pets. The result of owning pets means a more diverse bacterial community in the home. This can be both beneficial and harmful. Exposure to a broader range of microbes can lead to a more diverse microbiome, and as a result a lower risk of some allergies like asthma and eczema. However, pets can also introduce pathogens from outdoors or carried in their gut. Maintaining good hygiene in the home, especially around food and pet waste, can reduce the chance of getting ill from pet-borne bacteria.

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INSIDE A HEART-LUNG MACHINE

Without these life-saving machines, heart surgery would be a much more risky and messy job

WORDS SCOTT DUTFIELD

Each year, around 1.5 million operations are performed globally that require a specific device called a cardiopulmonary bypass machine (CPB). 'Being on the pump' involves creating an artificial diversion in your blood circulation to bypass two vital organs, the heart and the lungs. The machines drain blood outside of the body and pass it through a series of pumps designed to replicate the functions of those two organs, such as adding oxygen and removing carbon dioxide from the blood. The purpose of such an endeavour is to provide cardiac surgeons with a bloodless workspace. This allows surgeons to operate on those organs



without having to tackle a beating heart or inflating lungs, not to mention the up to six litres of blood that would otherwise move through the heart every minute.

To divert the flow of blood away from the heart and lungs, a series of pumps, cannulae and tubes is used. The 'CPB circuit' pumps blood from the heart via two cannulae, which are inserted into both the superior and inferior vena cava. The blood moves into a reservoir by the force of gravity and is pumped through devices called an oxygenator and a heat exchanger, which act as an artificial heart and lungs to exchange oxygen and carbon dioxide and regulate blood temperature.

To simulate the amazing abilities of these vital organs, a CPB uses millions of microscopic tubes that are semi-permeable. The deoxygenated blood, which would normally leave the heart and head to the lungs, is passed through the tubes. Fresh oxygen is passed into the tubes, which crosses the semi-permeable membrane into the blood. Through natural gas diffusion, the oxygen moves from areas of high concentration inside the tubes to areas of low concentration. The same is true for the high concentrations of carbon dioxide in the deoxygenated blood, which move into the area of low concentration inside the tubes. The treated blood is then pumped back into the body to complete its journey around it, delivering much-needed oxygen to organs.

Diverting blood outside the human body comes with some unsurprising challenges to overcome. For example, to prevent blood from excessively clotting when it comes into contact with artificial surfaces such as tubing, anticoagulants like heparin are used. Similarly, if any air bubbles find their way into the bloodstream, it can cause a gas embolism, blocking blood flow and starving vital organs of oxygen. Bubble detectors and filters are used to tackle any stray gas that finds its way into the system before the blood reenters the body. Overcoming these hurdles has made the CPB machine an indispensable tool in modern medicine. It facilitates complex surgeries such as heart valve repairs, unblocking coronary arteries and complete heart transplantations.

DID YOU KNOW?

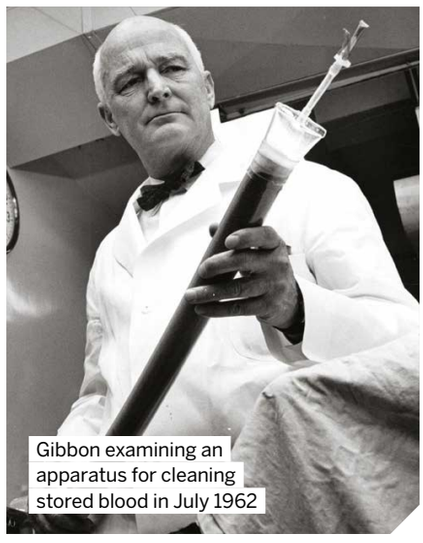
Red blood cells live for around 120 days in the bloodstream

ENTER ECMO

Extracorporeal membrane oxygenation (ECMO) is an advanced form of artificial life support that does a similar job to CPB, but for a longer period of time. A CPB machine is only designed for relatively short periods during open-heart surgery. However, ECMO is designed to help filter out carbon dioxide, insert oxygen and pump blood around the body for days, weeks or months. This is a closed circuit that doesn't require a blood reservoir like a CPB. There are two types: venoarterial (VA) and venovenous (VV). A VA ECMO pumps blood through the entire body to support the heart and lungs, while a VV EMCO only supports the lungs and relies on the heart to pump blood around the body.



The oxygenator of an ECMO in a critical care unit



Gibbon examining an apparatus for cleaning stored blood in July 1962

FROM TRAGEDY TO TRIUMPH

After watching a patient experience a massive pulmonary embolism in 1931, Dr John H. Gibbon sought to make a change that would revolutionise the surgical field forever. During the surgery, the patient was treated with an 'off-pump' surgical embolectomy, but ultimately died. While contemplating what could have been done differently, Gibbon wrote that "the idea naturally occurred to me that if it were possible to continuously remove some of the blue blood ... put oxygen into that blood ... and then continuously inject the now-red blood back into the patient's arteries, we might have saved her life." With this in mind, he spent the next 23 years developing what would eventually become the world's first heart-lung machine. In 1953, Gibbon became the first surgeon to perform an open cardiotomy (surgical incision into the heart muscle) while the patient, an 18-year-old female, was on bypass. The patient survived and made a full recovery.

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120.4 MILLION
Global blood donations are more than double the UK's population

42 DAYS
Red blood cells in blood packs last for over a month

1.5 TO 2 MILLION
The number of cardiac surgeries performed each year

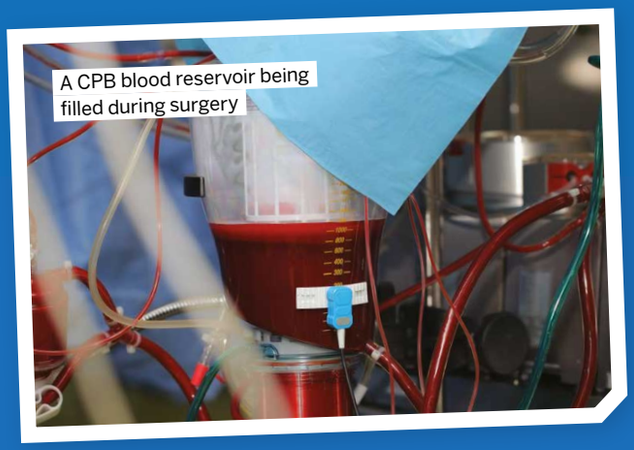
THE US CARRIES OUT THE MOST CARDIAC OPERATIONS IN THE WORLD

80%
The majority of blood transfusions in hospitals occur during cardiac surgery

12,000
There's around one cardiac surgeon for every 660,000 people on Earth

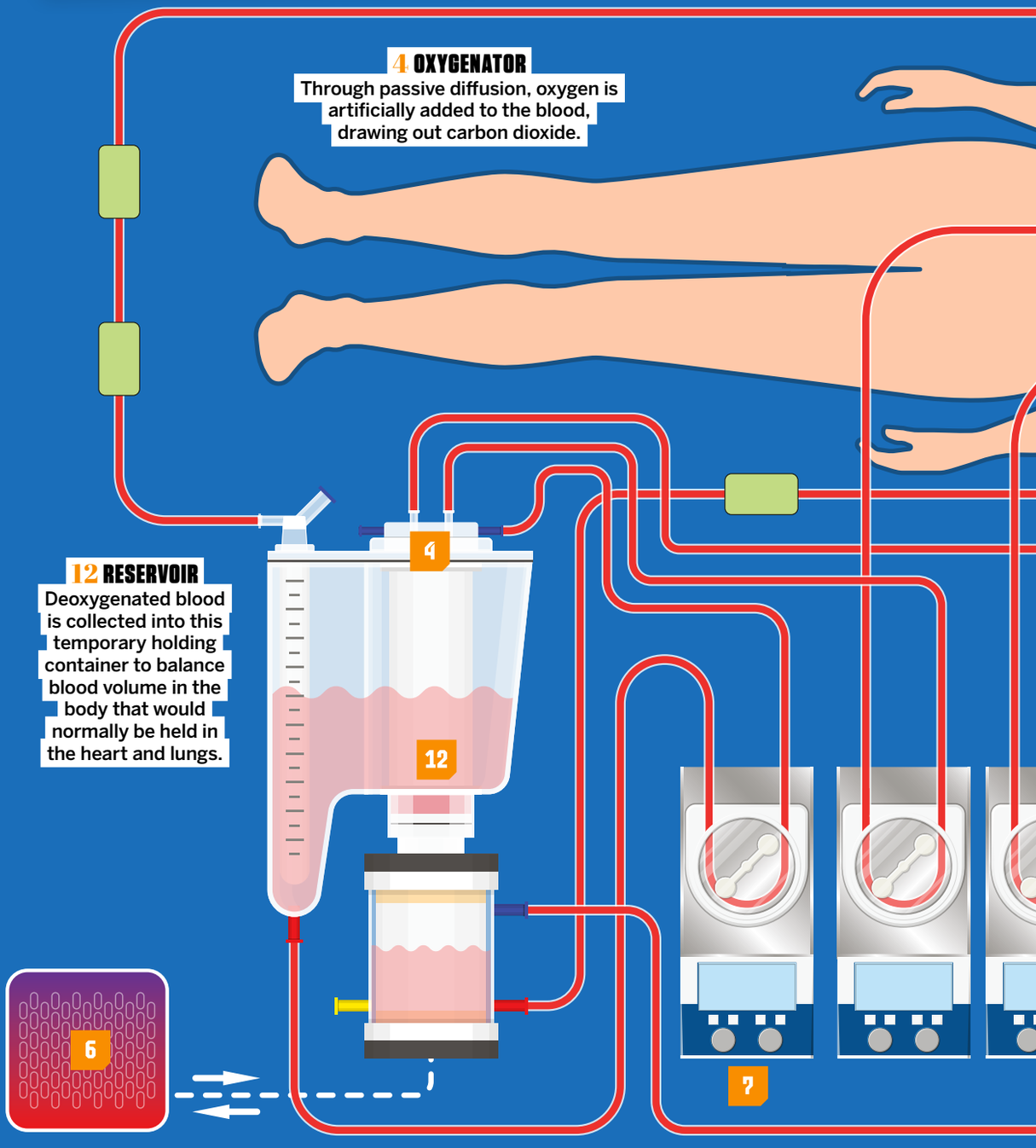
5,000
There are around 1,000 more heart transplants than lung transplants performed globally each year

HIGH-INCOME NATIONS COLLECT OVER ONE-THIRD OF GLOBAL BLOOD SUPPLIES


A CPB blood reservoir being filled during surgery

ARTIFICIAL ARTERIES

The pumps, membranes and tubes that form a fake circulatory system

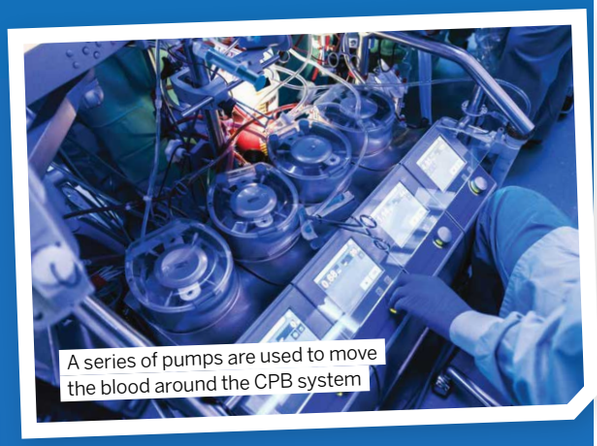


6 TEMPERATURE CONTROL
Integrated into the oxygenator is a heat exchanger, which often uses water and metal plates to regulate blood temperature below 37 degrees Celsius.

7 ARTERIAL PUMP
This pump is responsible for pumping the blood through the circulatory system.

8 VENTING PUMP
The job of this pump is to remove blood and air from the heart's chambers.

DID YOU KNOW? It takes four to six hours for surgeons to perform a heart transplant



A series of pumps are used to move the blood around the CPB system

1 VENOUS RETURN CATHETER
This tubing drains deoxygenated blood from the patient's venous system (to the heart).

2 ARTERIAL CANNULA
Returns oxygenated and temperature-regulated blood back into the patient's arterial system (away from the heart).

3 SUCTION DEVICE
Blood is suctioned away from the surgical field to maintain visibility during the operation.

9 MONITORING SYSTEM
Metrics such as blood pressure, oxygen saturation and blood volume are continually monitored.

10 ARTERIAL FILTER
Removes microemboli such as solid debris, cholesterol crystals or gas bubbles to prevent them from re-entering the body.

11 BUBBLE DETECTOR
Using sound waves, these sensors are able to detect the presence of any air bubbles in the blood.

5 CARDIOPLEGIA
Surgeons use a chemical solution, often high in potassium, to relax the heart muscles and temporarily stop it from beating.

DID YOU KNOW?
The body makes around 2 million red blood cells every second

PROFESSOR STEPHEN CLARK

As a consultant cardiothoracic and transplant surgeon at Freeman Hospital, Clark sheds some light on the challenges of bypass surgery



© NEWCASTLE HOSPITALS NHS

What are the biggest challenges of using a CPB?
The sort of issues from a surgeon's perspective are firstly establishing bypass in the first place. We have to cannulate the heart in order to connect it to the bypass machine. As we operate on an increasingly ageing population, sometimes people have a lot of calcification in their arteries or they've had previous cardiac surgery, which can make it difficult for the surgeon to establish bypass safely and not end up inadvertently displacing bits of calcium into the circulation, which could give the patient a stroke. We're very careful and mindful of where we cannulate. The next thing would be the complications of being on bypass for a long time. As we are doing bigger, more complex operations than we did in the past, that comes with needing to be on the bypass machine for longer than was normal. Although bypass machines are really good at what they do, they also come with their complications. The longer you're on the bypass machine, the higher your risk of bleeding after the operation and the greater the risk of things like brain injury, lung inflammation, kidney problems and liver problems. One of the big challenges in heart surgery is trying to keep that time on the bypass machine to an absolute minimum to avoid all of those systemic complications that you get from being on the heart-lung machine.

How does controlled hypothermia protect organ tissue during bypass?
The metabolic rate of your tissues, no matter what tissue it is, reduces the colder you are. It means that if you have periods where there's low profusion, your tissues are much more able to be protected from that. The brain would be the key thing. For most bypass operations, we cool the patients down just slightly, down to, say, 32 or 34 degrees Celsius compared to 37 in normal life. For some surgeries, we'll cool the patients down to 18 degrees Celsius, and we can actually switch the circulation off completely, drain the entire patient's blood volume into the bypass machine, hold it and operate on a cold, bloodless person. But you're limited by time. You've got maybe half an hour or 45 minutes in that circumstance.

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12 AMAZING SCIENTIFIC DISCOVERIES

Some were accidental and some are silly, but these breakthroughs have advanced science in their field



SCAN REVEALS A SPATULA LEFT INSIDE A MUMMY

1 Somewhere in the Egyptian afterlife, one embalmer is feeling pretty silly. In 2014, scientists at the British Museum in London found the 2,600-year-old brain-scooping spatula they left behind inside someone's skull. In preparation for a new exhibition, the museum ran the mummy of an unknown man through a computerised tomography (CT) scanner and discovered the spatula, highlighted in green on the scan shown here. It would have been used to help extract the brain through the nose when the body was preserved in Thebes in around 600 BCE.



A ZEBRA'S STRIPES HELP KEEP THE FLIES AWAY

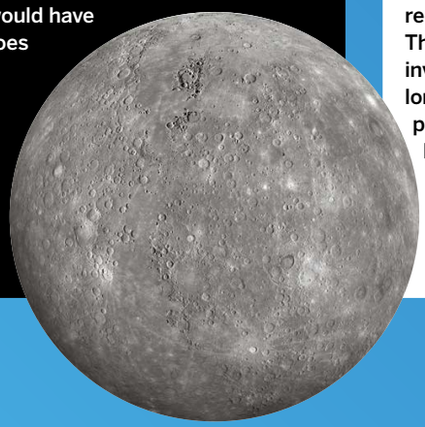
2 A Kalahari folk tale holds that the zebra got its stripes by running through a fire after fighting with a baboon over a water hole, scorching itself. What the tale fails to mention is flies. A team from the University of California, Davis, mapped horse-related species across the world and recorded how stripy they are. The researchers also looked at local predators, habitats, weather and parasites, coming to the conclusion that zebras are stripiest in areas where flies are most likely to bite. Specifically, the stripiest zebras come from areas in which conditions are right for horseflies to breed for consecutive months. Why the flies avoid striped surfaces remains unknown, however.

30 SECONDS

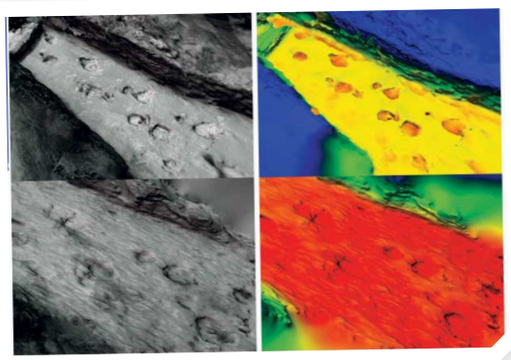
3 How long it would take to recharge a mobile phone with a new nanotech battery. StoreDot developed the tech after a team at Israel's Tel Aviv University noticed that 2.1-nanometre crystals of amino acids can store charges.

DID MERCURY MIGRATE TO ITS CURRENT LOCATION?

4 Could Mercury have moved through the Solar System? Scientists from Brown University in Rhode Island analysed scans of the planet from NASA's MESSENGER probe and discovered a volcanic past. Volcanic activity suggests there were volatile elements in Mercury's crust, but if it had formed as close to the Sun as it is now, these would have boiled off before volcanoes would have had time to form. The evidence of volcanicity has led to the hypothesis that Mercury might have formed further away and travelled to its current position.



DINOSAUR CHASE DIGITALLY RECREATED



5 A dinosaur hunt that took place 112 million years ago was reconstructed by scientists. The chase, thought to involve six to nine-metre-long predators – was preserved as footprints in Dinosaur Valley State Park in Texas. But after being excavated, the prints were removed, divided into blocks and distributed around the world. Now, using photos taken when the tracks were discovered, scientists at the Royal Veterinary College in London have reconstructed the site using photogrammetry, where digital photos are used to generate a 3D model.

© 2014 Falkingham et al

DID YOU KNOW? The recently discovered 'bone collector' caterpillar uses the bones of its prey to hide from predators

FOSSILISED ORGAN SYSTEM

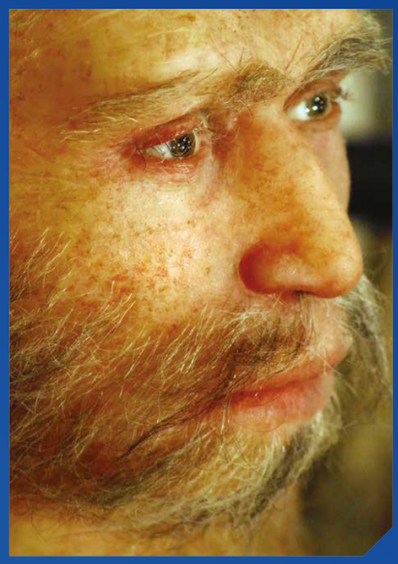
6 Palaeontologists from London's Natural History Museum discovered a 520-million-year-old arthropod fossil in China with the earliest known cardiovascular system. It dates from the Cambrian period, a time of rapid evolution that saw many familiar animal structures appear. Soft internal tissues don't often fossilise, so the find sheds new light on the evolution of animal bodies.



© CC WIKI xiquinhosilva

EUROPEANS ARE CLOSEST TO THE NEANDERTHALS

7 Scientists at the University of Edinburgh confirmed a close link between Neanderthals and modern humans. The former spread out from Africa 200,000 years earlier than modern humans, who interbred with established Neanderthal populations upon reaching Europe and Asia. Because of this, humans there carry traces of Neanderthal DNA not found in Africans.



2.4 METRES

8 This is how far viruses can travel when we sneeze. Researchers at the Massachusetts Institute of Technology studied the spray of droplets released in a sneeze and discovered they carried much further than expected.



© ROBOTICS SURGICAL

A ROBOSNAKE TO SLITHER DOWN YOUR THROAT

9 Called the Flex Robotic System, this robotic snake is a surgical endoscope with a high-definition camera and arms to manipulate tools and tissue. Based on research conducted at Carnegie Mellon University in Pennsylvania, it has since been used to assist in throat surgery. It can use specially designed surgical instruments to perform procedures. Surgeons use a joystick to steer the snake inside the body.

ASTEROIDS' DUST EXPLAINED

10 Cycles of heating and cooling turn the surfaces of small asteroids to dust, according to a study by a NASA-led international team of researchers. As they orbit the Sun, asteroids are warmed and cooled, producing heat stress and causing asteroids to crack up. The distinctive accumulation of dust and small particles, known as regolith, was thought to be caused by impacts, but the research showed that heat stress had the same effect in one year as impacts had over millions.



FOUR METRES

11 How tall a cherry tree grew in four years from a pit that was taken on a return trip to the International Space Station. The seed was planted in Japan and surprised scientists by growing four metres in just four years before producing buds – something that usually takes ten years. The pit was one of 265 that were blasted into space in 2008, returning to Earth the following year.



SYNTHETIC YEAST DNA CREATED

12 The first-ever synthetic chromosome has been created for yeast, replacing one of the cell's 16 pieces of genetic information. The human-made information has passed a significant test, as the yeast cell went on to reproduce. The work, carried out at New York University, has led to synthetic forms of the organism being manufactured that can produce vaccines and biofuels.

© Shutterstock

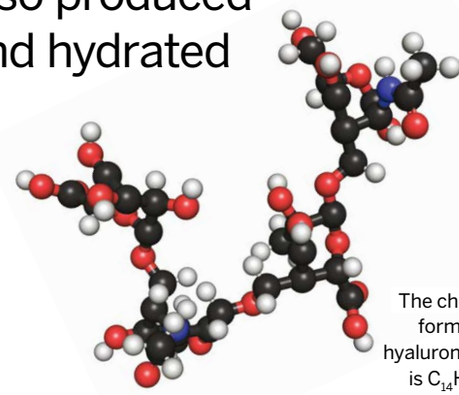
WHAT IS HYALURONIC ACID?

It's a skincare favourite, but hyaluronic acid is also produced naturally in your body to keep tissues healthy and hydrated

WORDS AILSA HARVEY

Hyaluronic acid sounds like a harsh, corrosive substance. However, it's proof that acids come in varying strengths. Despite being chemically weak, it holds great power in biological health as a natural moisture-binding humectant in the body. A humectant is a moisture-attracting substance, and hyaluronic acid uses this property to hydrate and lubricate the body's cells. The acid is produced mainly in the skin, joints and eyes and is a carbohydrate molecule made up of a chain of repeating sugar molecules – D-glucuronic acid and N-acetyl-D-glucosamine. Each long molecule acts like a sponge that attracts and latches onto water molecules, forming a gel-like consistency.

The body continually produces and breaks down hyaluronic acid, but its production slows with age. Other factors, such as exposure to ultraviolet radiation, can also cause the acid to break down more quickly. The result is that tissues lose moisture, deep wrinkles appear and joints become stiffer. To combat this, many healthcare and skincare products contain hyaluronic acid. It's produced commercially using bacterial fermentation.



The chemical formula for hyaluronic acid is $C_{14}H_{21}NO_{11}$

SKINCARE POPULARITY

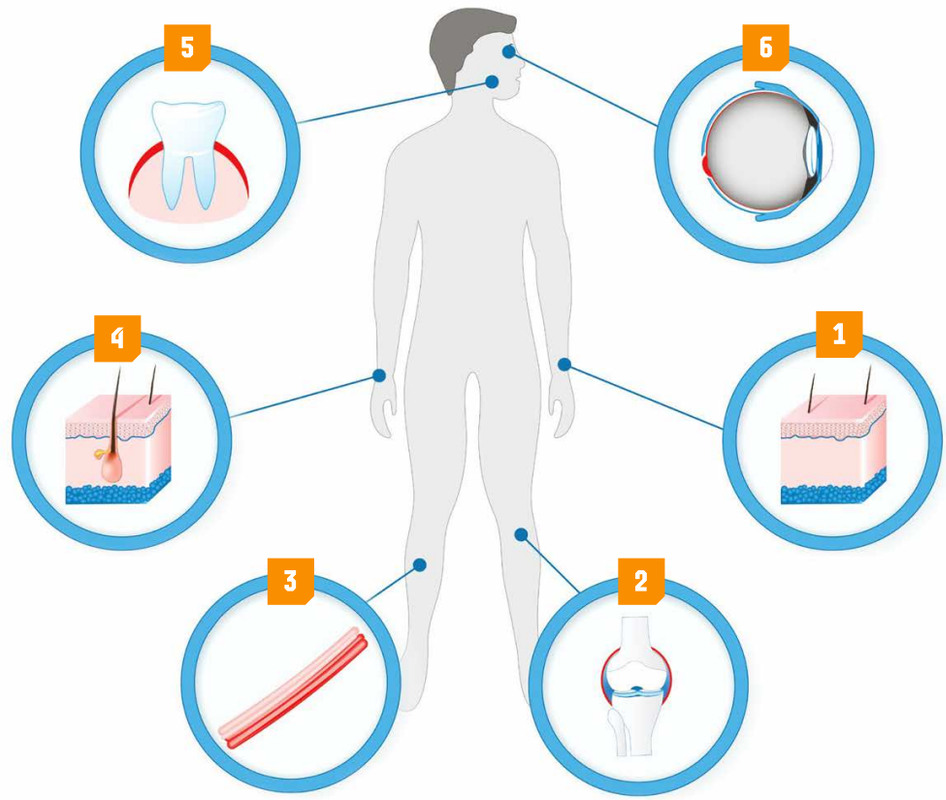
Hyaluronic acid has become one of the most common skincare ingredients due to its ability to hold water, hydrating and plumping the skin. Well-hydrated skin keeps the body smooth and can help soften the appearance of wrinkles. Additionally, when the skin is hydrated, the cells are plump and the skin serves as a stronger protective barrier for the body. As it's naturally produced in the body, the acid can be used on most skin types without causing irritation. Being lightweight, the ingredient generally doesn't clog pores or feel heavy on the skin after applying.



Hyaluronic acid is found in hydrating face serums, moisturisers and sheet masks

ACID ANATOMY

Hyaluronic acid plays essential roles from head to toe



1 SKIN HYDRATION

Hyaluronic acid attracts and retains water, keeping skin hydrated and cushioned to prevent damage.

2 JOINT MOVEMENT

The acid forms part of the synovial fluid, used to lubricate skeletal joints and prevent friction.

3 CONNECTIVE TISSUE STRUCTURE

Hyaluronic acid binds water together to make connective tissue flexible and strong.

4 HAIR HYDRATION

The scalp is hydrated by hyaluronic acid, increasing hair growth and tissue repair.

5 HEALTHY GUMS

It's naturally present in gum tissue, improving hydration and gum healing.

6 EYE CUSHIONING

The acid helps the eyes' gel-like substance, called vitreous, keep its shape.

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GIANT OIL SUPERTANKERS

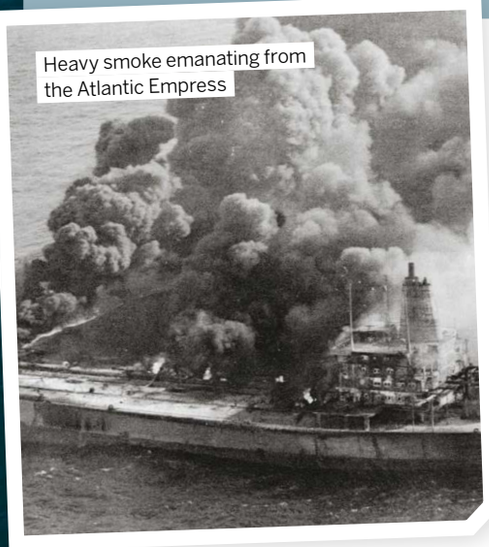
How millions of barrels of crude oil are ferried across the ocean

WORDS SCOTT DUTFIELD

Crude oil has long been a hot commodity and has been exported thousands of miles around the world. But how does it get from drill sites to the petrol pump? Since 1878, enormous tankers have ferried barrels of this 'black gold', initially in wooden barrels. Early sailing boats and barges paved the way for the colossal ships we now use to transport millions of barrels of raw, unrefined crude oil across the ocean in steel drums. Aptly named 'very large crude carriers' (VLCCs) or 'ultra-large crude carriers' (ULCCs), they're tasked with transporting hundreds of thousands of tonnes of oil in a single journey.

What separates a 'very large' and 'ultra-large' carrier is the amount of oil it can carry, otherwise known as its deadweight. VLCCs typically carry up to 2 million barrels of oil, or around 290 tonnes, whereas a ULCC can ferry more than 3 million barrels. The oil is pumped through a network of pipelines built into the vessel and then stored in tanks for transportation.

The first ULCC to ferry oil across the world was the Universe Ireland, a massive supertanker that could carry a deadweight tonnage – the total weight of the ship, its cargo and crew – of up to 312,000 tonnes. The Universe Ireland debuted in 1968, having been built in Yokohama in Japan. At the time, this vessel was the largest ship in the world, and was used to carry crude oil from Kuwait to Ireland. Universe Ireland was scrapped in 1984, but gave rise to the next generation of ULCCs.

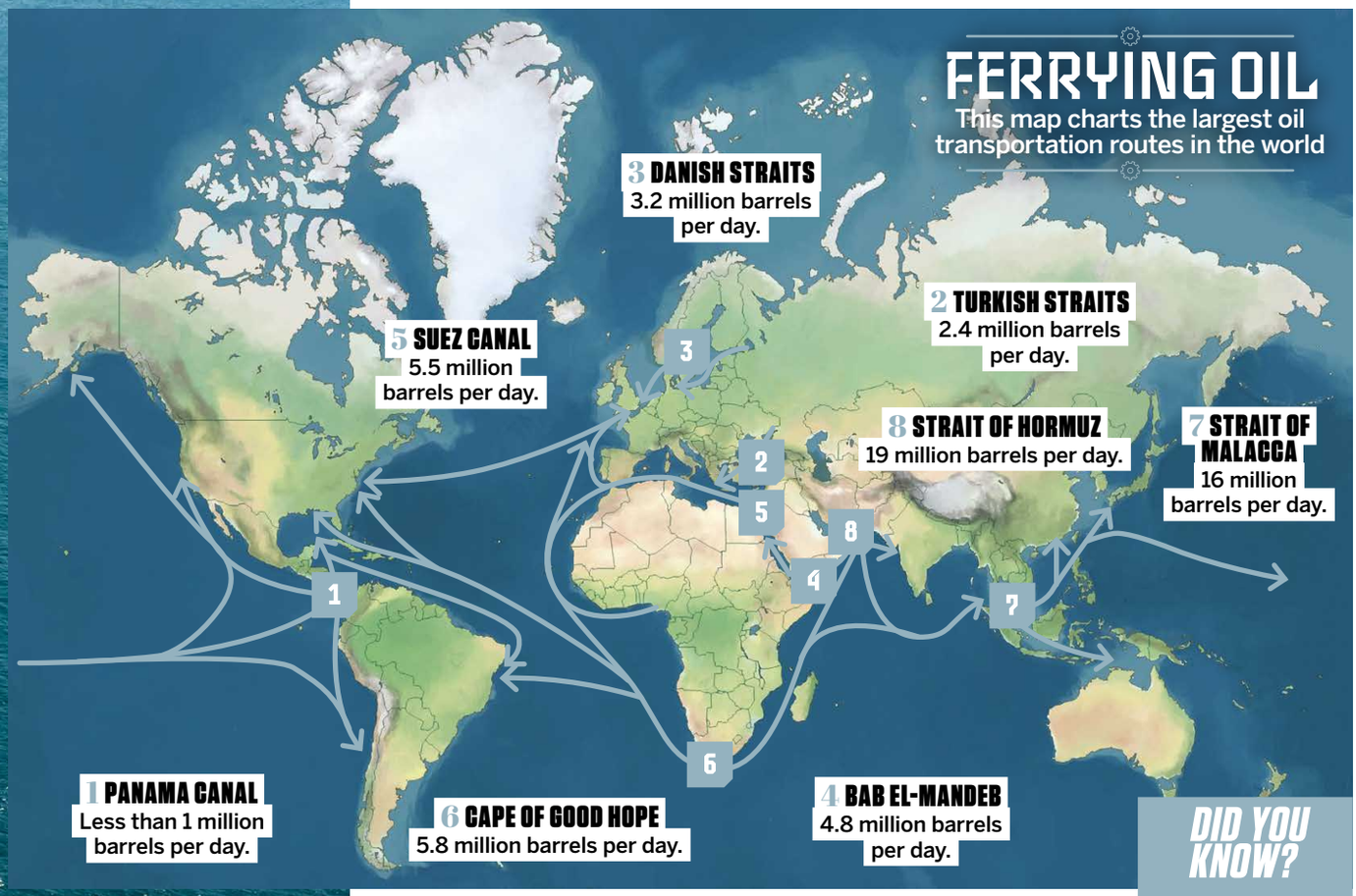


Heavy smoke emanating from the Atlantic Empress

TRAGIC SPILLS

Carrying millions of barrels of crude oil around the world hasn't always gone to plan for some tankers. On 19 July 1979, two VLCCs, the Atlantic Empress and Aegean Captain, were sailing off the Caribbean island of Tobago when tragedy struck. The giant oil tankers collided during a tropical rainstorm that impeded their vision. While the crew aboard Aegean Captain was able to evacuate, the catastrophic collision cost 26 of the 42 Atlantic Empress crew members their lives. Both ships were carrying hundreds of thousands of tonnes of oil and, following the impact, around 287,000 tonnes of oil was spilled into the ocean, making it the largest oil spill from a ship ever recorded. Ignited by the crash, the spilling oil set the Empress ablaze. The vessel was towed around 300 miles offshore before an explosion caused it to sink on 2 August.

DID YOU KNOW? The US produces around 13.58 million barrels of crude oil per day



DID YOU KNOW?

It takes millions of years to form crude oil

MEET THE TITANS

Leading the pack of modern-day supertankers, the TI-class ULCCs are operated by an international crude oil consortium called Tanker International. There are four TI-class vessels: Oceania, Europe, Asia and Africa, each built by South Korean shipbuilder Daewoo Shipbuilding & Marine Engineering. These oil tankers are the largest in the world, transporting more than 3 million barrels of crude oil per journey. However, due to their size, some routes are off limits. At around 68 metres wide, these vessels are too wide for some passages, such as the Panama Canal's locks. Two in the fleet, TI Africa and TI Asia, are out of the freight game. The pair are currently acting as floating storage and offloading vessels, holding processed crude oil for nearby production platforms. Unlike many of their supertanker predecessors, these vessels sported an all-white paint job. This wasn't done for aesthetic purposes, but rather as an exercise in thermodynamics. The highly reflective white paint minimised the solar radiation absorbed by the hull, keeping the cargo cool and reducing oil evaporation in the holding tanks.

TI EUROPE

GROSS TONNAGE	234,006
LENGTH	380 metres
BREADTH	68 metres
DEADWEIGHT TONNAGE	441,561
ELEPHANT EQUIVALENT	88,000



© Shutterstock

"They're tasked with transporting hundreds of thousands of tonnes of oil in a single journey"

OIL TANKER ANATOMY

Inside the belly of these ocean behemoths

1 BRIDGE
As the ship's brain centre, the bridge is the home of communications, navigation and engine control.

2 FUEL TANK
Separate from the crude oil tanks, fuel such as heavy fuel oil or marine gas oil is used to power the ship's engines.

3 ENGINE ROOM
To propel a massive VLCC or ULCC, equally massive diesel engines, typically with six or seven cylinders, are used. These have an output of 38,000 horsepower, enough to power around 20,000 homes.

4 PUMP ROOM
Heavy-duty cargo pumps used to transfer crude oil around the vessel are housed in this room.

6 BALLAST TANK
This is the seawater-filled tank that's used to adjust the balance of the ship.

DULL-HULLED GIANT

Before the late 1990s, the world's supertankers were built with a single hull. The exterior of these massive vessels only had one layer of steel separating the ocean from the crude oil cargo within. Should the single layer be punctured or struck, the oil could immediately pour into the surrounding water. For that reason, the International Maritime Organization changed global regulations to phase out single-hulled oil tankers by 2010. This made way for double-hulled supertankers such as Xin Lian Yang. The Chinese-built VLCC first set sail in 2014 and boasted a massive double hull that spanned the cargo-carrying length. Between the inner and outer hulls, ships like Xin Lian Yang use segregated ballast tanks filled with seawater to keep the ship weighted and stable while sailing. Double-hulled tankers aren't immune to spilling oil if the collision is big enough. For example, in 2009, the Norwegian crude oil tanker SKS Satilla collided with a submerged oil rig in the Gulf of Mexico, tearing a hole into the side of the ship. Luckily, none of its 150-million-litre crude oil cargo spilt into the ocean.

XIN LIAN YANG

- GROSS TONNAGE 234,006
- LENGTH 333 meters
- BREADTH 60 metres
- DEADWEIGHT TONNAGE 322,861
- ELEPHANT EQUIVALENT 65,000

TWIN-POWERED SUPERTANKERS

Between 1976 and 1979, four 'Batillus-class' supertankers were built in France: Batillus, Bellamya, Pierre Guillaumat and Prairial. These supertankers could hold between 3 and 4 million barrels of crude oil. At the start of their oil-hauling days, Batillus was making four trips from the Persian Gulf to Northern Europe a year, later reduced to just single or twice yearly trips at the end of its life on the water. Unlike other ULCCs throughout history, these giants were equipped with two separate propulsion shafts, propellers and boilers, known as screws, as opposed to just one. This made them less fuel efficient as they incurred more frictional resistance while they moved through the water. However, it meant that in the event one of the two boilers broke down, the vessels could still sail using the other.

BATILLUS

- GROSS TONNAGE 275,268
- LENGTH 414.2 metres
- BREADTH 63 metres
- DEADWEIGHT TONNAGE 553,662
- ELEPHANT EQUIVALENT 111,000





DID YOU KNOW? Venezuela has around 303 billion barrels of crude oil reserve, the largest in the world

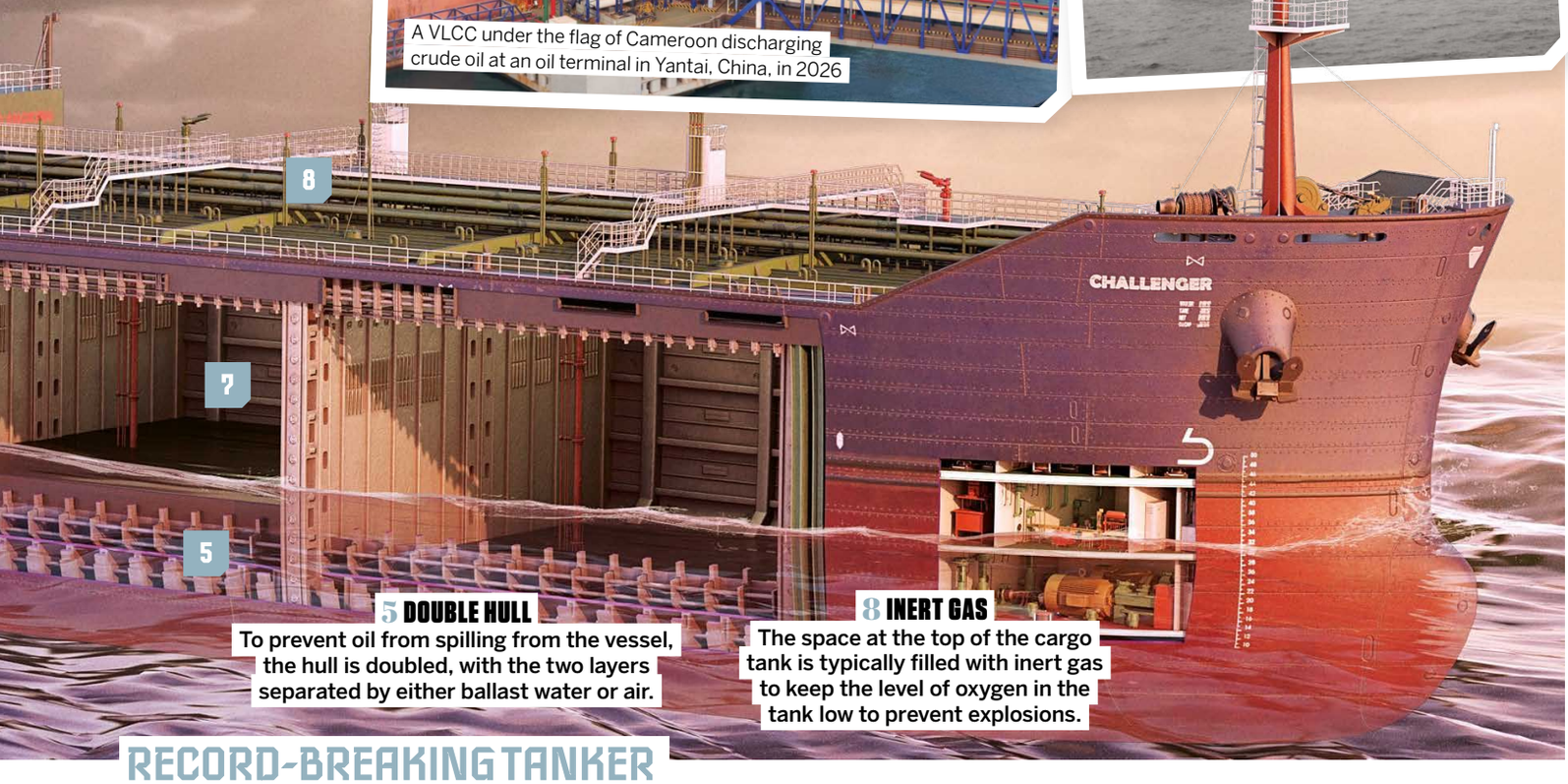
7 CARGO TANKS
Huge steel tanks take up the majority of the length of the oil tanker. These can be as tall as a ten-storey building.



A VLCC under the flag of Cameroon discharging crude oil at an oil terminal in Yantai, China, in 2026



Universe Ireland arriving at Bantry Bay, Ireland, in 1968



5 DOUBLE HULL
To prevent oil from spilling from the vessel, the hull is doubled, with the two layers separated by either ballast water or air.

8 INERT GAS
The space at the top of the cargo tank is typically filled with inert gas to keep the level of oxygen in the tank low to prevent explosions.

RECORD-BREAKING TANKER

Before the TI class ruled crude oil freight, there was a supertanker so big that it still holds the record as the largest oil tanker in history. Called the Seawise Giant, the Japanese-built ULCC was constructed in 1979 and retired in 2009. The vessel spent a brief time on the seabed during the Iran-Iraq War in 1988. After an Iraqi Air Force missile attack, the burning Seawise Giant sank near Larak Island, off the coast of Iran. Like a watery phoenix, however, after the war the wreckage was recovered by Norwegian company Norman International, which repaired the vessel to reenter service. The behemoth measured 485.45 metres long and could carry nearly 4.1 million barrels of oil. Too large for the Suez Canal, Panama Canal or the Strait of Kaletan, Seawise Giant sailed primarily around the Persian Gulf and Southeast Asia.

SEAWISE GIANT

GROSS TONNAGE
260,941

LENGTH
485.45 metres

BREADTH
68.6 metres

DEADWEIGHT TONNAGE
564,763

ELEPHANT EQUIVALENT
113,000



DID YOU KNOW?
A standard barrel of crude oil is around 159 litres

© Alamy / Getty / Shutterstock / Illustration by Nicholas Forder

REAL-LIFE BATMOBILE

This futuristic concept car could be something a certain Gotham billionaire drives at night



HIGH-TECH HELMET
As if the FFZERO1 didn't look and feel enough like a spaceship, it also comes with a helmet that supplies water and oxygen to the driver.

AIR CONDUITS
Aero tunnels run through the car, allowing air to flow through it rather than around it, reducing drag while cooling batteries.

QUAD-CORE MOTORS
While production models will only have one to three motors, the FFZERO1 has four – one by each wheel – giving it more than 1,000 horsepower and speeds of 200 miles per hour.



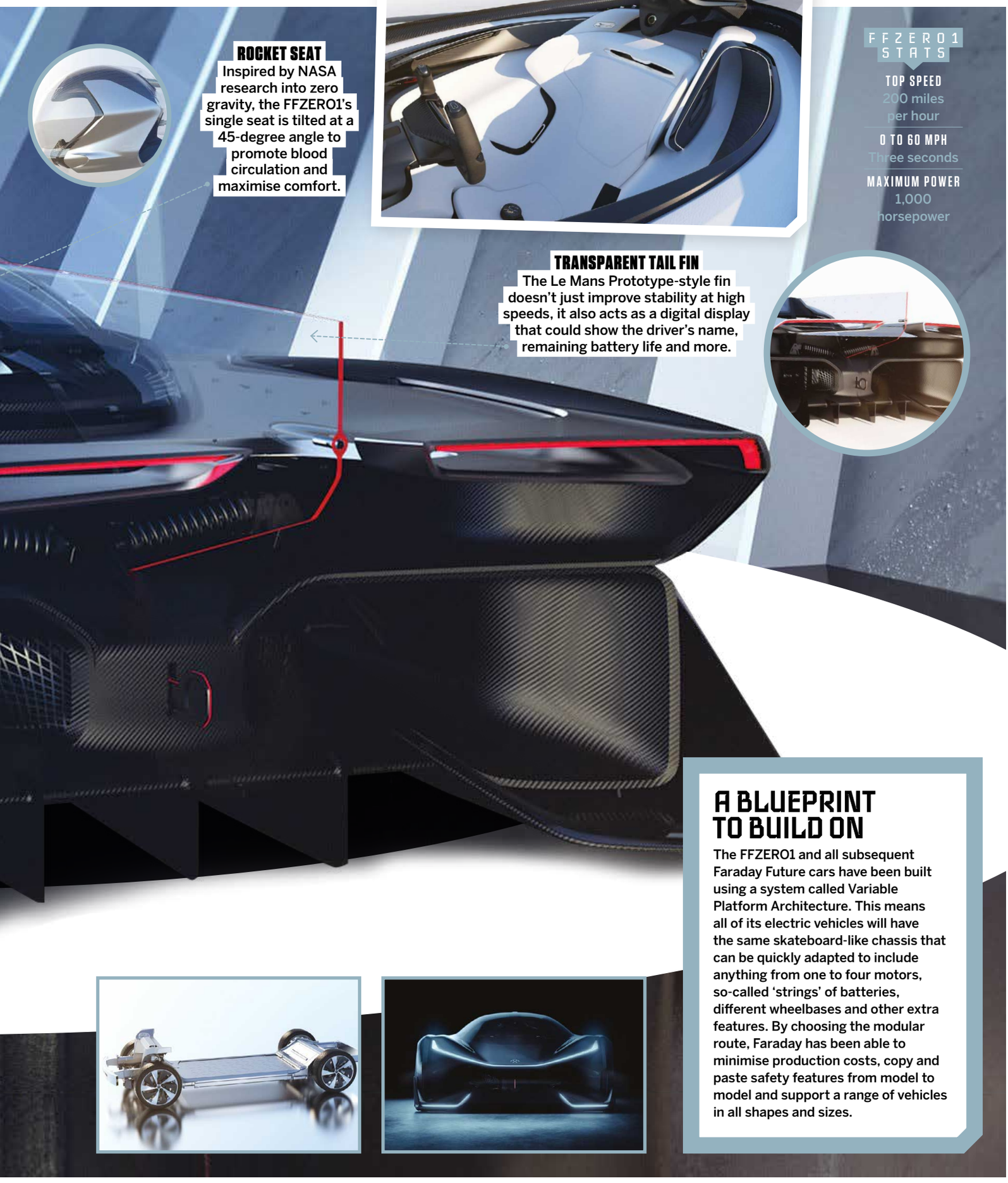
Looking like something out of *Batman* or *Speed Racer*, Faraday Future's 200-mile-per-hour electric hypercar wants to redefine what a car should be. Never heard of Faraday Future? That's not surprising, it's been eclipsed by Tesla ever since it sprang up in Silicon Valley in 2014, promising to revolutionise the motor industry. Just 18 months later, the company poached a huge contingent of Tesla's staff, broke ground on a billion-dollar factory outside Las Vegas and unveiled the FFZERO1.

Described by the company as a 'car of concepts', the FFZERO1 is a self-driving racing car with 1,000 horsepower, which you can also control with your smartphone. With only a single seat and the need to wear a specialist helmet, Faraday Future's subsequent mass-produced models don't look much like it – at least on the outside. Under the chassis, however, every Faraday Future car has the same modular architecture as the FFZERO1. This, the company says, is what makes them so easy to build, and it makes them confident that many more models like the FFZERO1 will be on the streets in the future.

SMARTPHONE CONTROLS
The car is autonomous, but it comes with the option to slot your smartphone into the steering wheel. You can then use this as an interface to further control the car.



DID YOU KNOW? Car customiser George Barris adapted the original 1966 Batmobile from a Lincoln Futura concept car



ROCKET SEAT
Inspired by NASA research into zero gravity, the FFZERO1's single seat is tilted at a 45-degree angle to promote blood circulation and maximise comfort.

TRANSPARENT TAIL FIN
The Le Mans Prototype-style fin doesn't just improve stability at high speeds, it also acts as a digital display that could show the driver's name, remaining battery life and more.

FFZERO1 STATS

TOP SPEED
200 miles per hour

0 TO 60 MPH
Three seconds

MAXIMUM POWER
1,000 horsepower

A BLUEPRINT TO BUILD ON

The FFZERO1 and all subsequent Faraday Future cars have been built using a system called Variable Platform Architecture. This means all of its electric vehicles will have the same skateboard-like chassis that can be quickly adapted to include anything from one to four motors, so-called 'strings' of batteries, different wheelbases and other extra features. By choosing the modular route, Faraday has been able to minimise production costs, copy and paste safety features from model to model and support a range of vehicles in all shapes and sizes.

© Faraday Future

WHAT IF... HUMANS NEVER DISCOVERED FIRE?

Our journey to the modern day would look very different if we didn't learn to harness this hot, bright plasma

WORDS **SCOTT DUTFIELD**



THE EXPERT



Dr Herman Pontzer is a professor of evolutionary anthropology and global health at Duke University and the author of *Burn: The Misunderstood Science of Metabolism*

© Riley MacLean

Where would we be without fire? While prehistoric humans were figuring out how to stand up straight, some curious cavemen decided to tackle the task of harnessing the power of fire. And thank goodness they did. Without a doubt, the discovery and subsequent ability to contain the power of flames in prehistoric pits and hearths propelled human evolution at rocket speed. "It would be hard to find another single discovery or invention that had that kind of impact," says Pontzer.

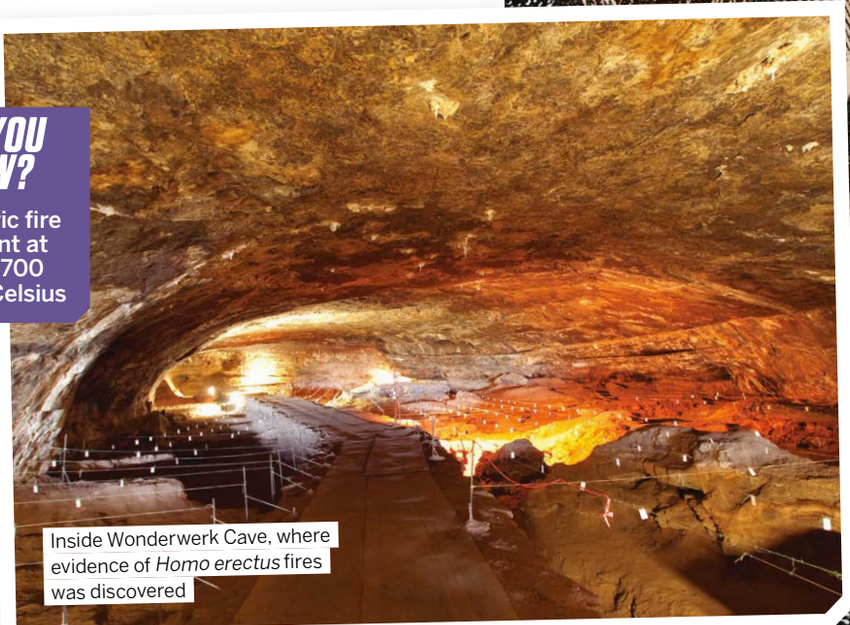
How our ancestors came to uncover the scorching nature of fire may have come from watching the world burn around them. "It's a big mystery. All you can say is that wildfires happen. It's not uncommon in Africa or Asia or the parts of the world where we think our ancestors come from," says Pontzer. "The most plausible scenario is that an ancestral species of human was just not afraid of fire and was curious about it. That kind of fits with an overall behavioural pattern you see in humans. We're very neophilic; we like new things."

Pontzer suggests early humans may have stumbled across prey that had been caught in the fire and incidentally cooked, feasted on their charred flesh and preferred the flavour. "I mean, a good sear on a steak... come on." From there, humans may have started to harness fire by 'borrowing' it from wildfires, keeping them fuelled all the time and then eventually learning how to make them themselves, but "exactly how that happened, I don't think we know".

What we do know is that humans have been cooking on open fires for more than a million years. However, it wasn't *Homo sapiens* that were first, but our ancestors, *Homo erectus*.

DID YOU KNOW?

Prehistoric fire pits burnt at around 700 degrees Celsius



Inside Wonderwerk Cave, where evidence of *Homo erectus* fires was discovered

DID YOU KNOW? *Homo erectus* is the longest-surviving human species to ever exist, surviving for more than 1.5 million years

HOW MUCH TIME WOULD YOU HAVE LEFT?

Without fire, our daily diet would be completely different, and it would take a whole lot longer to eat. With only raw fruits, seeds and fibrous meat to chow down on, you'd have to survive on a diet similar to a modern-day chimpanzee.

A 2012 study suggested that humans would have to spend more than nine hours a day eating unprocessed raw food to support our large brains. According to the study, our brains consume 20 per cent of our body's energy while resting, compared to the around nine per cent spent by other primates. That's because we have around 86 billion neurons in our brains compared to the 28 billion neurons in chimpanzees' heads. With all that time needed to fuel our minds, how much time would you have left over to complete all the other things on your to-do list?



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REALITY LAB



Wildfires likely introduced early humans to the concept of fire

Although the exact point humans started using fire is widely debated, a recent piece of research published in June 2026 suggests *Homo erectus* may have been cooking in a cave in South Africa. The study, published in the journal *PLOS One*, suggests that Wonderwerk Cave in South Africa's Northern Cape province, a known site for prehistoric fire use, housed burnt animal bones dating back to between 1.07 and 1.79 million years ago.

If *Homo erectus* were already capable of cooking, "*Homo sapiens* would have evolved with fire in our toolkit," says Pontzer. But what if *Homo erectus* hadn't created the hearth, had never struck flint for that first spark and left fire to exist only in the wild? Quite simply, we physically wouldn't have become who we are today. Along with providing heat and warmth, fire provided humans with a way to transform raw foods into energy-efficient superfoods.

BUILDING BIG BRAINS

The neurological milestones in human evolution and the brain food that helped along the way

TOOLS
Homo habilis are thought to have been the first tool makers, crafting chipped pebbles and flakes of stone to prepare food.

FIRE
Homo erectus is thought to have been the first in our lineage to master fire, using it to cook, along with our Neanderthal cousins.



1 AUSTRALOPITHECUS

Cranial capacity: 450 millimetres

Several different species of human-like animals that lived from around 4.4 to 1.4 million years ago. These animals were plant-based omnivores, feasting on fruits, bark and insects.



2 HOMO HABILIS

Cranial capacity: 609 millimetres

Living in Africa between 2.4 and 1.4 million years ago, these human ancestors fed on hard foods such as nuts, woody plants and dried meat.



3 HOMO ERECTUS

Cranial capacity: 959 millimetres

The last ancestor before the modern-day human emerged lived from 1.89 million to 110,000 years ago. Meat and other proteins were the main source of food for these early humans.



4 HOMO SAPIENS NEANDERTHALENSIS

Cranial capacity: 1,415 millimetres

A cousin, not a direct ancestor of humans, commonly known as Neanderthals, lived around 400,000 to 40,000 years ago. With comparable brain sizes to *Homo sapiens sapiens*, these archaic humans also feasted mostly on meat.



5 HOMO SAPIENS SAPIENS

Cranial capacity: 1,499 millimetres

Our species first emerged around 300,000 years ago. Early *Homo sapiens* ate a variety of plants and meats that could be cooked over controlled fires.

DID YOU KNOW?

The brain uses 20 per cent of your body's energy intake

DID YOU KNOW? *Homo erectus* was the first human species to migrate out of Africa

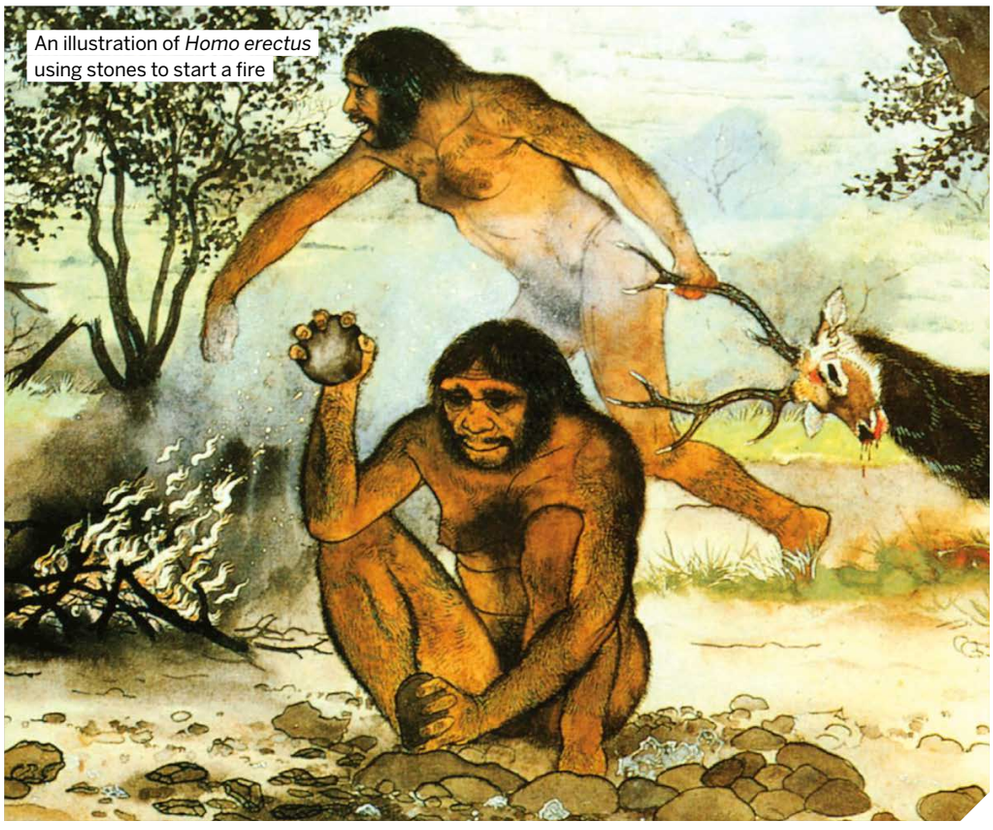
"By taking all of the work it takes to break down our food that we normally have to do inside and doing it over the fire, we reduced how much energy it takes us to digest, and it also kind of supercharged the foods we eat," says Pontzer. "Every bite of cooked food packs more calories, more energy, than a bite of raw food. We basically changed our fuel to this hyper-energy fuel of cooked food, and it provides energy for being more active. It provides energy for having big brains, but we spend less energy digesting it."

As a result, humans have evolved a digestive system relatively smaller than other apes, but a much bigger brain. "Humans burn more energy than any other apes. We get more calories every day, but if you were to weigh our food every day, we eat a third of the food that another ape would eat, and somehow we are still getting more energy out of it than any other ape gets. That's just how supercharged our foods are because of cooking," says Pontzer. "We'd probably stick to eating raw wild foods [otherwise]. We'd probably never break out of the hunter-gatherer approach that our deep ancestors had, like *Homo erectus*," he hypothesises. "It's not an ape-like existence because you can still have hunting and gathering, and apes don't do that, but it's not a fully fledged, really big-brained physiology that we've got today," he clarifies.

Not only would our physiology be stuck in the ancient past, so would our social skills. The discovery of fire meant that humans spent less time hunting and gathering every day. It gave them time to sit around the fire and communicate with one another. "That's where culture develops. The stories we tell, inventions and new ideas all stem from that. I think you need the fire to break away from a kind of more animal-like existence to what we think of as a very human-like existence."

Pontzer doesn't think it would have changed our desire to explore the planet: "I still think we might be all over the globe. *Homo erectus*, certainly without any sort of constant use of fire, was all over the globe, and there's no reason it wouldn't have eventually gotten into the Americas as well. Imagine a kind of ape-like existence, you know, small communities, maybe 50 or 60, but instead of just going up to the trees to get fruit and killing the occasional monkey like a chimpanzee, they're hunting and gathering. It's more cognitively complex, more sophisticated; they're smarter. But they just haven't gotten the whole way, because I think that fire really launches that last chapter that gets us all the way. It's not the only thing, and there's never just one thing, but it's a really crucial piece of that last chapter."

"Humans have been cooking on open fires for more than a million years"



An illustration of *Homo erectus* using stones to start a fire



IS AI THE NEW FIRE REVOLUTION?

If our prehistoric ancestors outsourced their digestive requirements to fire, are modern humans outsourcing neurological requirements to AI? Humans have been excellent exporters throughout history. As Pontzer has already pointed out, without fire, our bodies could not have obtained the amount of energy they need from a relatively small amount of food. He also highlights the fact that, during the Industrial Revolution, we outsourced muscle power to machines. Now Pontzer makes the suggestion that the next instalment of biological outsourcing in our history could be with AI. "AI is an outsourcing of our brains, where the LLMs [large language models] – Claude and the rest – will eventually be as good as our brains are," Pontzer says. Fire is the first example of humans releasing functions of the human body that can be outsourced, and now technology is making it possible to potentially take that outsourcing one step further and make computers do a lot of the neurological heavy lifting.

PROBABILITY RATING...

★★★★★

Humans are naturally inquisitive and curious creatures. Our ancestral need to learn more would have inevitably led us to inspect the flames of wildfires and discover how to harness fire's power.

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WHAT IS HAVANA SYNDROME?

This mysterious illness is thought to have targeted the United States government in 2016

WORDS SCOTT DUTFIELD

For the last ten years, US diplomats and officials have been coming down with bouts of nausea, bloody noses and memory loss, symptoms which have become collectively known as 'Havana syndrome'. The condition gets its name from the first case in 2016, which was reported in Cuba's capital, Havana. According to the BBC, in 2017, the US government pulled more than half of its staff from its embassy in Havana. Since then, however, more than 1,000 cases have been reported by US government employees around the world.

It's been reported that the symptoms of this curious condition followed a loud noise and then intense pain in the ears and head. Initially, this led people to speculate that the cause might not be viral, bacterial or even biological. According to a report from the National Academies of Sciences, Engineering and Medicine, it's plausible that the illness may have been caused by 'directed pulsed radio frequency energy'.



The American embassy in Havana, Cuba

However, there's no definitive proof linking Havana syndrome to a specific weapon. According to a joint investigation in 2024 by several media outlets, including *The Insider*, *60 Minutes* and *Der Spiegel*, the US officials are thought to have been targeted by Russian sonic weaponry, and it's been suggested that members of Russia's military intelligence sabotage squad GRU Unit 29155 might have been behind it.

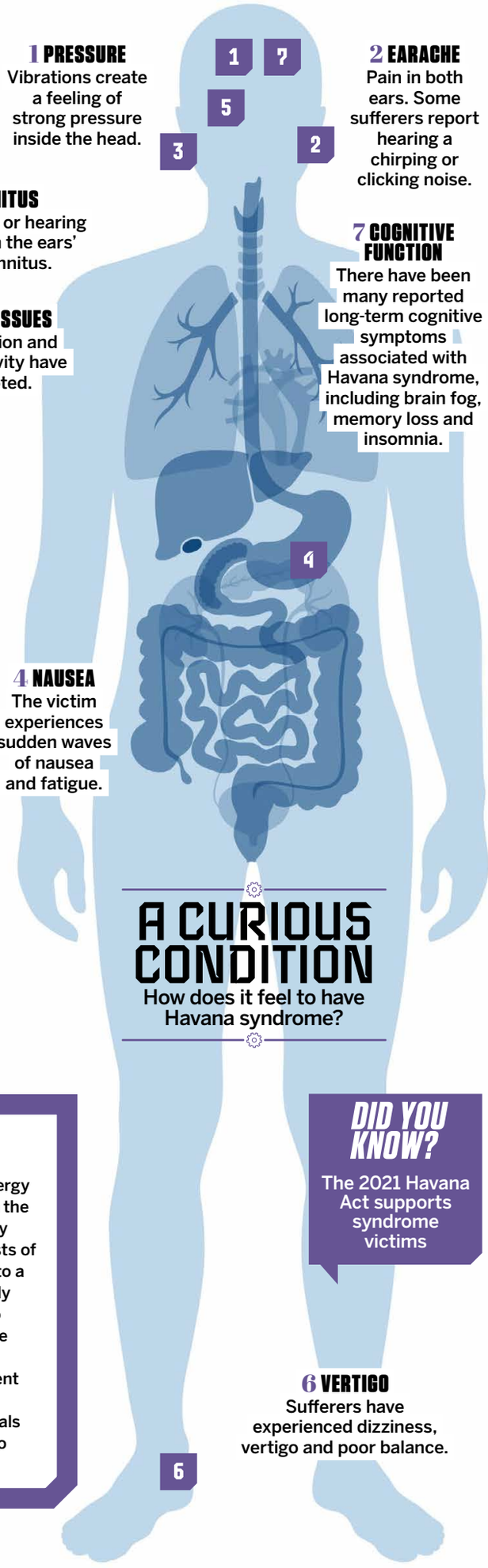


Pulsed radio frequency treatment can be used to treat chronic nerve and joint pain

© Shutterstock

PAIN OR PAIN RELIEF?

Although directed pulsed radio frequency energy may have been used to harm, it's also used in the medical field to heal. The technology works by converting electrical energy into intense bursts of electromagnetic waves and focusing them into a beam, which is directed at the target. Typically used to treat chronic nerve pain, pulsed radio frequency is applied by placing a needle to the problem area, such as a joint. The burst of electromagnetic waves can temporarily prevent pain signals between nerves. The resulting 'neuromodulation' can help prevent pain signals from reaching the spinal cord and travelling to the brain in some cases.



1 PRESSURE
Vibrations create a feeling of strong pressure inside the head.

2 EARACHE
Pain in both ears. Some sufferers report hearing a chirping or clicking noise.

3 TINNITUS
Hearing loss or hearing a 'ringing in the ears' called tinnitus.

5 VISUAL ISSUES
Blurred vision and light sensitivity have been noted.

7 COGNITIVE FUNCTION
There have been many reported long-term cognitive symptoms associated with Havana syndrome, including brain fog, memory loss and insomnia.

4 NAUSEA
The victim experiences sudden waves of nausea and fatigue.

A CURIOUS CONDITION

How does it feel to have Havana syndrome?

6 VERTIGO
Sufferers have experienced dizziness, vertigo and poor balance.

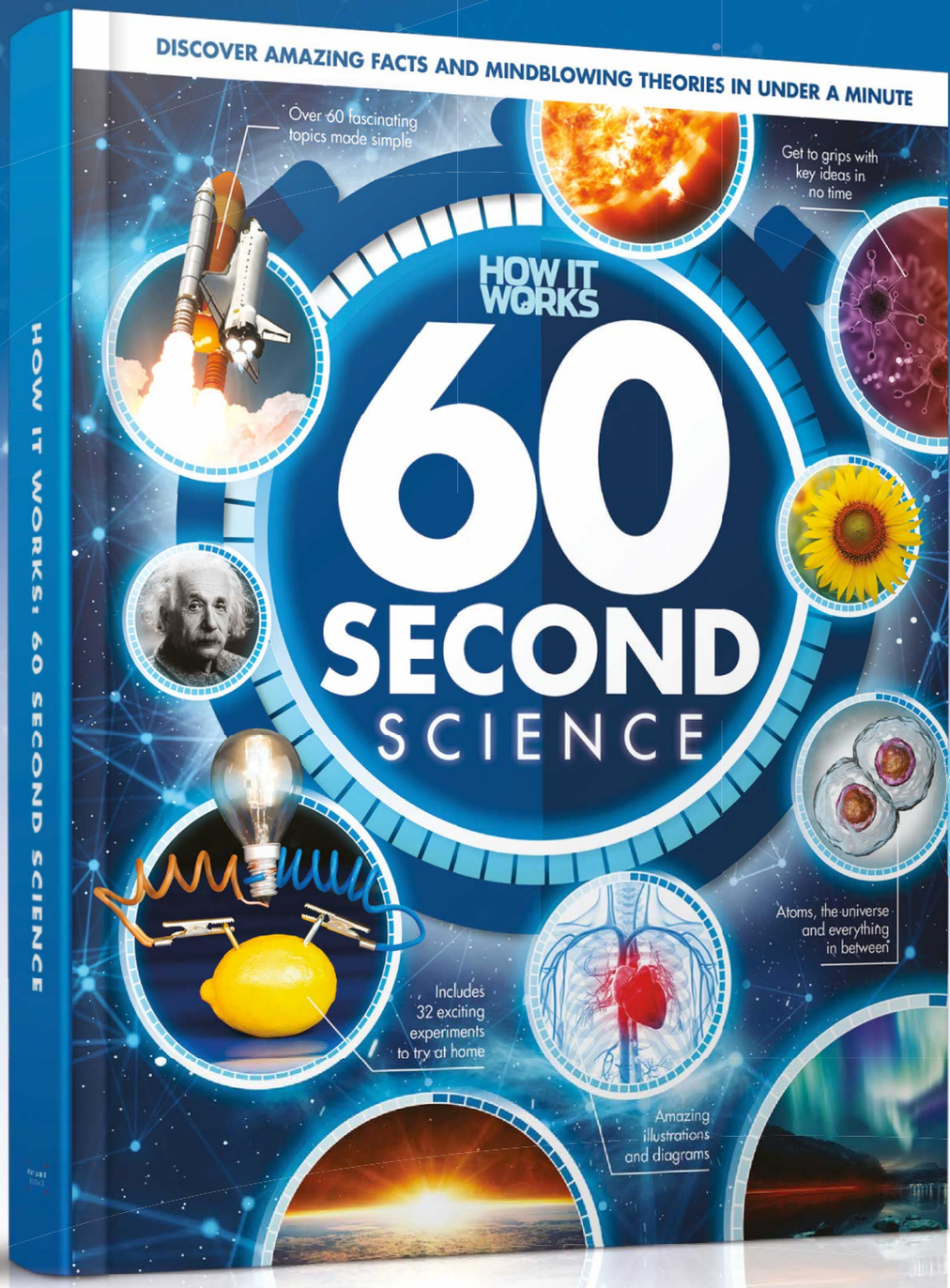
DID YOU KNOW?

The 2021 Havana Act supports syndrome victims

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SCAN ME

HOW SLEEP TRACKERS WORK

These smart devices know your nighttime routine better than you do

WORDS AILSA HARVEY

When you wake up in the morning, you might feel refreshed, or perhaps groggier than expected. Because you're unconscious for most of the night, you're likely to be oblivious to small disruptions in your sleep pattern. However, breaks in deep sleep, even if you remain unconscious and unaware, can have greater consequences for how you feel the next day and how well your body and brain have been able to rest and repair. This is where technology comes in.

Nearly half of American adults and 40 per cent of British adults use smart devices to track their sleep. These come in a variety of device types. Smart rings, watches and fitness bands are all equipped with sensors that can monitor biological changes during sleep. These forms of wearable technology need to be worn throughout the night to gather data, which is then presented on a connected smartphone. However, there are other forms of sleep trackers, including sleep mats, that don't need to be worn on the body. Sleep mats are placed underneath the mattress and contain sensors that collect data on body movements and breathing sounds throughout the night.

Wearable sleep trackers are generally more effective and can collect more biological data due to being closer to the skin and moving more with the body. After the devices collect a night's worth of physiological data, including blood oxygen levels and heart rate changes, the results are compared using an advanced algorithm. The combination of variations throughout the night usually match up to reveal when the wearer was in light sleep, deep sleep and rapid eye movement (REM) sleep.

Sleep quality is important, as it's the time when the body undergoes maintenance. Tissues repair themselves, hormones are released and the immune system becomes more active. Getting a good night's sleep increases a person's concentration abilities in the day, improves reaction times and boosts mood. Many people use sleep trackers to better understand their rest patterns and maximise their bodies' potential in the day – revealing how changes in activities such as drinking caffeine, stress, exercise or alcohol impact their sleep. Quantitative data helps people build healthier habits and appreciate how much their body is working when conscious thought is switched off.



Smart rings can monitor blood flow in arteries closer to the surface than watches can

HOW CAN A TRACKER KNOW YOU'RE IN REM SLEEP?

REM sleep makes up 20 to 25 per cent of sleep and supports brain health, memory consolidation, emotional processing and learning. Sleep trackers can't measure brain waves directly to know you're in REM sleep, but they can recognise other combinations of body signals. For example, your brain becomes more active in this stage of sleep, and vivid dreaming is common. REM is detectable through an increased heart rate compared to deep sleep, less regular breathing and a still body. The latter is because the body experiences temporary muscle paralysis during REM sleep. A combination of these changes makes it easy for the device's algorithms to accurately measure REM sleep cycles.

2 BIO-IMPEDANCE SENSOR
Tiny electrical currents are sent into the skin. These detect conductivity changes caused by breathing or movement.



DID YOU KNOW? Sleep trackers are 78 per cent accurate in identifying sleep versus wakefulness

SOPHISTICATED SLEEP RINGS

These tiny devices are packed with analytic technology

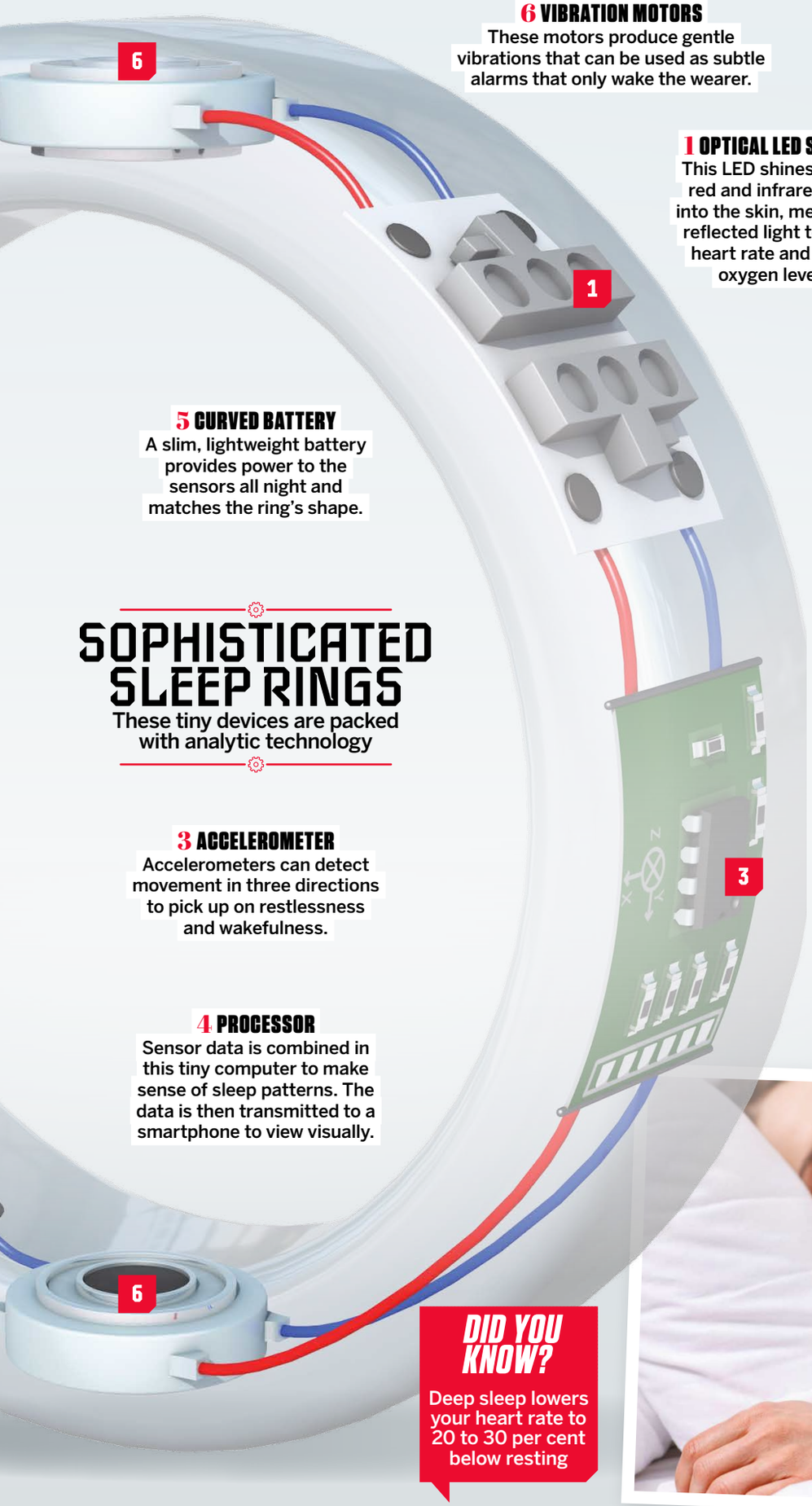
6 VIBRATION MOTORS
These motors produce gentle vibrations that can be used as subtle alarms that only wake the wearer.

1 OPTICAL LED SENSOR
This LED shines green, red and infrared light into the skin, measuring reflected light to track heart rate and blood oxygen levels.

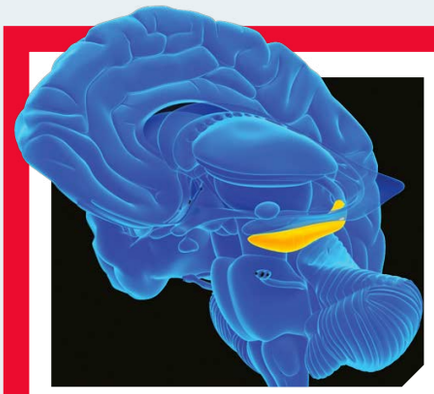
5 CURVED BATTERY
A slim, lightweight battery provides power to the sensors all night and matches the ring's shape.

3 ACCELEROMETER
Accelerometers can detect movement in three directions to pick up on restlessness and wakefulness.

4 PROCESSOR
Sensor data is combined in this tiny computer to make sense of sleep patterns. The data is then transmitted to a smartphone to view visually.



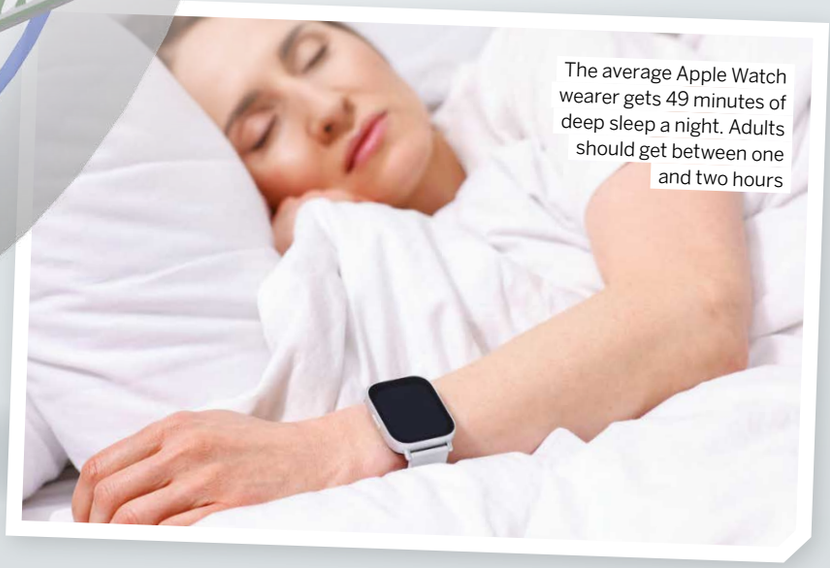
DID YOU KNOW?
Deep sleep lowers your heart rate to 20 to 30 per cent below resting



When in deep sleep, the hippocampus of the brain replays memories at a fast speed to consolidate them

THE SLEEPING BODY

In order for trackers to detect sleep patterns, the body needs to undergo changes. But how much does your biology change when sleeping? As you drift into sleep, your heart rate slows and blood pressure falls. This is because the parasympathetic nervous system takes over – part of the body's autonomic nervous system that promotes relaxation over the sympathetic nervous system's fight-or-flight responses. This allows the body to recover better. Breathing becomes slow and regular and core body temperature drops by around one degree Celsius. During deep sleep, your muscles relax and tissues undergo self-repair. Sleep trackers can use all of these changes to monitor sleep. They detect shifts in heart rate, breathing rate, skin temperature and movement. These signals provide a clear interpretation of the body in wakefulness and light, deep or REM sleep.



The average Apple Watch wearer gets 49 minutes of deep sleep a night. Adults should get between one and two hours

© Shutterstock / Alamy / Illustration by Adrian Mann

WHAT'S INSIDE... A DUALSHOCK 4?

The secrets of Sony's PlayStation 4 controller revealed

WORDS JACK PARSONS

Standing proudly alongside the famous little grey box that brought the world *Crash Bandicoot*, *Final Fantasy VII* and *Gran Turismo* was the original PlayStation controller. Stickless and simple, this controller introduced the world to four soon-to-be famous icons: Triangle, Circle, Cross and Square. This was 1994, and just the start of the PlayStation pad's decades-long journey.

Continuing the trend of introducing new controller technoogies in 2013, the DualShock 4 featured a two-point capacitive touchpad on the front side of the controller that also counts as a button when 'clicked'. This allows players more 'mouse-like' control on games. The pad also features an LED light bar that illuminates in various scenarios: usually, it'll light up in the colour of one of the four face buttons to identify you as player one, player two and so on.

This light bar was also a forward-thinking asset for VR: the PlayStation Camera can track this bar and locate the position of your hands in VR when using the DualShock 4 – Sony's unique approach to the problem of control input when you've got a VR mask covering your eyes. While Sony has moved on to the DualSense, gamers still use the DualShock 4 for a more authentic experience playing retro games on the PlayStation 5.



1 THUMBS DOWN
Early models of the DS4's thumbsticks were subject to tearing.







3 PULL THE TRIGGER
As with the face buttons, pressure sensitivity has been removed from the trigger buttons. This is a shame, because on the Xbox One pad, the sensitivity and trigger-specific haptic feedback feel wonderful when shooting or driving.



2 LIGHT 'EM UP
The light bar has its own mini circuit board to power the illumination. Different games use this in various ways, but it's not essential. You can disable the bar altogether to make your battery last a good deal longer.

DUALSHOCK TO THE SYSTEM



1994 PlayStation controller
Based on the basic button configuration of the SNES control pad, the PlayStation controller added an extra set of shoulder buttons so players could navigate the three-dimensional game environments that were becoming more popular.



1997 DualShock
The main addition the DualShock brought was vibration, powered by two motors in the palm grips/handles. Each motor was a different strength so games could modulate various levels of rumble depending on the situation.



2000 DualShock 2
The DualShock 2 didn't change too much. It was lighter, though, and had one fewer screw holding it all together. It did introduce readable values on the buttons – meaning games could request you to push them harder or softer.

DID YOU KNOW? The PlayStation 2 is the best-selling console in history, with 160 million units sold

4 A STEP BACKWARDS?
This was the first time since the DualShock 2 that a PlayStation controller did not have sensitivity sensors under the face buttons for hard and soft presses.

5 A TOUCHING IDEA
The small sensor that sits under the plastic cover detects finger movement over the surface, enabling the controller to act as a touchpad. It also has two clickable inputs: left and right.

"The DualShock 4 introduced a two-point capacitive touchpad on the front"

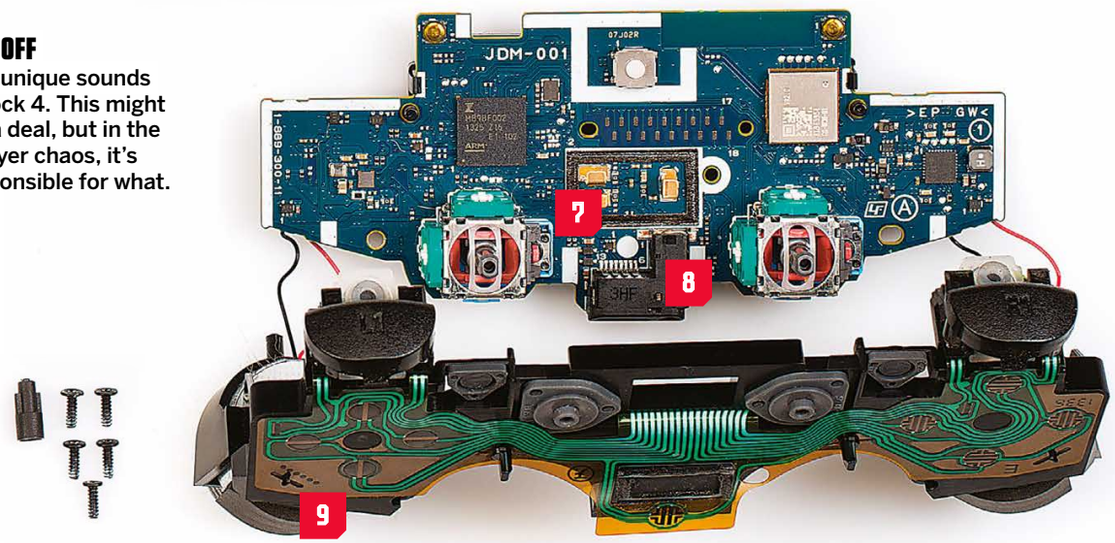


6 EXTRA LIFE
The pad shipped with a 1,000mAh battery that will give you about six to seven hours of life per charge. It's easily replaced with a 2,000mAh battery, though.

7 CENTRAL CIRCUIT SYSTEM
This is the brain of the pad, where all the split-second logistics occur. This can be taken away from the pad and used to make other hardware, such as fight sticks or custom controllers.

8 SOUNDING OFF
A mini loudspeaker lets unique sounds play through the DualShock 4. This might not seem like too big of a deal, but in the midst of local multiplayer chaos, it's useful to know who's responsible for what.

9 GOOD VIBRATIONS
These motors – one featuring a three-ringed vibration motor, the other with a single ring – are triggered at certain points in games and provide haptic feedback to the player. These also contain the six gyrometers and accelerometers.





2007 DualShock 3
The PlayStation 3 iteration of the pad went fully wireless, powered by an internal lithium-ion battery, and introduced Bluetooth compatibility with other PlayStation products – the PSP Go, for example. Sixaxis tech also enabled control via tilt.



2020 DualSense
Sony dropped the DualShock name for its PlayStation 5 controller, reflecting the move away from rumble motors to dual voice-coil actuators that deliver detailed haptic feedback. It also features dynamic resistance on its L2 and R2 buttons.



The DualShock 4 was designed by Sony with ergonomics and comfort in mind. That's why it feels so pleasant to hold

© Getty

HOW TO MAKE A HOME WEATHER STATION

Get a personalised forecast come rain or shine

1 ANY WAY THE WIND BLOWS

You can record data on everything from gusts to gales thanks to the Netatmo wind gauge. Its ultrasonic transducers convert airflow into minute vibrations and enable the device to give strength and directional readings in a variety of different metrics.

2 SOUND METER

You'll probably already be aware if your house is noisy, but the weather station gives you an exact decibel count.

3 TEMPERATURE AND HUMIDITY

The weather station can give live updates on the temperature and humidity levels in your home, accurate to within 0.3 degrees Celsius.

4 BAROMETER

The outdoor module includes a barometer and uses it to make accurate weather predictions based on changes in the surrounding air pressure.

5 CARBON DIOXIDE SENSOR

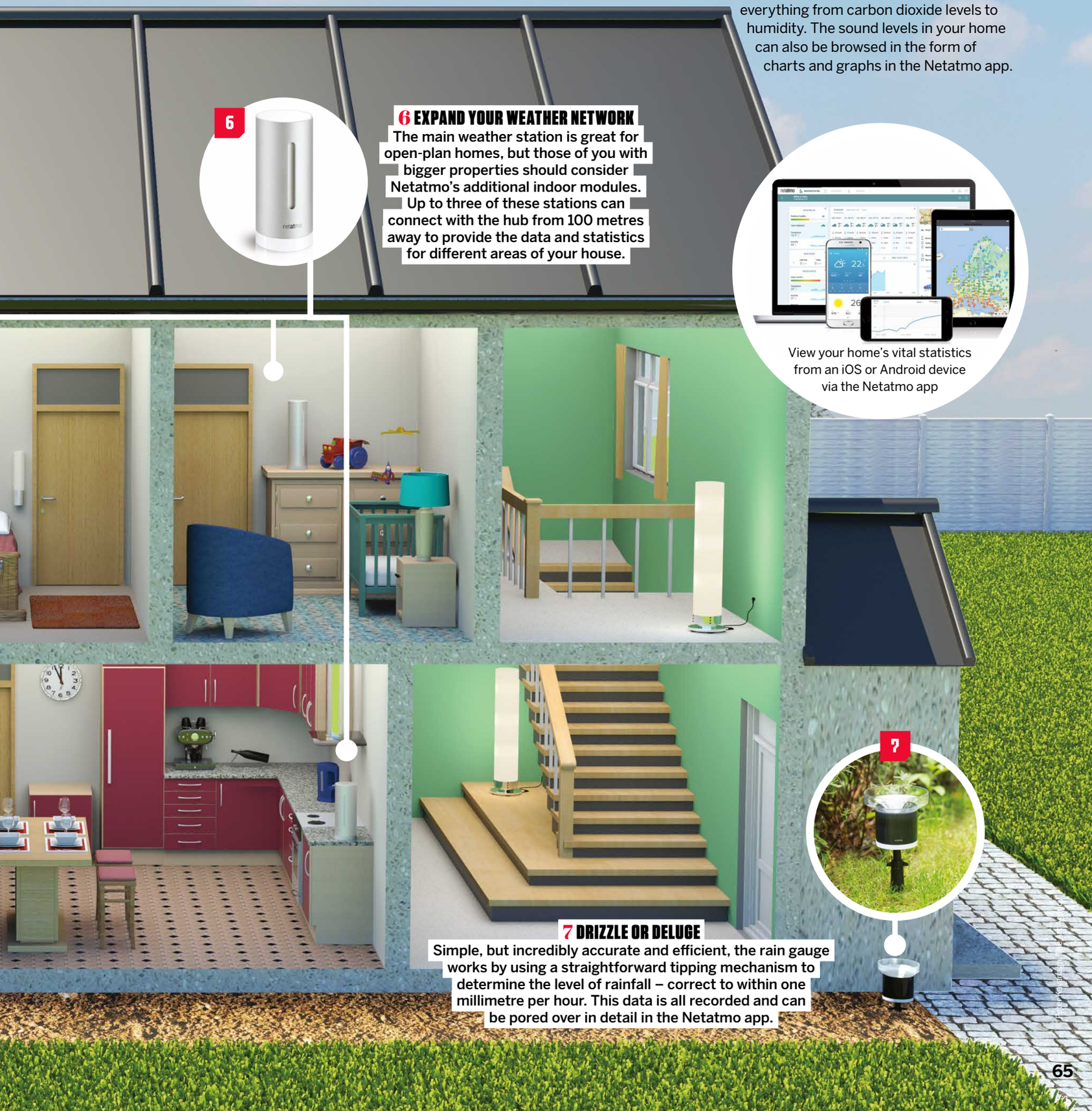
The weather station's carbon dioxide sensor gives you an instant status report on your indoor pollution levels – just press the top.

DID YOU KNOW? In 2018, Norway's public weather service started using Netatmo data to improve its forecasts

You probably check the weather forecast every day to see what sort of meteorological maelstrom you're likely to encounter should you venture out into the open, but have you ever considered the atmospheric status inside your home? This might seem like an odd question, but the indoor air in many homes can be more hazardous and polluted than the average city street. Usually, you can solve this problem by opening a window, but how do you measure the air quality in your home to begin with? Thankfully, there's a gadget for that.

The Netatmo weather station is a smart environmental hub for your home that comes with a frankly ridiculous number of sensors crammed into its sleek aluminium body. Together with its range of additional modules, which measure outside factors like rainfall, air pressure and so much more, the weather station can give you incredibly accurate and detailed data on the status of your home's ecosystem – inside and out.

If air quality is reaching dangerous levels, it will notify you and provide information on everything from carbon dioxide levels to humidity. The sound levels in your home can also be browsed in the form of charts and graphs in the Netatmo app.

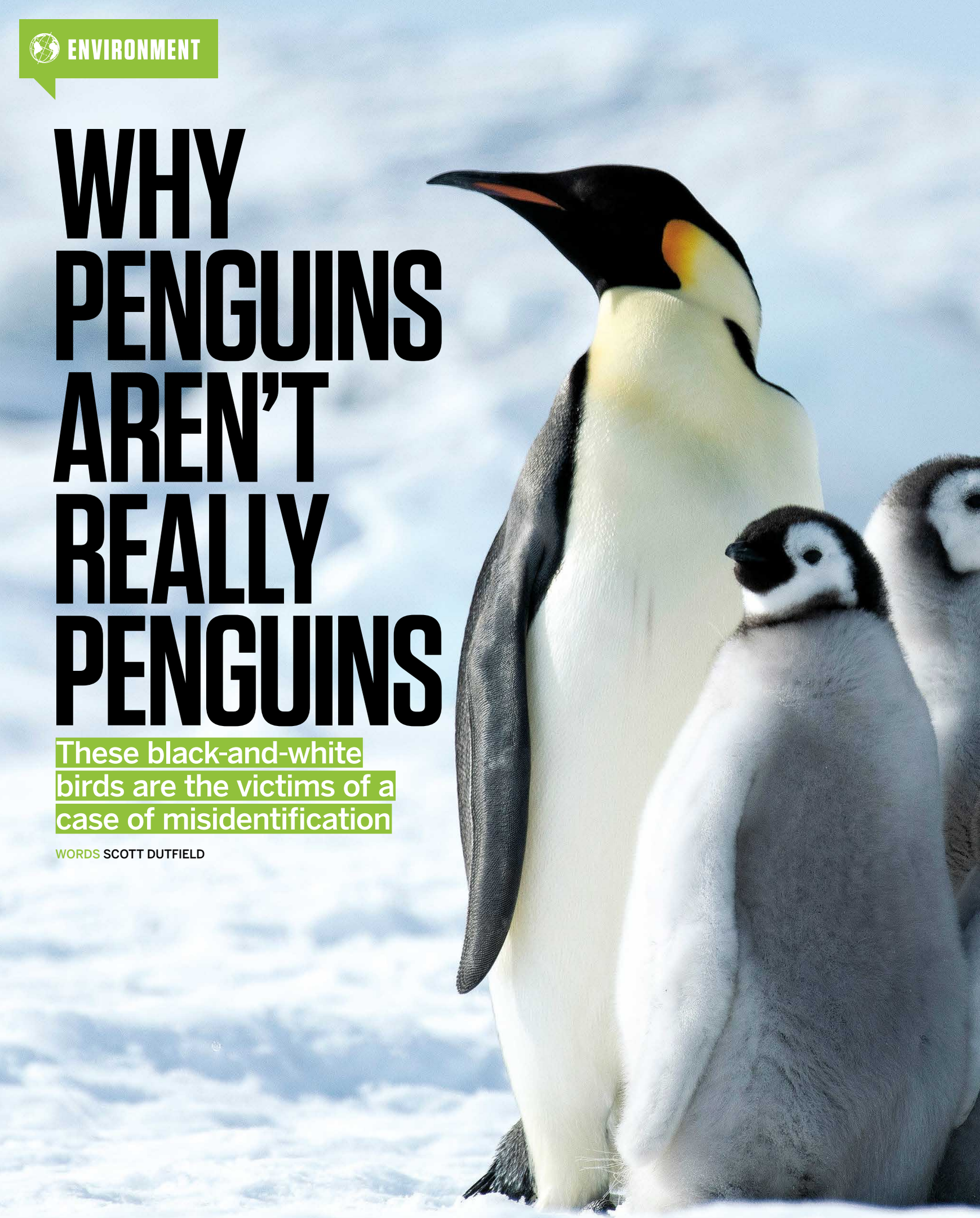


6 EXPAND YOUR WEATHER NETWORK
The main weather station is great for open-plan homes, but those of you with bigger properties should consider Netatmo's additional indoor modules. Up to three of these stations can connect with the hub from 100 metres away to provide the data and statistics for different areas of your house.

View your home's vital statistics from an iOS or Android device via the Netatmo app

7 DRIZZLE OR DELUGE
Simple, but incredibly accurate and efficient, the rain gauge works by using a straightforward tipping mechanism to determine the level of rainfall – correct to within one millimetre per hour. This data is all recorded and can be pored over in detail in the Netatmo app.

WHY PENGUINS AREN'T REALLY PENGUINS



These black-and-white birds are the victims of a case of misidentification

WORDS SCOTT DUTFIELD

Why do we give animals the names we do? Who decides? And what happens when they get it wrong? The world of taxonomy (the naming and categorisation of animals) is a weird and wonderful place. From honouring those who made animal discoveries, such as Darwin's frog, *Rhinoderma darwinii*, to immortalising pop stars, such as the millipede *Nannaria swiftae*, naming species can be fun, but it's much more than an identifier, as it places them on the evolutionary tree of life. For modern-day discoveries, scientists follow a standardised system called binomial nomenclature, which is governed by the International Code of Zoological Nomenclature (ICZN).

This system takes into account many qualities of the animals, such as physical traits, anatomy, behaviour and DNA composition. It spits out a scientific name, or 'binomial' name, which you'll more often than not see written in Latin. But humans haven't quite taken to referring to our animal neighbours by their Latin names in common conversation. Using the common name 'cat' instead of *Felis catus* is much easier. But common names can lead to confusion.

Gulls are a prime example of a group of animals that have fallen victim to a common nickname. Much to the surprise of any beach-goer, technically, there's no such thing as a 'seagull'. The general term has been used to describe more than 50 different species of birds in the *Laridae* family, which includes black-headed gulls, herring gulls and common gulls.

The common culprit for naming mismatches is a principle called convergent evolution. When two completely unrelated species are exposed to similar environmental pressures, they can adapt and evolve in similar ways, resulting in animals sharing very similar traits. Take hawkmoths and hummingbirds, for example. Both tiny creatures have rapidly beating wings and tongue-like appendages to sip flower nectar. One's a bird and the other's an insect, but at a passing glance one might be mistaken for the other.

DID YOU KNOW?

Slow worms are actually legless lizards, not snakes or worms

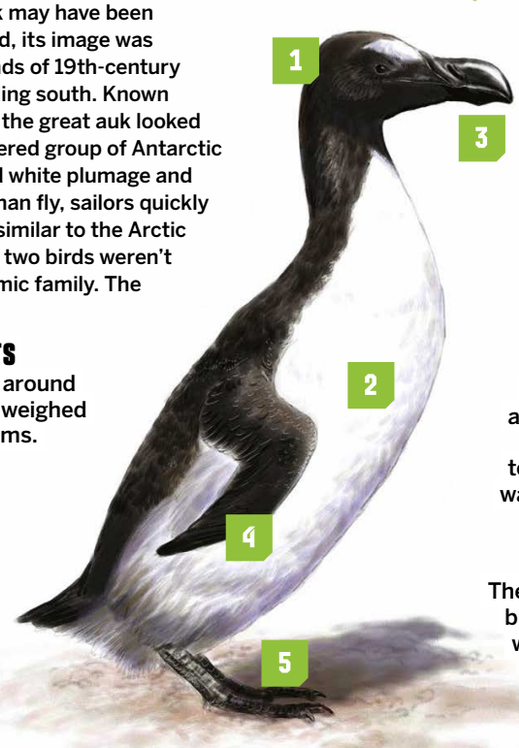
IDLE ORNITHOLOGY

There's a problem with the world's penguins. They're not really penguins. Well, at least not the original 'penguins'. Long before people knew that penguins were swimming around our southern waters, a similar-looking bird was diving from coastland in the North Atlantic. Known as the great auk (*Pinguinus impennis*), these black-and-white birds bore a remarkable resemblance to the penguins of today. However, in the early 1800s, these birds were driven to extinction, with the last sighting of a great auk in 1852. While ashore to breed, the flightless birds were hunted for food, feathers, oils and for trophies.

Although the great auk may have been eradicated from the world, its image was still imprinted on the minds of 19th-century European travellers heading south. Known commonly as 'penguins', the great auk looked much like a newly discovered group of Antarctic birds. Boasting black and white plumage and choosing to dive rather than fly, sailors quickly assumed the birds were similar to the Arctic alternative. However, the two birds weren't even in the same taxonomic family. The great auk belonged to a family of stout seabirds that includes puffins and auks, called Alcidae, whereas modern-day penguins are among the completely flightless family Spheniscidae.

PENGUIN PROPERTIES

What is it about the great auk that made sailors think they were found in Antarctica?



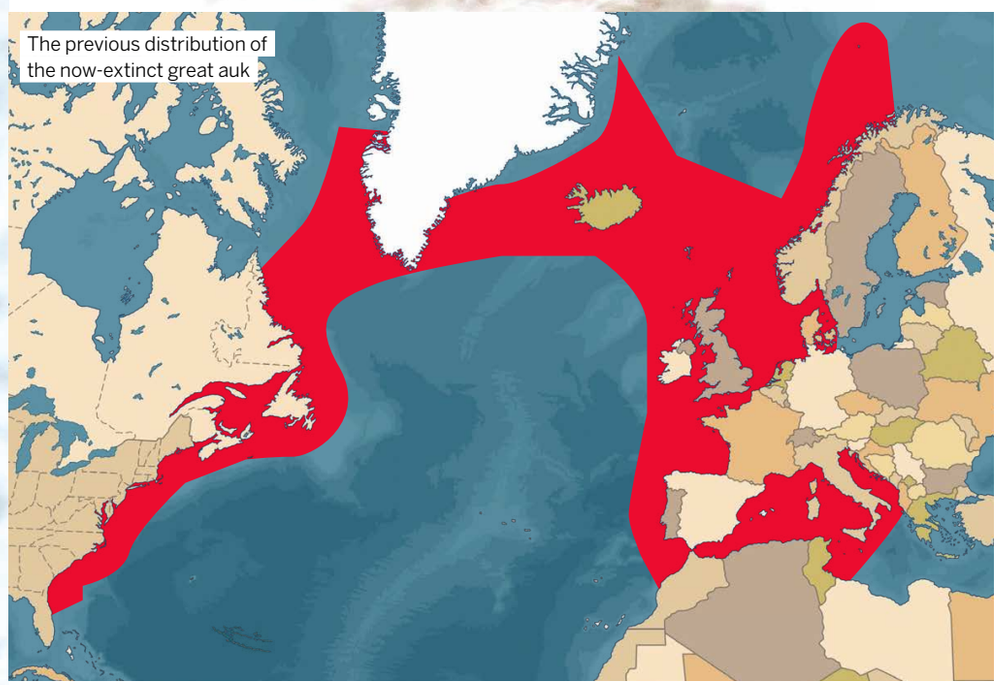
1 MEASUREMENTS
Adult birds were up to around 75 centimetres tall and weighed around five kilograms.

2 PLUMAGE
The body of the great auk was covered in black and white feathers, densely packed together to provide waterproof plumage.

3 BEAK
Unlike penguins, the great auk had a wide puffin-like beak, with eight or more grooves along it.

4 WINGS
Used more as fins, their wings were less than 15 centimetres long and were used to swim underwater.

5 FEET
These birds had large black webbed feet with short claws.


The previous distribution of the now-extinct great auk

© Shutterstock

WHO'S WHO?

How well do you really know these animal mismatches?

BEARCATS

Neither bear nor cat, bearcats, or binturongs (*Arctictis binturong*), are furry tree-dwellers found in the tropical forests of South Asia. Bearcats are a member of the Viverridae family. But with the body of a long-tailed bear and a cat-like face, it's easy to see why they've been mislabelled. Bearcats have a prehensile tail, which they use to move through the trees and which they wrap around branches while they sleep for stability. They also boast an aroma you'd recognise, but not typically from an animal. In close encounters, bearcats emit the distinct scent of buttered popcorn. The potent smell comes from a chemical called 2-acetyl-1-pyrroline (2-AP), found in the animal's urine. It's the same chemical formed when sugars and amino acids in popcorn react during popping. While squatting to relieve itself, a bearcat's urine soaks into its feet and tail, hence the lingering scent. It appears that males secrete more 2-AP than females, suggesting that it may be a form of chemical communication to identify gender.



CLOSEST RELATIVES

CIVETS

These cat-like animals share some similarities with our pets, such as whiskers and a muzzle. However, civets have a notable difference – five toes on their hind feet, unlike a cat's four, which they use to help navigate their tropical forest habitats.



GENETS

There are around 14 known species of these lean carnivores. These nimble animals are some of nature's best contortionists and can squeeze their way through any space that's slightly larger than their head.



LINSANGS

As the smallest members of the Viverridae family, linsangs grow to lengths of up to 43 centimetres. Linsangs can be found in the Asian tropics like the bearcat, but also in mountainous rainforests in West and Central Africa.



CLOSEST RELATIVES

RACOONS

If you look close enough, you can see a distant connection between red pandas and raccoons. The pair both belong to a subfamily of carnivoran mammals called Musteloidea.



WEASELS

Another Musteloidea, weasels are often defined by elongated bodies which help them follow prey into tunnels and burrows. Their meals include small mammals like voles and lemmings, along with birds and their eggs.



SKUNKS

Also a Musteloidea member, skunks are famous for their foul defensive spray, and it's a quality skunks and red pandas share. When threatened, both animals release a potent smell from scent glands beneath their tails to ward off predators.





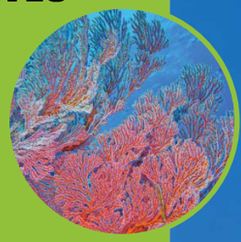
RED PANDAS

While they share a love for quick-growing bamboo, the red panda and the giant panda don't belong to the same family. While the two have a distant common ancestor, their evolutionary journey diverged around 43 million years ago, culminating in the red panda, which belongs to the Ailuridae family, and the giant panda in the family of bears called Ursidae. During the 19th and 20th centuries, the giant panda (*Ailuropoda melanoleuca*) was sorted into the family of the red panda's closest relative, the Procyonidae, which includes raccoons. However, after modern DNA testing, the black-and-white mammals formally joined the true bear family in 1985. Other than their obvious size and colour differences, the two animals share a lot of qualities, especially their digestive system. Despite having a digestive anatomy built for a carnivore, these animals eat almost exclusively bamboo – over 90 per cent. While red pandas enjoy fresh shoots and leaves, giant pandas spend their day tearing through the stems, or culms, of the plant.

DID YOU KNOW? Mountain goats aren't true goats, and instead belong to a 'goat-antelope' genus called *Oreamnos*

CLOSEST RELATIVES

CORALS
These living marine animals are made up of colonies of tiny creatures called polyps. Together, the polyp colonies build a 'skeleton' by extracting calcium carbonate from the ocean and turning it into aragonite crystals.



SEA ANEMONES
These soft-bodied animals boast stinging cells to catch and kill prey, but cannot swim. Instead of using an umbrella-like body to swim, anemones use a specialised foot called a basal disc to stick to the seabed.



HYDRAS
Tiny tube-shaped organisms that grow up to around 20 millimetres long. Unlike jellyfish, these creatures live in freshwater rivers and lakes, but similarly wave around stinging tentacles to catch tiny animal prey, such as worms and fish fry.





JELLYFISH

Despite the name, jellyfish don't share a whole lot in common with actual fish. Instead, jellyfish are invertebrates called cnidarians. There are a few clear distinguishable features that separate them from 'real' fish, including lacking a brain and heart. These marine animals don't even have gills to breathe underwater, and instead exchange oxygen through a thin epidermal skin layer. They do, however, sport a nervous system which they use to orient themselves and detect touch, especially from passing prey. The jellyfish is a prime example of a mistake humans have been making for centuries. You may have heard the phrase, 'there's no such thing as a fish', and to a large extent, that's true. We typically use the word 'fish' to name the countless marine animals that swim. But biologically speaking, the word really doesn't have any merit. Considering that all life rises from the oceans, the evolutionary lineage of one fish might make it more closely related to land-dwelling cats than to another 'fish'.

"The system takes into account many qualities of the animals, such as physical traits, anatomy, behaviour and DNA composition"

KOALAS

If you go down to the Australian woods today, you might be lucky enough to see a 'koala bear'. However, what you're looking at is genetically and physically miles away from real bears. The most distinguishing difference between the two is how they give birth. Unlike bears, which are placental mammals, koalas are marsupials, which means they give birth to a foetus in a tiny pouch, where it feeds on milk while it grows. Not only are koalas not in the bear family, they're the only living member of their own family, Phascolarctidae. It's estimated that there are at least 16 species of koala that have gone extinct throughout Earth's history, with the last dying out around 28,000 years ago. However, the lone koala species, *Phascolarctos cinereus*, consists of three subspecies of koala: one found in Queensland (*P. cinereus adustus*), another in New South Wales (*P. cinereus cinereus*) and one in Victoria (*P. cinereus victor*). While they look extremely similar, the Victorian koalas are larger, boast thicker fur and are often darker in colour.



DID YOU KNOW?

Horseshoe crabs are more closely related to spiders than crabs

CLOSEST RELATIVES

WOMBATS
The closest relatives to koalas are wombats. These two animals both belong to the suborder Vombatiformes, of which they are the only surviving species. Anatomically, the two are very similar, with the exception that wombats use their forelimbs as a fossorial animal (adapted for digging) and koalas use them arboreally (moving through trees).



KANGAROOS
As members of the marsupial group, koalas, wombats and kangaroos share evolutionary history. However, around 50 to 55 million years ago, the suborder Macropodiformes was formed, which also includes wallabies.



© Shutterstock / Alamy

INSIDE A BIRD EGG

Discover what different species of developing bird foetuses look like and how their eggs provide life support

WORDS AILSA HARVEY

There are around 11,000 bird species on Earth, and every one was delivered in a remarkable natural package – the egg. This serves as a self-contained life-support system for chicks to develop outside of the mother's body. Unlike most mammals, which grow their young from embryo to baby internally before they're born fully developed, birds receive everything they need to mature from an embryo inside the egg shell.

Egg formation begins in the ovary, where a developing egg grows into a yolk. The yolk accumulates fats, proteins, vitamins and minerals that will be used to fuel the embryo as it grows. When the yolk is mature, it's released into the oviduct, which is like an egg assembly line. As the yolk travels down this tube, the egg whites, membranes and hard outer shell form around it. Different sections of a female bird's reproductive tract are responsible for adding different components. In the shell gland, calcium carbonate is deposited around the egg to form the hard shell as it crystallises. Pigments that determine the shell's colour are added here too. Within 24 to 26 hours, the egg is ready to be laid. Bird eggs appear to be fragile, but their shape helps provide the strength required to remain intact until hatching while withstanding the pressure of an incubating adult bird sitting on it.

When the bird inside an egg is fully formed and has used up the nutrients within, it needs to break free from the egg itself. Before hatching, it absorbs the remaining yolk, then uses a temporary egg tooth to peck away at the inside of the shell. The egg tooth is a sharp bump on the bird's beak that's only used as a tool for hatching before it drops off within a day or two of breaking free. Bird eggs are not just containers, but ecosystems for early life. They help keep chicks safe in their nests, while mothers are free of the extra weight of pregnancy, allowing them to continue flying.

2 ALLANTOIC FLUID
Embryonic waste is stored in this fluid. It also assists in oxygen and carbon dioxide exchange through pores in the shell.

7 AIR CELL
A pocket of air sits between the shell membranes to provide the chick with oxygen before hatching.



6 EMBRYO
This is the living part of a fertilised bird egg. Its cells rapidly divide and specialise to form organs, feathers, bone and tissue.


Guillemots, also called murres, lay rough eggs to prevent sliding

TINY TO ENORMOUS

Bird eggs come in similar shapes, but drastically different sizes. This reflects the huge diversity in the size of birds themselves. The bee hummingbird lays the smallest known bird eggs, measuring just six to eight millimetres in length and weighing less than one gram. On the other end of the spectrum, ostriches lay the largest at 15 centimetres long and 1.5 kilograms in weight. That's about the same weight as 20 chicken eggs. While bird eggs usually reflect the size of the bird, the kiwi bird is an exception. They lay eggs that are 20 per cent of the female's body mass – making it the largest egg relative to body size of any bird egg in the world. Larger eggs usually have more nutrients to provide for the developing chick.

A Japanese quail egg is one-quarter the size of a chicken egg, and one bird lays up to 300 per year

"Bird eggs appear to be fragile, but their shape helps provide strength"

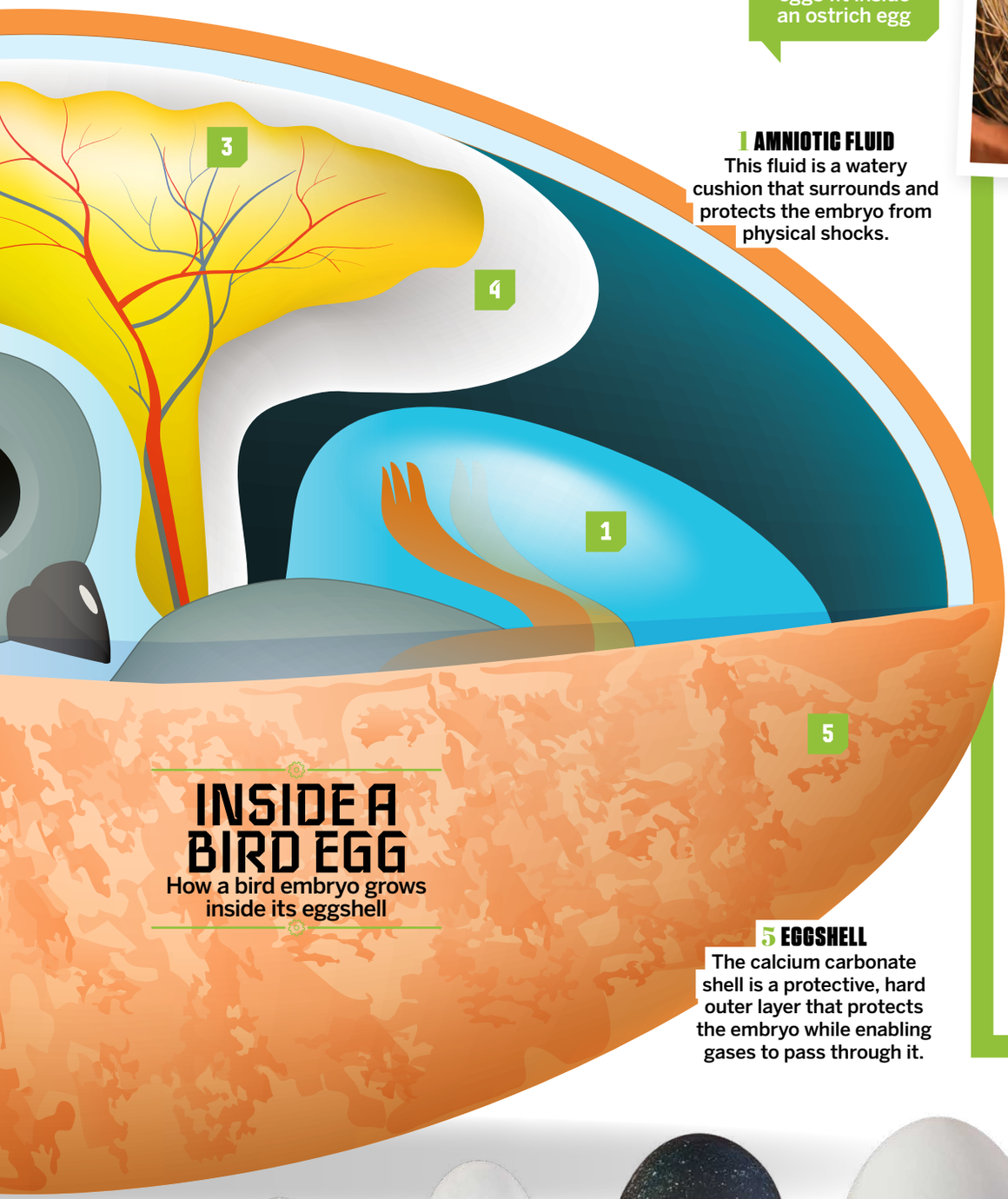


DID YOU KNOW? The same pigments in today's bird eggs were also found in dinosaur eggs

3 YOLK
Energy, protein, fats and nutrients needed for growth are provided by the yolk. It also carries antibodies from the mother to protect the bird from disease.

4 ALBUMEN
The egg white supplies water and proteins to the embryo while serving as an additional shock absorber.

DID YOU KNOW?
4,700 bee hummingbird eggs fit inside an ostrich egg



INSIDE A BIRD EGG
How a bird embryo grows inside its eggshell

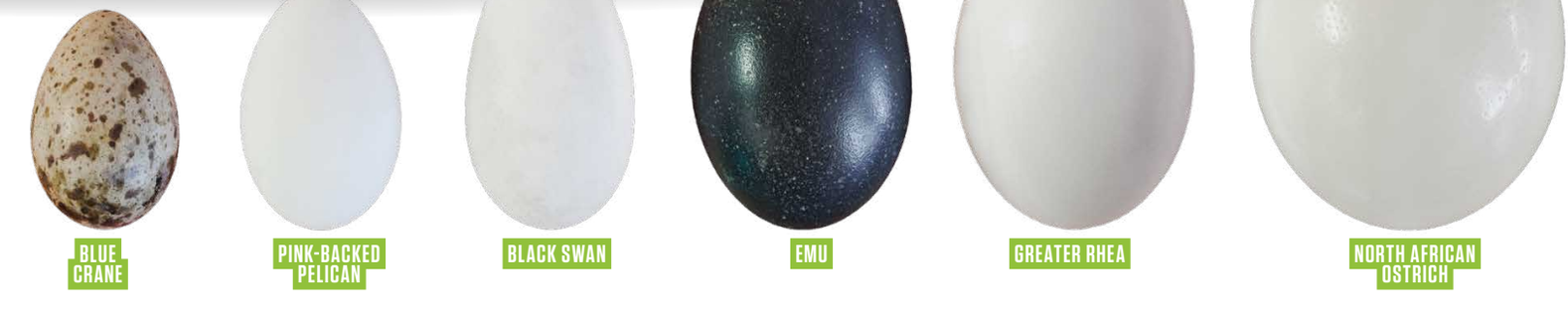
1 AMNIOTIC FLUID
This fluid is a watery cushion that surrounds and protects the embryo from physical shocks.

5 EGGSHELL
The calcium carbonate shell is a protective, hard outer layer that protects the embryo while enabling gases to pass through it.


Blue-green pigments can absorb ultraviolet radiation, protecting the developing embryo

WHY ARE EGGS DIFFERENT COLOURS?

Bird eggs form in a great range of colours, depending on the species. This includes the bright blue of a robin's egg and the speckled brown of a song thrush egg. A large factor in these colours is due to chemical pigments that enter the shell as the egg is forming. Biliverdin is a blue-green pigment that's produced when the body breaks down haem – the iron-containing part of haemoglobin in red blood cells. When this is deposited in the egg, it results in the blue-green colours displayed in robin and emu eggs. Protoporphyrin is a pigment that presents itself as a reddish brown or chocolate brown. This pigment is responsible for the spots on a song thrush egg. The specific colours of bird eggs isn't random, it's a result of evolution. Over millions of years, the eggs most camouflaged to their surroundings bettered the birds' chances of survival and continued the species. Camouflage helps ground-nesting birds hide eggs among vegetation, and speckled patterns can break up the eggs' outline to make their shape less obvious to predators from afar.


BLUE CRANE | PINK-BACKED PELICAN | BLACK SWAN | EMU | GREATER RHEA | NORTH AFRICAN OSTRICH

© Shutterstock / Alamy

THE FASTEST MOVERS ON PLANET EARTH

The speediest animals in the world are engineering marvels. Evolution has given them bodies optimised for moving quickly through their habitats

WORDS LUIS VILLAZON

A cheetah is roughly the same size and weight as a greyhound, yet has almost double the top speed. The difference is the cumulative effect of dozens of subtle engineering improvements. Cheetahs have longer forelimbs than a greyhound and a more flexible spine that allows the hind legs to reach further forward on each stride. As a result, their effective stride length is over eight metres long. What's more, 45 per cent of a cheetah's muscle mass is concentrated in the spine and back legs, which provide most of the driving force.

However, cheetahs owe most of their kills to their incredible acceleration, rather than their straight-line speed. They can go from 0 to 62 miles per hour in just three seconds, brake to a standstill in just four strides and change direction faster and more often during a chase than any other cat. Despite this, cheetahs only catch their prey about 25 per cent of the time, because gazelle are also optimised for speed.

A gazelle runs on the tips of its toes: its hooves are evolved from toenails that have enlarged and fused together. What look like the gazelle's forelimbs are actually the toe bones, greatly lengthened, and the knee and elbow joints are tucked up against the body. This gives them much longer legs, with most of the weight near the centre of gravity. If the chase goes beyond 300 metres, a Thomson's gazelle can outrun a cheetah.

1 COMMON SWIFT

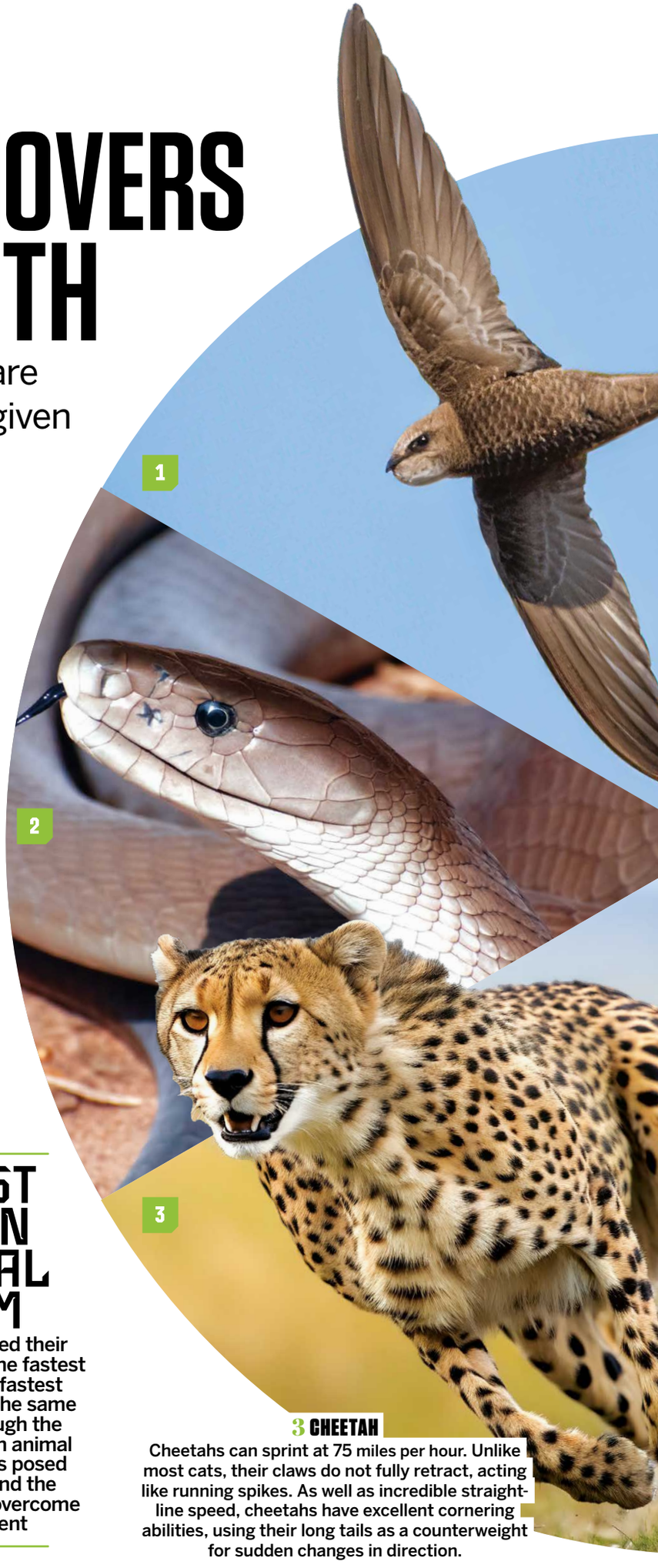
Peregrine falcons are the fastest animals in the air, but their top speed of 186 miles per hour is only achieved in a steep dive – essentially, the peregrine is the master of falling. The record for fastest flapping flight goes to the swift, which can propel itself to 69 miles per hour.

2 BLACK MAMBA

The fastest snake in the world is also one of the largest and most venomous. Its three-metre-long body is thin and combines good grip on the ground with low drag. It can slither at 12 miles per hour through dense undergrowth – which is faster than you can run.

SPEEDIEST BEASTS IN THE ANIMAL KINGDOM

All of them have conquered their environments. Incredibly, the fastest flyer, fastest runner and fastest swimmer all have almost the same top speed. But even though the upper speed limits of each animal are similar, the challenges posed by their environments and the adaptations employed to overcome them are quite different



3 CHEETAH

Cheetahs can sprint at 75 miles per hour. Unlike most cats, their claws do not fully retract, acting like running spikes. As well as incredible straight-line speed, cheetahs have excellent cornering abilities, using their long tails as a counterweight for sudden changes in direction.

DID YOU KNOW? Pronghorns are sometimes called pronghorn antelopes – they're not, but they do occupy a similar ecological niche

6 SAILFISH

Unlike tuna, which have mainly red muscle adapted for sustained cruising, sailfish and marlins have 93 per cent white muscle. This high-speed sprinting muscle allows sailfish to reach speeds of over 62 miles per hour. Sailfish also leap out of the water to temporarily reduce drag and boost their speed.

6

5 GREY KANGAROO

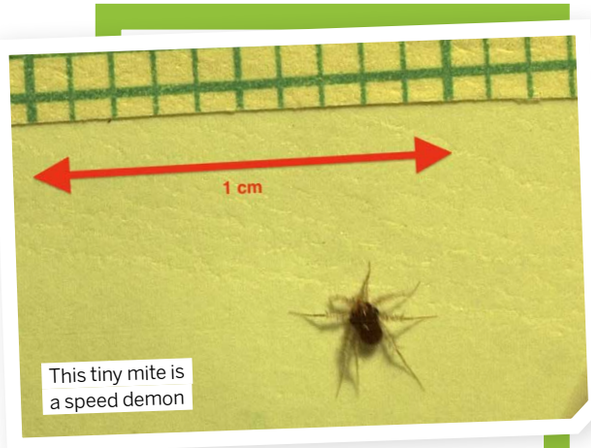
The fastest hopper. Amazingly, kangaroos use the same amount of energy to hop at walking pace as they do at their cruising speed of 25 miles per hour. Kangaroos can sprint up to 44 miles per hour, but the force this puts on their legs is so large that they risk rupturing their tendons.

5

4 PRONGHORN

The fastest endurance runner and the fastest animal in the western hemisphere, the pronghorn has a top speed of 55 miles per hour and can maintain speeds of 35 miles per hour for up to 3.7 miles.

4



This tiny mite is a speed demon

© samuel rubin/pomona college

THE ULTIMATE SPEEDSTER IS TINY

A minute mite is the fastest animal relative to its body size. Clearly the tiniest creatures will have a lower top speed than a cheetah. But if you measure top speed relative to body size, the fastest mover is actually a mite called *Paratarsotomus macropalpis*. This mite is just 0.7 millimetres long – smaller than a sesame seed – but has recently been discovered to sprint at 322 body lengths per second. That's equivalent to a human running at 1,300 miles per hour. The mite's speed relative to its size is also nearly double that of the Australian tiger beetle, previously thought to be the fastest creature, which reaches a comparatively puny 171 body lengths per second. To put this into perspective, despite its high top speed, a cheetah can only manage 16 body lengths per second.

A team of researchers led by Samuel Rubin at Pomona College in California were actually studying the creature's muscle biochemistry when they discovered the surprising result. They used high-speed cameras to film the mite, endemic to California, as it scuttled across concrete, and then analysed the footage. As well as its impressive top speed, *Paratarsotomus macropalpis* can also turn and stop extremely quickly. It can even run across concrete that's as hot as 60 degrees Celsius, a temperature that would be lethal to many beasties.

DID YOU KNOW?

The slowest animal on Earth is coral, as it never moves

"The difference is the cumulative effect of dozens of subtle engineering improvements"

© Shutterstock

STAR SHREDDER

WORDS ANDREW MAY

How galactic black holes form and grow in the centres of galaxies, tearing nearby stars to shreds in one of the most extreme physics events in the cosmos

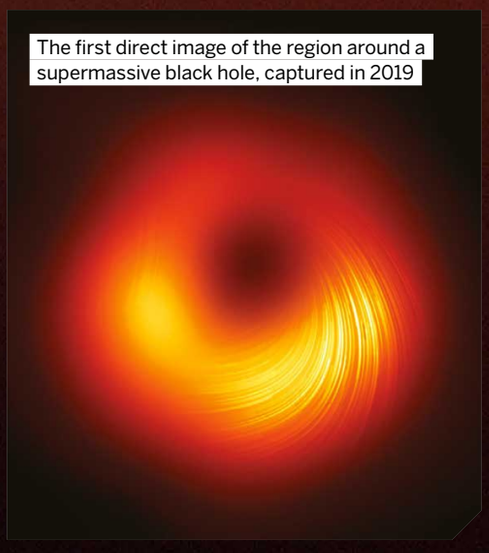


DID YOU KNOW? A black hole's gravity is so strong that not even light can escape – that's how it gets its name

S

Black holes are among the most mysterious and fascinating – and, some might say, frightening – objects in the universe. Yet as recently as 60 years ago, astronomers spent very little time thinking about them. There were two good reasons for this: observationally they were considered almost impossible to detect, and theoretically they displayed such bizarre properties that many people simply refused to believe they existed. The situation began to change, however, with the first unambiguous detection of a black hole in 1972, and since then they have played an increasingly central role in our understanding of the universe. Astronomers have made detailed observations of thousands of black holes using state-of-the-art instruments like NASA's Hubble Space Telescope and James Webb Space Telescope (JWST), soon to be joined by the latest addition to the roster, the Nancy Grace Roman Space Telescope.

This new telescope will be especially well suited to studying a particular class of 'star-shredding' black holes, but before we look at exactly what these are and how they can be found, it's worth taking a broader look at the physics of black holes to see just what makes them so unique. The key lies in one of the most fundamental properties of the universe: gravity. This acts like an inexorable force between any two objects that draws them together, no matter how far apart they are. It's gravity that pulls all the constituent parts of planets, stars and galaxies together, while other forces and physical effects push outwards, in the opposite direction, to



The first direct image of the region around a supermassive black hole, captured in 2019

© NASA / European Southern Observatory

balance gravity and produce a stable, long-lived structure. At one time, people imagined the universe must have a built-in rule saying that this kind of balance always has to be achieved, because the alternative – that gravity would just keep on pulling material closer and closer together till it was all concentrated in an infinitesimally small point – was so unthinkable. But it turns out that no such rule exists, and the 'unthinkable' happens all the time – the result being a black hole.

Although it's valid enough to describe gravity as a 'force' in everyday situations, when it's put through a rigorous mathematical treatment it emerges as something completely different, often described in distinctly science-fictional sounding terms as a 'curvature of space-time'. This theory was first worked out by Albert Einstein in 1916, and then applied the following year by another German physicist, Karl Schwarzschild, to the specific case of what we would now call a black hole. He defined a sphere, since dubbed the event horizon – whose diameter, governed by the black hole's mass, is what we usually mean by the 'size' of the black hole – outside of which the universe is not too different from what we're familiar with in other astrophysical situations. Once past the event horizon, however, the well-known laws of physics start to break down – and at the very centre, called the singularity, space and time become infinitely curved and effectively cease to exist.

All this remained a theoretical curiosity until 1939, when a pair of American physicists – including Robert Oppenheimer, who would soon become notorious as the father of the atomic bomb – showed that above a certain mass, a star's gravity would eventually cause it to collapse down to something very like the 'singularity' described by Schwarzschild. This provided the first credible theory for how a black hole might be formed, so perhaps it's no surprise that the first examples to be found by observational astronomers in the 1970s were in this 'stellar-mass' category. As the name suggests, a black hole doesn't emit any light of its own, but if it's located close to an easily

DID YOU KNOW?

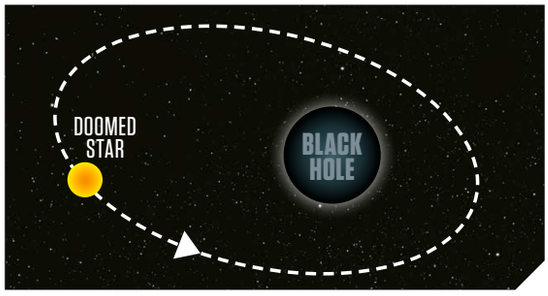
Isaac Newton first linked tides to gravity theory



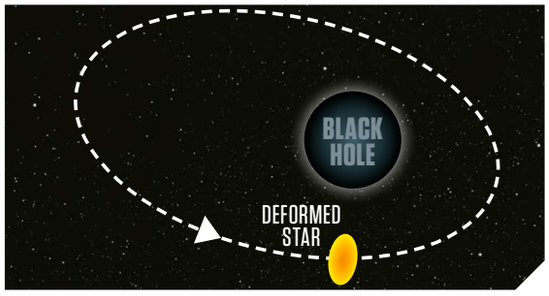
Karl Schwarzschild devised the first mathematical description of what we now call a black hole

TIDAL DISRUPTION EVENTS

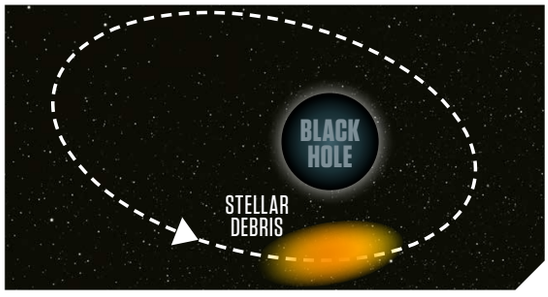
Here's how a supermassive black hole can shred a star that gets too close



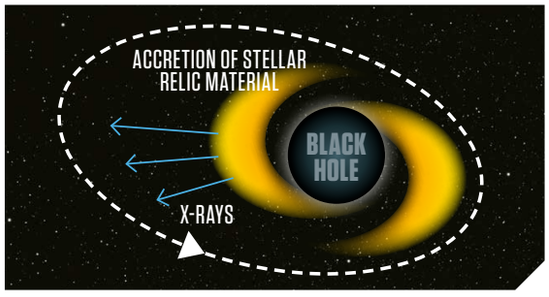
1 APPROACHING PHASE
The star is captured into an elliptical orbit. At large distances, the black hole's gravity is similar across the whole star, so tidal effects are insignificant.



2 TIDAL DEFORMATION PHASE
As the star gets closer to the black hole, it begins to feel a difference in gravity between one side and the other, causing a distortion of its shape.



3 TIDAL DISRUPTION PHASE
Eventually, the tidal forces become stronger than the star's own gravity, which is no longer able to hold it together. As a result, the star is torn apart.



4 ACCRETION AND FLARE PHASE
The shredded remains of the star spiral into the black hole, generating a burst of X-rays and other radiation that may be seen by astronomers on Earth.

BLACK HOLE STATS

CYGNUS X-1
DISTANCE
7,000 light years
MASS
21 solar masses

SGR A*
DISTANCE
27,000 light years
MASS
4 million solar masses

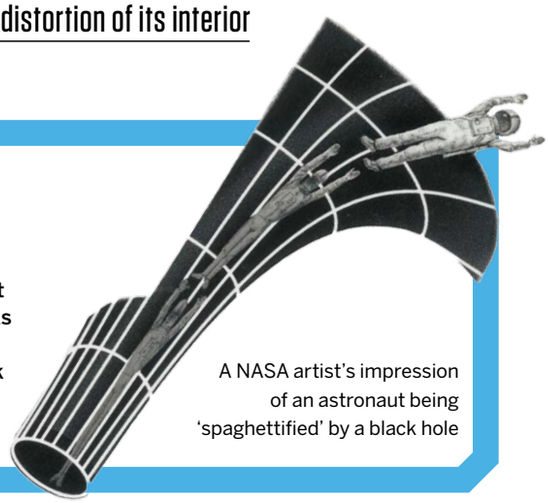
NGC 7727
DISTANCE
89 million light years
MASS
154 million solar masses

TON 618
DISTANCE
11 billion light years
MASS
66 billion solar masses

DID YOU KNOW? Jupiter's moon Io has intense volcanic activity due to heat generated by tidal distortion of its interior

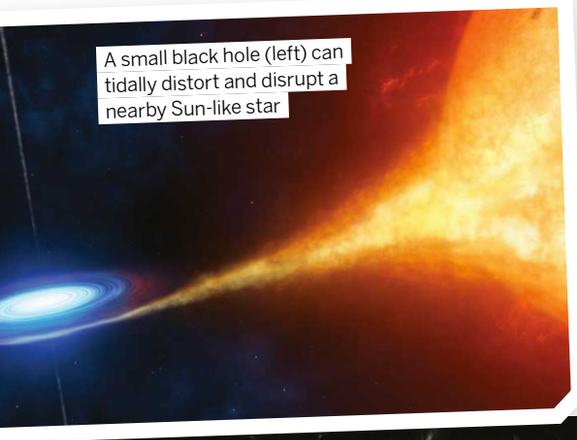
SPAGHETTIFICATION

Tidal forces are strongest when the distance to the object exerting the gravitational pull is relatively small compared to the size of the body being acted on. That's why Earth feels a stronger tidal effect from the Moon than from the Sun. Because the event horizon of a black hole is so small, it's possible to get close enough to it that there's an appreciable difference in gravity between, say, a falling astronaut's feet and head. The result, as Stephen Hawking famously pointed out, is that the astronaut is stretched out like spaghetti. As fanciful as this situation is, the same principle applies to stars falling into supermassive black holes – a process astronomers have given the whimsical name of 'spaghettification'.



A NASA artist's impression of an astronaut being 'spaghettified' by a black hole

visible object, such as a star, then it's often possible to detect it from the gravitational effect it produces. For example, if a stellar-mass black hole orbits around a normal star, its gravity can pull mass off the latter into a super-hot rotating disc, which can then be detected via the X-rays it emits.



A small black hole (left) can tidally distort and disrupt a nearby Sun-like star

Around the same time the first stellar-mass black holes were discovered, there was another theoretical development that was triggered by an observational mystery. Since the early 1960s, astronomers knew of extremely distant galaxies, dubbed quasars, that blasted out far more energy than could possibly be accounted for by their stellar content. And there were other, closer galaxies that were observed to have mysterious active nuclei whose energy source couldn't easily be explained. It was hypothesised that these galaxies had 'supermassive' black holes at their cores that were producing all this energy by constantly gobbling up stars and gas. These black holes are called supermassive not because they're huge – they aren't, by galactic standards – but because they pack an unimaginable amount of mass into a relatively tiny volume. For example, a typical supermassive black hole might have an event horizon roughly the size of the Solar System, yet contain as much mass as a billion stars – comparable to a respectable dwarf galaxy in its own right.

At first, it was assumed that supermassive black holes were the exception rather than the rule, only occurring in galaxies where ongoing high-energy activity was clearly visible. With the launch of Hubble, more subtle clues – such as the anomalously high speeds of stars deep inside galactic nuclei – indicated that most, if not all, perfectly ordinary galaxies also have supermassive black holes lurking in their central regions. It's assumed that these grew to their present size by steadily accreting matter from surrounding stars, but the precise mechanism and timescale for this process is still an active area of study. Of particular interest are 'tidal disruption events', in which a supermassive black hole shreds a passing star and swallows its remains, resulting in a flare-up that can outshine the host galaxy for several months. It's this kind of event that NASA hopes its new Roman Telescope will excel at finding.



A Hubble image of two tidally interacting galaxies, informally known as 'the mice'

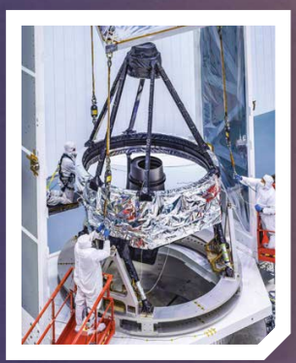
WHAT ARE TIDAL FORCES?

Tidal forces are an important physical effect that occurs on various scales throughout the universe. They can also be called 'differential gravitational forces', which is more of a mouthful but a better description of how they work. Because the pull of gravity weakens with distance, it's different on one side of an extended body than the other. So rather than staying in a fixed shape, the body tends to be stretched or distorted. The best known example is the way the Moon's gravity pulls more strongly on one side of the Earth than the other, causing the oceans to bulge out and creating the tides. That's where the name 'tidal force' comes from, since tides were known long before the gravitational explanation was worked out. Now, however, astronomers have seen tidal forces in action everywhere from binary stars to groups of galaxies – and, of course, black holes.

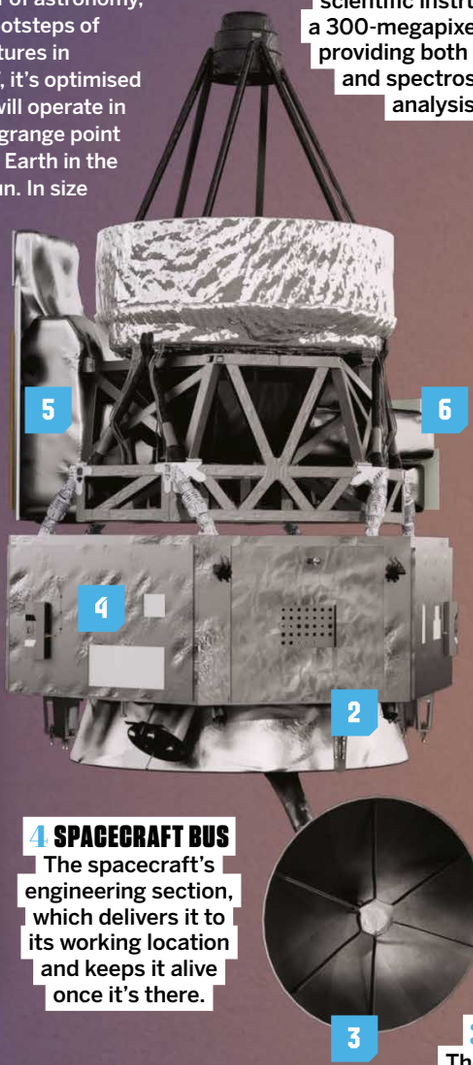
© Alamy / Shutterstock / NASA

THE NANCY GRACE ROMAN SPACE TELESCOPE

Named after NASA's first chief of astronomy, this telescope follows in the footsteps of Hubble and JWST and has features in common with both. Like JWST, it's optimised for infrared wavelengths and will operate in the same region of space – Lagrange point L2, about 930,000 miles from Earth in the opposite direction from the Sun. In size and appearance, however, Roman is more like Hubble, with a main mirror of the same diameter, 2.4 metres. It's not an exact clone of Hubble's mirror, though, because it has a much shorter focal length. Just like winding in the zoom lens of a camera, this gives the new telescope a much wider field of view. This will allow it to see 100 times as much sky as Hubble in a single observation, making it ideal for rapid deep-sky surveys.

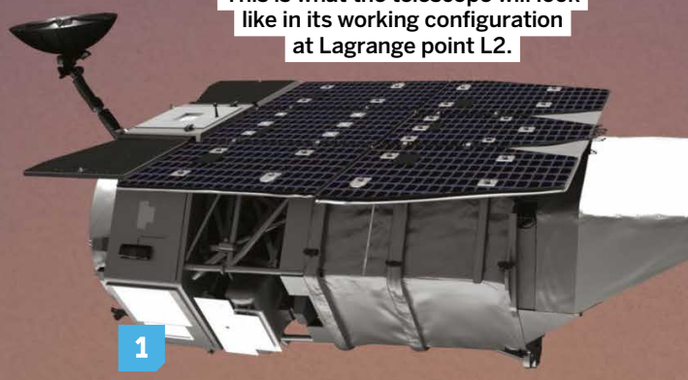


The Roman Telescope's optical system, including its huge mirror, seen under construction



5 WIDE-FIELD INSTRUMENT
This is Roman's main scientific instrument – a 300-megapixel camera providing both imaging and spectroscopic analysis.

1 OPERATIONAL SPACECRAFT
This is what the telescope will look like in its working configuration at Lagrange point L2.



6 CORONAGRAPH
Roman's secondary instrument, this will block out light from specific stars in order to view any planets orbiting them.

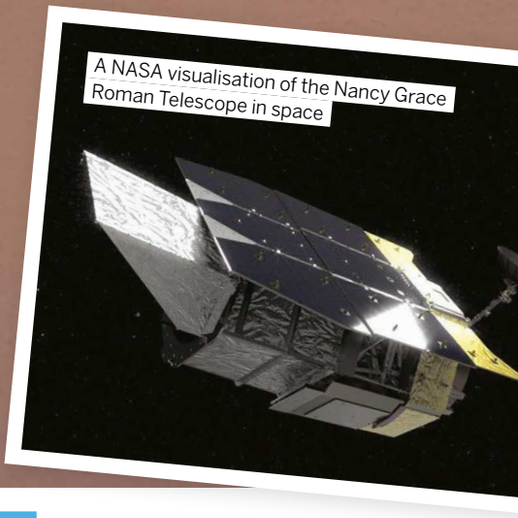
4 SPACECRAFT BUS
The spacecraft's engineering section, which delivers it to its working location and keeps it alive once it's there.

2 SPACECRAFT INTEGRATED PAYLOAD ASSEMBLY
The core of the spacecraft, containing both the propulsion system and the telescope itself.

3 HIGH-GAIN ANTENNA
The main communications system, receiving commands from Earth and sending back observational data.

INSIDE NASA'S NEW SPACE TELESCOPE

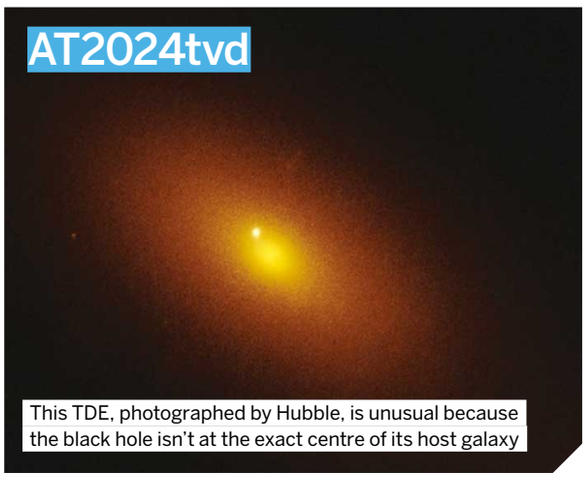
Looking a little like Hubble, Roman's internal systems embody four decades of technological progress



A NASA visualisation of the Nancy Grace Roman Telescope in space

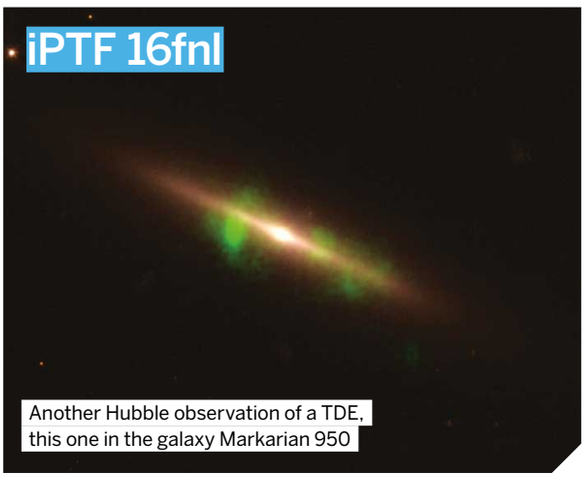
A GALLERY OF TDEs

Over 100 tidal disruption events (TDEs) have been observed to date – here are a few of them



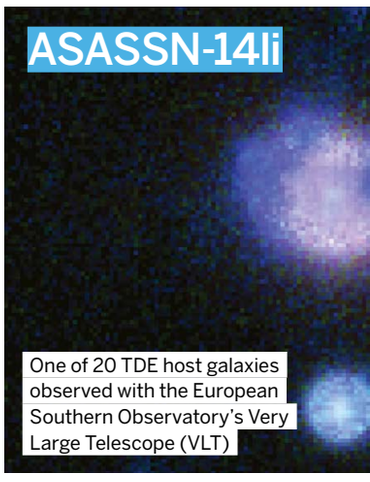
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This TDE, photographed by Hubble, is unusual because the black hole isn't at the exact centre of its host galaxy



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Another Hubble observation of a TDE, this one in the galaxy Markarian 950



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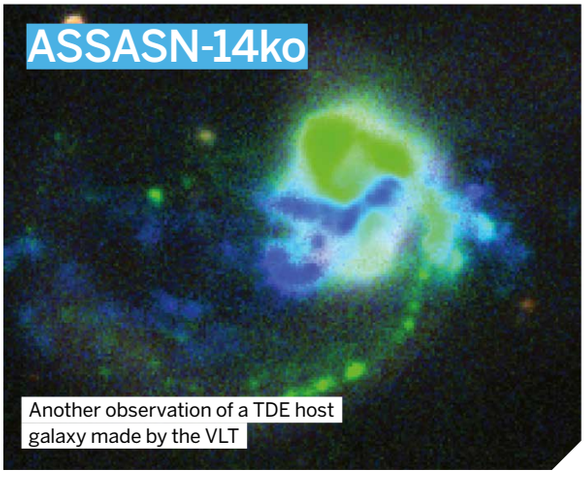
One of 20 TDE host galaxies observed with the European Southern Observatory's Very Large Telescope (VLT)

DID YOU KNOW? Roman's mirror was built for a spy satellite and was donated to NASA when its original mission was cancelled



"A flare-up can outshine the host galaxy for several months"





Another observation of a TDE host galaxy made by the VLT

HOW TO OBSERVE A TDE

We speak to Rebekah Hounsell, a member of NASA's Nancy Grace Roman Space Telescope team

When astronomers talk about observing tidal disruption events around supermassive black holes, what is it they actually see and measure?
A TDE is caused when a star gets too close to a black hole and gets ripped apart by its gravity. Stellar debris from the star then falls onto the black hole, causing a flare and the release of multi-wavelength electromagnetic radiation, which astronomers observe. This radiation ranges from ultraviolet and X-ray to optical, infrared and radio. The time series that would be observed is that of a very luminous object which gradually fades out over time. The rate of fading is thought to be related to the time it takes for stellar debris to fall back towards the black hole.

Why is the Roman Space Telescope particularly suited to this kind of observation – more so than, say, Hubble or JWST?
Because Roman has a wide field of view and acts as a survey telescope, it means that it will observe many stars for a given pointing on the sky. This means there's a greater likelihood of capturing these fast-evolving objects. It also observes in the near-infrared, which means that it can look at what's called the dust echo that can occur when high-energy radiation interacts with surrounding cosmic dust, heating it up. This leads to an infrared signature that can be observed and would be detected by Roman.


Hounsell is a research astrophysicist at NASA's Goddard Space Flight Center

How often do you anticipate observing this kind of event?
With Roman's large field of view, the number of TDEs to be detected will likely be in the order of 100 per year. Many of these will be very distant, so will transform our understanding of these events and black holes in the early universe.

"The number detected will be in the order of 100 per year"

© NASA / European Southern Observatory

WHAT IS A SPACEPORT DRONE SHIP?

These rocket-recovering ocean vessels make space launches more sustainable



SpaceX is the primary operator of autonomous spaceport drone ships

WORDS AILSA HARVEY

A space launch is a mesmerising spectacle, demonstrating raw power as a rocket launches hundreds of thousands of kilograms of machinery and explosive fuel into the sky. Parts of these rockets often fall from the spacecraft during the initial takeoff, including the rocket booster – a first-stage propulsion system that provides extra thrust during the ascent. However, this part of the rocket doesn't need to crash down to Earth and be destroyed. To retrieve these parts without damage, large empty platforms wait far out in the ocean to catch rocket boosters in a controlled fashion. These platforms are called autonomous spaceport drone ships (ASDSs) and are modified barges with thrusters to keep them still and steady. They convert patches of sea into temporary landing zones.

Before a space launch, an ASDS is towed to a specific calculated location beneath the rocket's flight path. The exact location depends on the rocket's payload weight, trajectory and destination. The booster and the drone ship are programmed to meet at this specific point. During a mission, engineers on land continuously receive information from the drone ship, through high-definition cameras and onboard sensors, to monitor conditions.

Once the booster has been secured, support vessels are sent out to the platform to help return it to port. Once there, cranes will offload the booster so that it can be inspected and refurbished for its next flight. Without ASDSs, rocket launches would be much less efficient and sustainable, and rocket boosters would be lost to the ocean, constantly needing to be rebuilt.

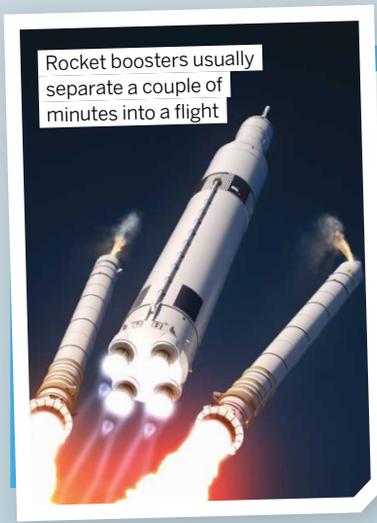
PLATFORM PARTS

How these landing platforms are built for careful touchdown



1 LANDING DECK

The platform is built with a heat-resistant steel deck to withstand the rocket's heat during the final landing burn.



Rocket boosters usually separate a couple of minutes into a flight

WHY NOT LAND ON LAND?

Many rockets return to Earth using powered vertical landing methods. After separating from the upper stage, the rocket fires its engines to reverse its direction and slow its descent through the atmosphere. But why do so many of these land at sea? When a rocket lifts off, most of the fuel is spent leaving Earth's atmosphere. By the time the first-stage booster separates from the rocket, it can be hundreds of miles away from where it launched. To return to this spot would use a lot of fuel. To be more efficient, rockets land at sea, along the flight path, to be met by a drone ship. A drone ship's computer-controlled thrusters hold it in a specific position, even when the sea is turbulent, so it can be in the right spot for the landing.

DID YOU KNOW? SpaceX has completed over 400 Falcon booster landings on drone ships

7 AUTONOMOUS CONTROL
No one is on board during a landing. Sensors and remote supervision mean that the drone ship and rocket align autonomously.

5 COMMUNICATIONS
Antennae are used to communicate with mission control and remotely supervise the vessel.

4 DIESEL GENERATORS
Diesel generators provide electricity for the thrusters, computers and communication equipment.

3 THRUSTERS
Powerful thrusters beneath the ship push the vessel into position and keep it within a few metres of its target location.

2 LANDING CIRCLE
The painted target guides the rocket booster to a precise touchdown. Onboard computers aim for this target.

6 SAFETY PERIMETER
The landing area, marked by a painted border, is kept clear of equipment to avoid collisions.

DID YOU KNOW?
Octagrabber is nicknamed 'Roomba' due to its flat disc shape

"The booster and the drone ship are programmed to meet at this specific point"

MEET OCTAGRABBER

Once a rocket lands on the floating platform, it needs to be steadied quickly to prevent it toppling into the sea. This is where Octagrabber lends a helping hand – or four. Octagrabber is a remotely operated robot that latches onto rockets to secure them. Working remotely is essential for safety, as the freshly landed rockets are usually extremely hot and might still contain some highly flammable rocket propellant. The robot's hydraulic mechanisms clamp onto the rocket. Then, once secured, engineers can transport and inspect the booster more safely and restore it for reuse in a future launch. Octagrabber is designed to attach to Falcon 9 rocket boosters. The base of this rocket that the robot's arms attach to is called the Octaweb, which is how Octagrabber gained its name.



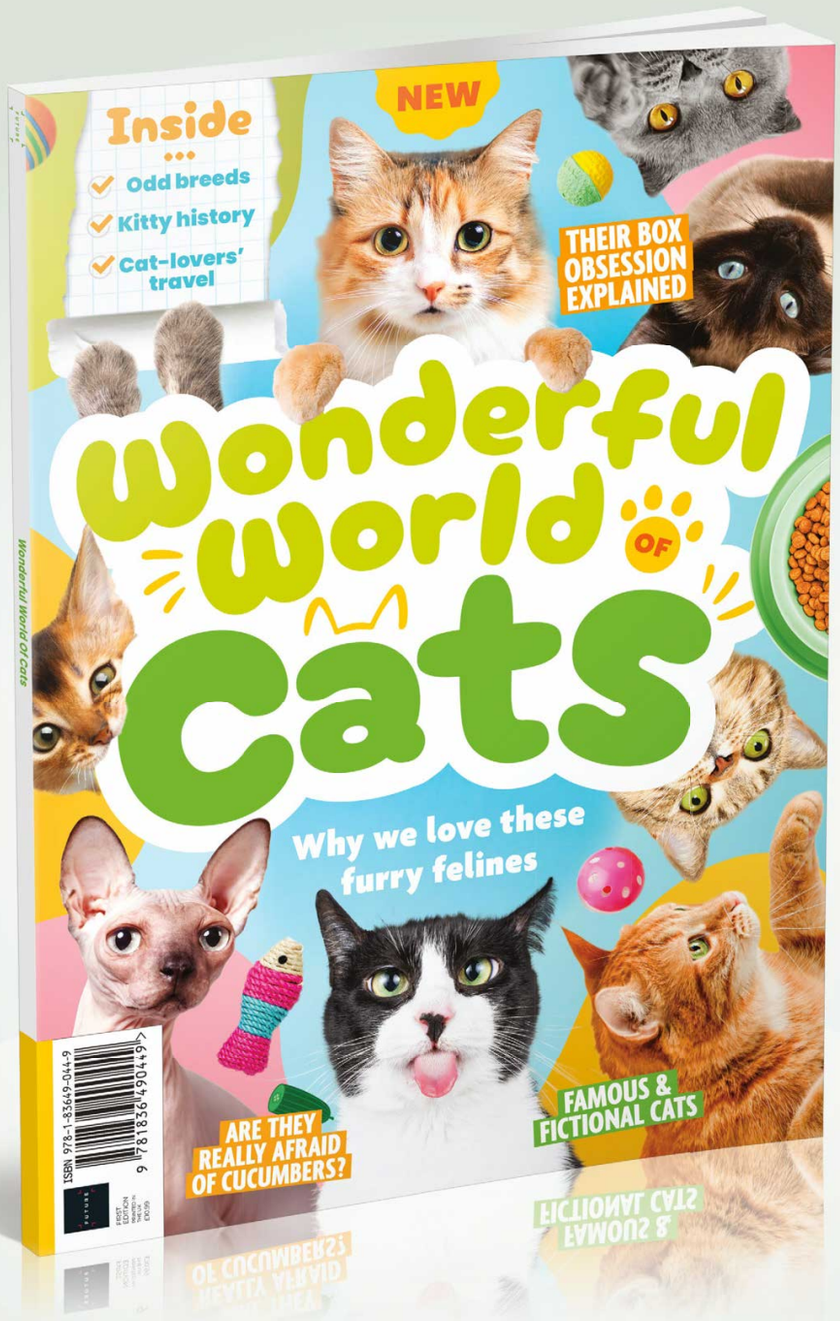
Before Octagrabber, a team would have to manually secure boosters

© Getty / Shutterstock / SpaceX

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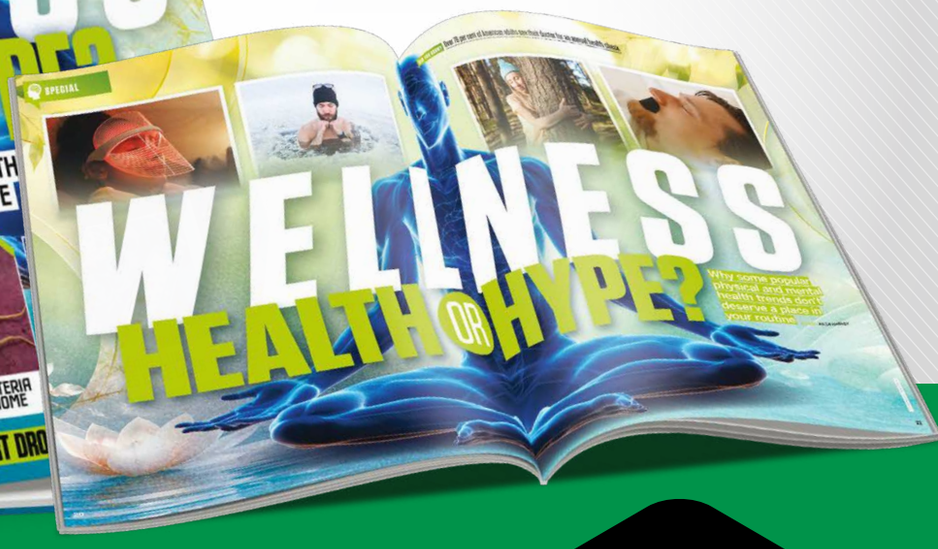
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BRAINDUMP

Amazing answers to your curious questions

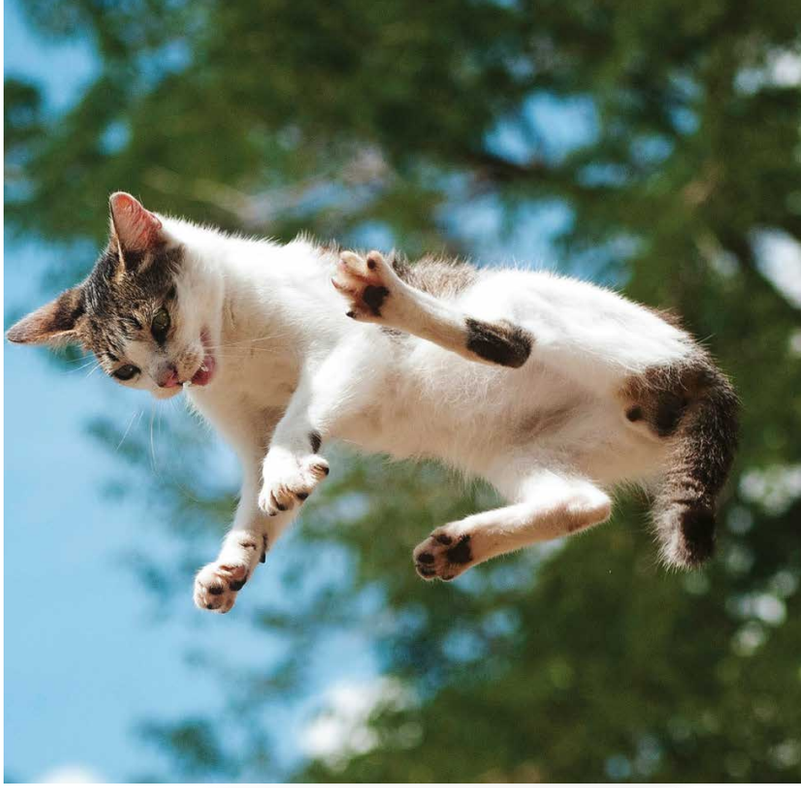
Is there a boundary between the core of the Earth and the mantle?

There seems to be a very definite transition at a depth of around 1,801 miles, known as the core-mantle boundary. We don't know for sure what's going on inside our planet, but by looking at how seismic waves travel through the Earth, scientists have a pretty good idea. Secondary seismic waves, known as S-waves, can't travel through liquids, and at the core-mantle boundary they abruptly disappear, indicating that they have moved from a solid (the mantle) into a liquid (the core). The boundary region contains patches known as ultra-low velocity zones, which are thought to contain high levels of iron that make them very compressible, giving them their strange wave-slowing properties.



WHY IS SEAWATER SALTY?

Most of the salt in the oceans comes from a process that takes place on land. Rainfall contains carbon dioxide from the atmosphere, making it acidic. As the rain erodes rocks on land, it releases ions – atomic particles that carry an electric charge. Rivers and streams eventually carry these dissolved ions out to the ocean. Some are removed from the water by various plants and animals, while other ions – mainly sodium and chloride – remain and become more concentrated. These two ions are what make seawater salty. It's estimated that if all of the oceans evaporated and their salts were spread evenly over the surface of the Earth, it would form a 152-metre-thick layer.



WHY DO CATS ALWAYS LAND ON THEIR FEET?

When they take a tumble, cats move their front and back limbs separately to create spin (angular momentum) and right themselves in mid-air. This feat requires great flexibility. First, a falling cat uses its eyes and inner ear to work out which way is down. It then stretches out its hind legs while pulling in its front legs. Turning its rear end slightly one way, it twists its front end in the other direction until its front paws are facing down. From this position, it tucks in its back legs and swivels them around, enabling it to stretch all four limbs towards the ground.



WHICH ORGANISM HAS THE SMALLEST GENOME?

Nasuia deltocephalinicola is a symbiotic bacterium that lives in the abdomen of leafhopper insects. It has just 112,000 base pairs (the building blocks of DNA) compared to our 3 billion.



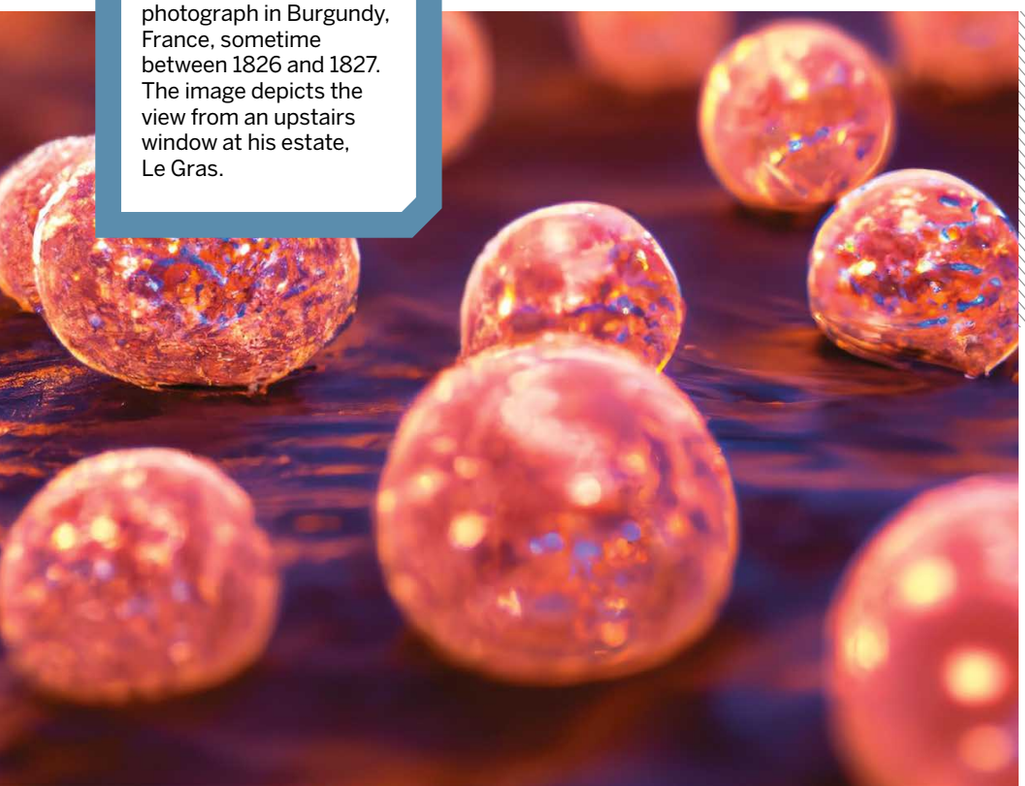
WHERE WAS THE WORLD'S FIRST PHOTO TAKEN?

Joseph Nicéphore Niépce took the first known photograph in Burgundy, France, sometime between 1826 and 1827. The image depicts the view from an upstairs window at his estate, Le Gras.

DO HORSE CHESTNUTS REALLY KEEP SPIDERS AWAY?

There's no evidence to back up the claim that conkers repel spiders. In 2009, the Royal Society of Chemistry (RSC) offered a prize to anyone who could provide proof of this old wives' tale. One theory was that a chemical in horse chestnuts might smell unpleasant to arachnids. But with nobody able to substantiate the claim, the RSC concluded it was false, awarding its prize to schoolchildren who had conducted a number of experiments suggesting spiders were indifferent to horse chestnuts. Instead, lemon juice or essential oils may be a more effective natural spider repellent.





How do we become resistant to antibiotics?

It's not us that become resistant, it's the bacteria we are trying to kill. Bacteria multiply quicker than other organisms and have simpler genomes, so random mutations happen more often. Some of those might give them a tougher cell wall or a way to metabolise a toxin. Low doses of antibiotics given to farm animals, and as medicine to humans who don't really need it, provide an environment that only kills the weaker bacteria. The ones that are left are those with the genes for antibiotic resistance, so they go on to multiply and spread those genes.

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BRAINDUMP



WHAT'S THE DIFFERENCE BETWEEN HORNS AND ANTLERS?

Horns, unlike antlers, are a permanent fixture, and are really an extension of the animal's skull. They are typically found on bovine animals like cattle, antelope and bison. Most horns are made up of bone surrounded by proteins and keratin, the same stuff our hair and nails are made of. Antlers, on the other hand, which are commonly sported by male deer, reindeer and moose, will grow and shed seasonally in order to attract a mate and ward off potential competition during the mating season. They grow from the pedicle, which is positioned above the animal's skull, and are made up entirely of bone.



How is tequila made?

Tequila is only produced in the region of Tequila in Mexico. It originates from the blue agave plant, which can take between eight and ten years to fully mature. Once ripe and ready for harvesting, the agave's core, known as the piña, is extracted. A piña can weigh over 90 kilograms, and each litre of tequila requires around seven kilograms of piña to produce.

At the distillery stage, the piña hearts are split open and roasted in large ovens in order to break their complex starches into sugars. The released liquid is then sealed within large steel vats for fermentation, where yeast is added. Fermentation can last hours or even days, and the fermented juice, or mosto, as it's known, will have a low alcohol content at this stage. In order to increase the volume of alcohol, the mosto is distilled twice, heating the liquid to alcohol's vaporisation point before cooling and condensing it. Purified water is then added to dilute the tequila for a 40 per cent alcohol content, and it's either bottled immediately or transferred to wooden barrels in order to age for up to three years.



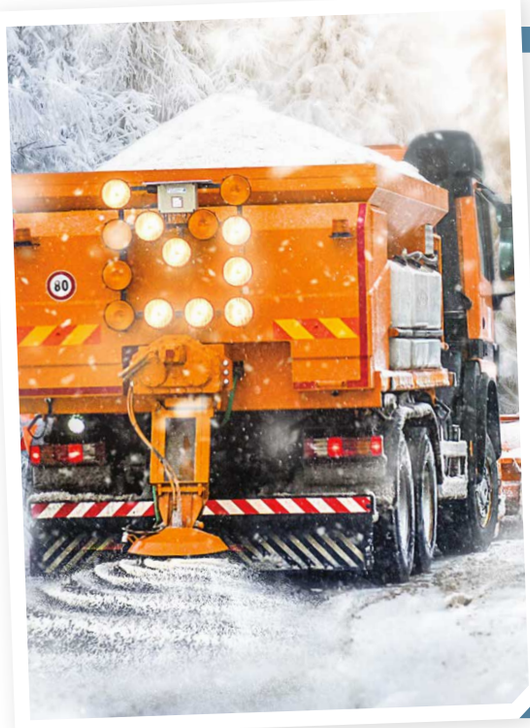
WHAT PET IS THE WORLD'S FAVOURITE?

Dogs are the most popular household pet in the world in 2026, outnumbering cats by as many as two to one. It's estimated that there are up to a billion dogs being kept as pets around the world.



WHICH COUNTRY HAS THE OLDEST FLAG?

Denmark's flag, called the Dannebrog, was adopted in the 17th century, making it the world's oldest continuously used flag. Its cross-shaped design inspired the flags of other Scandinavian countries.



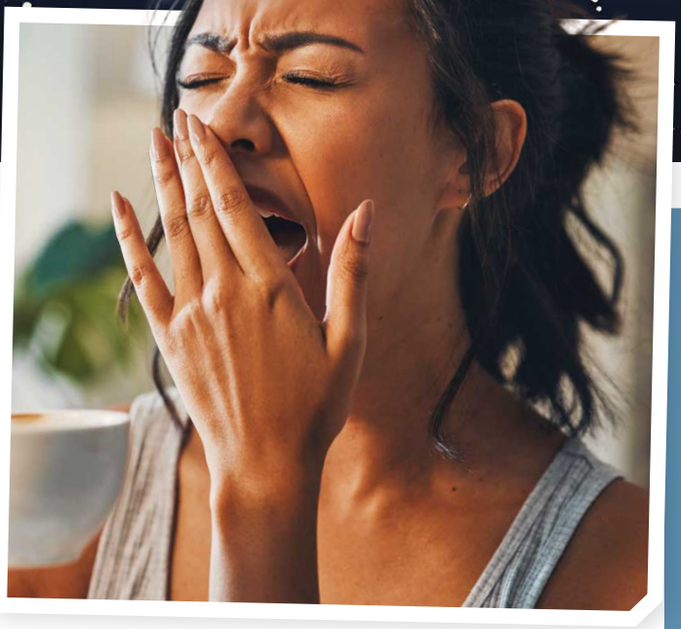
HOW DOES SALT MELT ICE ON THE ROADS?

We spread granulated salt on icy roads because it lowers the freezing and melting temperature of water. When water cools to zero degrees Celsius or below, it freezes into ice. But when you add salt, the water must be at a much lower temperature to freeze. For example, a 20 per cent salt solution would freeze at -16 degrees Celsius instead. If you sprinkle salt on ice that's formed on the road, it will dissolve into the liquid water film on the surface of the ice and ultimately melt it.

There is a limit, however. If the road temperature is lower than -9 degrees Celsius, the salt cannot penetrate the surface of the ice to begin the process of melting it. Some colder places add calcium fluoride to their road salt mixture at these frosty temperatures, which allows for melting at slightly lower temperatures.

Why do stars twinkle?

Stars twinkle when it appears that there are variations in their brightness. Astronomers call this phenomenon atmospheric scintillation, and it's caused by motion in the atmosphere. Specifically, changes in atmospheric temperature cause small fluctuations in the air's density. As starlight passes through the atmosphere, it's refracted, or slightly alters direction, creating a twinkling effect. Atmospheric scintillation is more obvious when viewing stars closer to the horizon, because there's a thicker layer of atmosphere. Astronomers compensate for atmospheric scintillation by using special adaptive optics on the most sophisticated telescopes. Space-based observatories like Hubble allow us to view stars and other objects without atmospheric scintillation.



WHY DO WE YAWN?

Yawning involves a deep, involuntary intake of breath, and until recently, the most popular explanation was that it increased the supply of oxygen to the brain. However, this idea didn't hold up to testing, and there's mounting scientific evidence to suggest that yawning has more to do with temperature than with oxygen. As the temperature rises in our brains, concentration and memory suffer, and a number of different tests in humans and animals have shown that yawning is actually linked to heat, and increases when our brains are getting too warm. The idea is that by taking a deep breath of cool air, brain temperature drops back down, increasing alertness.

WHY IS GLASS TRANSPARENT?

Let's consider the opposite situation first. When light strikes something opaque, such as a brick, the photons interact with the electrons of the atoms in the brick. The energy in each photon can promote an electron to a higher energy level, but the laws of quantum mechanics say that it's all or nothing – the electron must jump all the way up to the next energy level or stay where it is – there's no in-between. If the photon has the right energy, the electron jumps up a level and the photon is absorbed. In brick and most other materials, that's easy to do, because the next energy level is in easy reach, and so most photon wavelengths are absorbed. Glass just happens to have a big gap up to the first available energy level, and the photons in visible light don't have enough oomph to boost the electrons this high, so they pass straight through.



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What are sinkholes?

Sinkholes form when water slowly erodes the bedrock underground, until the surface is no longer supported and collapses into the cavity beneath. This occurs most commonly in areas where the bedrock is made of salt or carbonate rocks such as gypsum or limestone, which are particularly susceptible to dissolving. In the absence of surface drainage, water accumulates in the sinkhole, draining through to the subsurface. Cover-subsidence sinkholes create a small depression at the surface, which sinks slowly. Cover-collapse sinkholes are far more dramatic, collapsing in a matter of just a few hours and potentially causing catastrophic damage. One of the most spectacular sinkholes ever seen opened up in Guatemala City in 2010, swallowing a three-storey building. It measured 20 metres across and had a depth of 90 metres. Sinkholes are a natural phenomenon, but human-made changes to drainage flows (such as ground pumping) or land use changes can encourage them to occur.



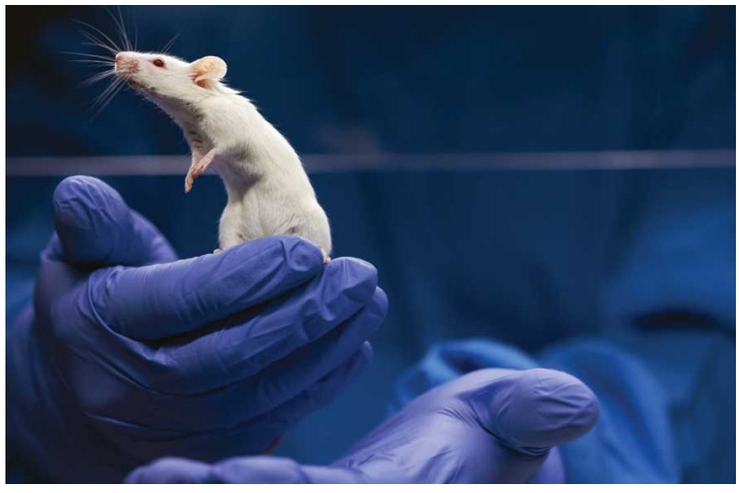


WHAT CAUSES LENS FLARE IN PHOTOS?

Lens flare can be problematic, as it's capable of drastically reducing contrast in an image, as well as introducing halos and scattered polygonal shapes across the frame. That being said, many photographers opt to include lens flare in their photos for artistic effect. It occurs when bright light, such as from the Sun, hits the surface of the lens at an unusual angle as opposed to straight on. This strong stream of light will then reflect and bounce off multiple elements within the lens before finally reaching the sensor, where it will be recorded as part of the picture.

WHY ARE MICE TYPICALLY USED FOR ANIMAL TESTING?

Mice are convenient because they are small, easy to keep and quick to breed. They are mammals, like us, and have 99 per cent of the same genes as us. Mice have been used for long enough now that there are lots of mutant varieties commercially available to researchers that allow them to simulate various human diseases or quickly stimulate the growth of cancerous tumours. Testing medical treatments on mice is generally considered more ethical than using highly experimental drugs on humans, but it's only a first step. Many drugs that cure cancer in mice have turned out to be less effective in humans.





HOW HEAVY IS A CLOUD?

If you consider the weight of the water droplets the average cloud contains, it weighs in at around 500 tonnes. Clouds are made up of tiny droplets of water or ice crystals, suspended in the air. On average, a cumulus-type cloud – the white, fluffy type – has a volume of one cubic kilometre, containing 0.5 grams of water per cubic metre. This adds up to a total of 500 tonnes, although in reality this can vary significantly based on the size of the cloud. Despite this huge weight, clouds still float because the dryer air below them is denser.

WHAT ARE PENGUINS IN THE WATER CALLED?

Penguins in the water are sometimes known as a raft. A breeding group of penguins is generally referred to as a colony, but there's little agreement on collective nouns for other groups.

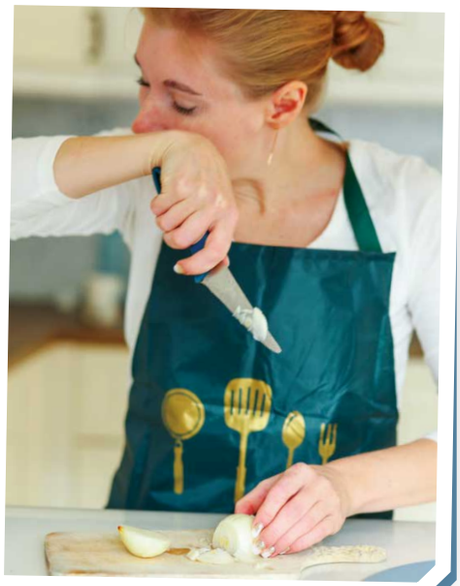


WHY DOES MY VOICE SOUND DIFFERENT ON A RECORDING?

A recording only captures part of the sound of your voice – the part that travels through the air to the microphone. This is the same as the sound that reaches the ears of everyone else, so the recording sounds just like your real voice to them. But when we normally hear our own voices, the sound is a combination of this airborne sound and the sound that travels through the bones of our jaw and skull. This favours the lower sound frequencies, so we hear our voices as deeper and more resonant than the rest of the world does.

WHY DOES CHOPPING ONIONS MAKE YOUR EYES WATER?

Crying over a cut onion is commonplace in the kitchen, but it's all down to a unique chemical reaction. In fact, it starts underground, as a growing onion will naturally absorb sulphur from the earth, creating molecules known as sulphoxides to form. When you cut into an onion with a kitchen knife, you're essentially breaking into its cells, which release certain enzymes. These enzymes react with the sulphoxides, converting them into sulphonic acids. This powerful combination results in the release of a vapour that will irritate your eyes. In order to flush out the irritation, nerve endings in your cornea will inform your brain of the aggravation, which in turn will instruct the lachrymal glands above your eyelids, that regulate the release of tears, to flush it out by making you cry.





How do chameleons camouflage themselves?

Certain species of chameleons have layers of cells called chromatophores that contain different-coloured pigment granules. By moving these granules around, they're able to control their colour. However, this technique is more commonly used as a method to signal emotions than for camouflage, and the species with the best colour-changing abilities tend to use their talents to attract a mate rather than to hide from predators. For most species of chameleons, camouflage works in a similar way to camouflage in other animals, and they have evolved over time to blend in with their surroundings. For example, the mottled colour and spiky shape of the brown leaf chameleon make it almost invisible among dead leaves.

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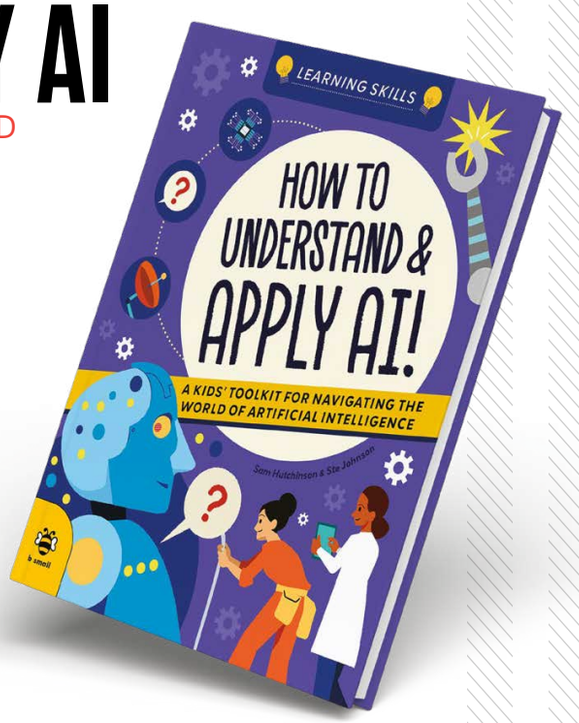
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The latest book releases for curious minds

HOW TO UNDERSTAND AND APPLY AI

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AUTHOR **SAM HUTCHINSON**
ILLUSTRATOR **STE JOHNSON**
PUBLISHER **B SMALL PUBLISHING**
PRICE **£8.99 (APPROX. $12.26)**
RELEASE **1 OCTOBER**



Ask anyone you know to explain in relative detail how a chatbot like ChatGPT can generate images and video, write letters or solve very involved mathematical problems, and even hold sophisticated and human-like conversations, and you'll probably be met with a nonplussed shrug of the shoulders. If you take a look under the hood of a large language model (LLM) like ChatGPT, you'll discover a rabbit warren of daunting digital fields – and the hardware that powers these LLMs is no less technical. According to this book's author, Sam Hutchinson, these are just examples of narrow, or 'weak', AI... which we're assuming is less complicated than 'strong' AI, or artificial general intelligence. In any case, Sam has broken this turgid subject down into 19 double-page chapters on AI for kids.

How to Understand and Apply AI begins with the very basics of the basics, explaining in the most general of terms what AI is, how it learns and how it compares to the way humans sense the world around us, how we learn and how we apply that knowledge. Naturally, there are sections that discuss chatbots or LLMs (the best known examples of AI in the real world) and how they aren't infallible – that chatbots can get things wrong or even completely fabricate content for the sake of answering your question. There's a bit of AI history (shout-out to the original chatbot, ELIZA) and an interesting section on 'AI Wins and Fails', such as when the Deep Blue computer beat chess grandmaster Garry Kasparov, or when an AI was used to take fast food orders and put bacon on ice cream.

> **"Fun vector graphics, a few tables and flowcharts accompany the author's text"**

Fun vector graphics, a few tables and flowcharts accompany the author's text, which explains a complex topic clearly with simple language that anyone can understand. This is especially important because *How to Understand and Apply AI* will be getting extra scrutiny from adults trying to make sense of this new and seemingly omnipotent digital entity – which includes the **How It Works** team.

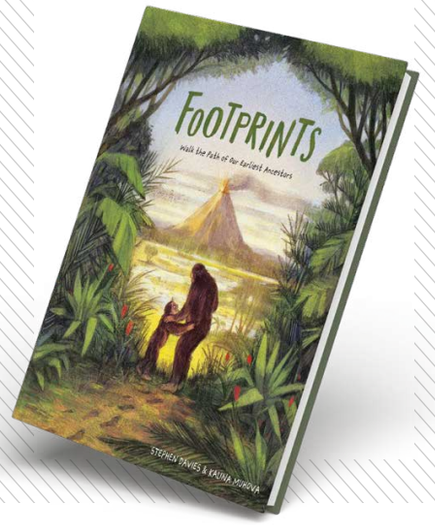
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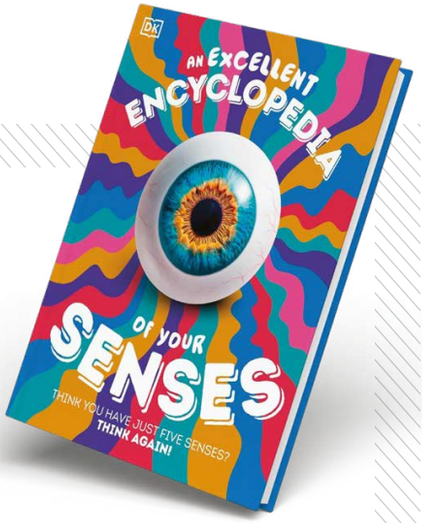
WALK THE PATH OF OUR EARLIEST ANCESTORS

AUTHOR **STEPHEN DAVIES**
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RELEASE **17 SEPTEMBER**

In this book, you'll be taken back millions of years to explore the planet as you've never seen it before – a land with no countries, no borders and just one large landmass surrounded by ocean. As the land began to stretch and break apart, continents formed, including the continent of Africa. This is the continent where the story of humans begins and upon which *Footprints* focuses. Learn about all the creatures that began to roam planet Earth before coming across the footprints of Lucy – an early human ancestor from 3.6 million years ago.

Through immersive comic-style illustrations, you'll delve into the life of Lucy and your ancestors and learn how those who came before you lived. Each page is its own work of art, providing close-up imagery of the faces archaeologists have uncovered in mesmerising detail. This book does an excellent job of highlighting the intricacies of daily life while seamlessly spanning across a massive timeline.





AN EXCELLENT ENCYCLOPEDIA OF YOUR SENSES

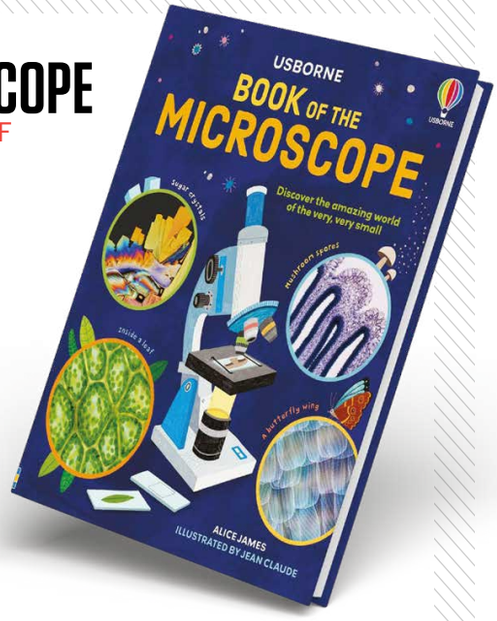
THINK YOU HAVE JUST FIVE SENSES? THINK AGAIN!

AUTHOR **DK**
PUBLISHER **DORLING KINDERSLEY**
PRICE **£25 / $29**
RELEASE **17 SEPTEMBER**

This quirky encyclopedia is both interactive and informative. From sight, touch and hearing to optical illusions and wonderfully weird animal senses, *An Excellent Encyclopedia of your Senses* is far from boring. Each turn of the page is a surprise. Some pages are interactive, with 'make your own' projects and experiments, while others show informative diagrams, and some feature close-up photography of your body in incredible detail. This encyclopedia engages children not only by explaining the science behind each sense, but demonstrating them visually and exploring how senses vary across the animal kingdom. For example, one image of a fruit bowl can be viewed from the eyes of a huge range of species, breaking up the image to look exactly how each species sees it. *An Excellent Encyclopedia of your Senses* is your chance to view the world from different animals' perspectives.

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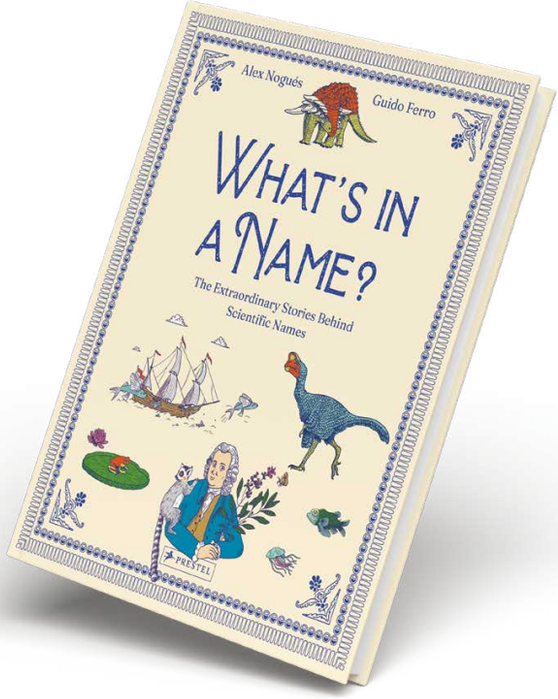
Bringing the microscopic to the masses, the Usborne *Book of the Microscope* looks through the magnifying lens to showcase the magnificent hidden world around us. From cells to minibeasts, readers of this charming and vibrant children's book will be rushing to grab a microscope and gather things from around the house and garden to see what they really look like up close. Along with being an inspiration for scientific investigation, there are heaps of amazing facts and photographs to discover within, plus lots of practical hands-on activities to complete at home. This book is a great way to get your children excited about science, as well as a source of engaging experiments for them to try out. All you need is a basic microscope and you can start peering into leaf pores, watch salt crystals form and identify tardigrades in water droplets.

WHAT'S IN A NAME?

THE EXTRAORDINARY STORIES BEHIND SCIENTIFIC NAMES

AUTHOR **ÁLEX NOGUÉS**
ILLUSTRATOR **GUIDO FERRO**
PUBLISHER **PRESTEL**
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RELEASE **OUT NOW**

Why are plants and animals named the way that they are? If that's a question you find yourself asking, then this inquisitive reference book is a good place to start. Initially taking a dive into the history of taxonomy and the logic behind naming species, *What's in a Name?* is packed full of weird and wonderful backstories of some of nature's curious names. From honouring pioneering naturalists such as Alfred Russel Wallace to celebrating comedian John Cleese and singer Freddie Mercury, you'll discover the human inspirations behind some species names. You'll even discover works of fiction, such as *Moby Dick* and *The Jungle Book*, which inspired the naming of real-world whales and panthers. Each taxonomic tale is told in a humorously illustrated comic-book-strip style, which will be sure to engage a young audience aged ten years or older.



"Full of weird and wonderful stories of some of nature's curious names"

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

MEDIUM

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

HARD

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

Word search

Find the following words

EGG
PENGUIN
BACTERIA
ACID
DRONE
WELLNESS
DIGITAL
OIL
TRACKER
FOLDING
HAVANA
CARDIO

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

What is it?

Hint:

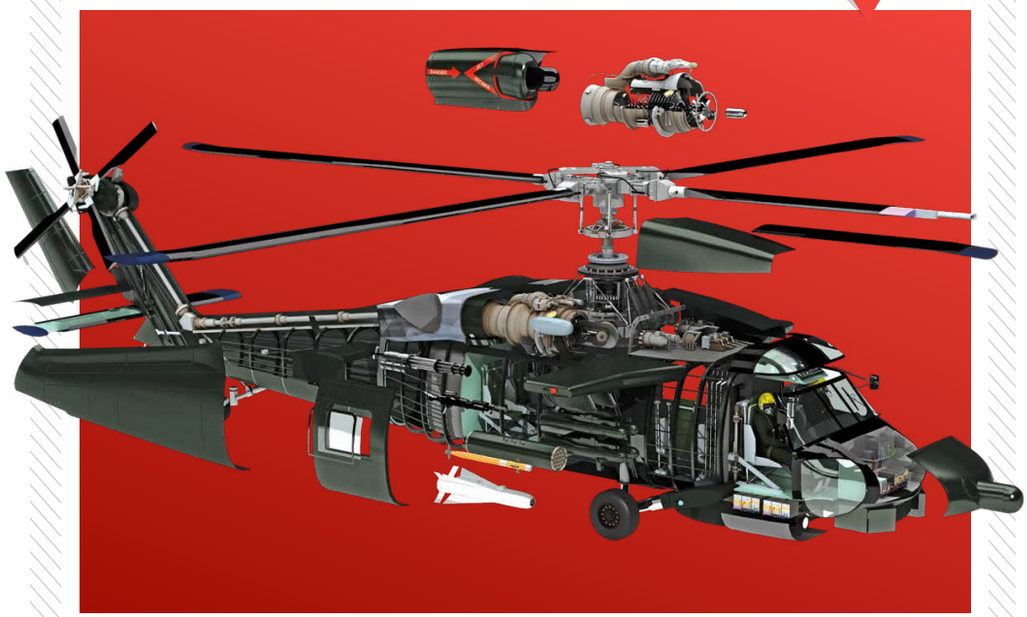
Add heat for a distorted view

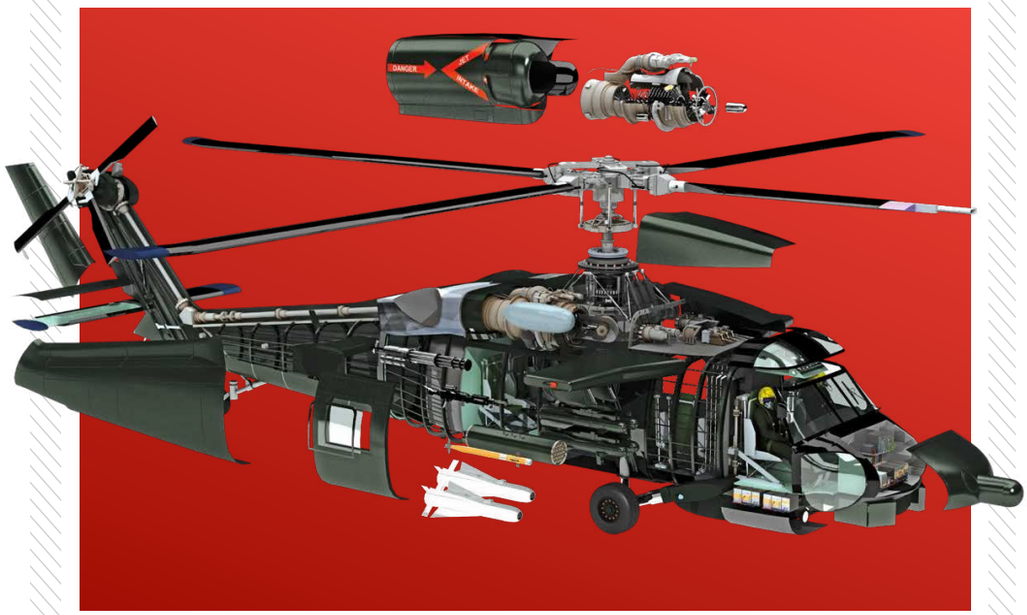
A



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 DOUBLE HELIX
Q2 EARTH'S AXIAL TILT
Q3 4.5 BILLION YEARS
Q4 SATELLITES
Q5 VIOLET
Q6 HORSE



What is it?
A MOLE

Spot the difference



QUICKFIRE QUESTIONS

Q1 How does nuclear fusion produce energy?
- By joining atoms
- By splitting atoms
- By splitting chemicals
- By radioactive decay

Q2 Why do astronomers find Europa, one of Jupiter's large moons, interesting?
- It's covered in trees
- It has a subsurface ocean
- It's made of diamond
- It emits digital signals

Q3 Which organ filters waste products from the blood?
- Heart
- Liver
- Lungs
- Kidneys

Q4 What was the Bayeux Tapestry made for?
- To map Europe
- Depict the Norman conquest
- Record the Black Death
- As a medieval comic strip

Q5 What do petrol engine spark plugs ignite?
- The air-fuel mix
- Coolant
- Diesel
- Burnt exhaust gases

Q6 Which animal's teeth grow throughout its life?
- Rabbit
- Elephant
- Dog
- Human

© Getty

MAKE AN INSTANT SLUSHIE

Turn your drink into a cooling slushie with a couple of kitchen ingredients

KIT LIST

- Ziplock plastic bag or small plastic cup
- Large bowl
- Spoon
- Ice
- Salt
- Juice

1 GATHER YOUR INGREDIENTS

Find all the materials and ingredients needed. Make sure the bag or cup fits inside the bowl with significant space around the outside of it. Any fruit juice should work for this experiment.



2 HALF FILL YOUR BAG

Half fill the bag or cup with your fruit juice of choice. The juice will expand as it freezes, so it leaves room for this process.





3 PLACE INTO THE BOWL

Take the juice bag or cup and place it in the centre of the large bowl.



4 SURROUND WITH ICE

Fill the bowl with ice around the juice until the ice reaches three-quarters of the way up the side of the small cup.



5 SPRINKLE THE SALT

Sprinkle some salt over the ice in the bowl. The ratio should be around one part salt to four or five parts ice. Make sure you don't get any salt in the juice if you're using an open cup.



6 WAIT 30 MINUTES

Wait around half an hour for the juice to change consistency. If you have a no-contact digital thermometer, you can use this to take readings of the ice temperature over time.

DON'T DO IT ALONE!

If you're under 16, make sure you have an adult with you

7 STIR THE JUICE

After 30 minutes, stir the juice. If it isn't yet at the ideal slushie consistency, leave the juice in the ice for a further 30 minutes.





8 DRINK THE SLUSHIE

When you're happy with the slushie's consistency, you can consume the juice and enjoy a refreshing cold beverage.

SUMMARY

In this experiment, you will see how salt changes the behaviour of ice. When in contact with the ice, the salt dissolves in the thin layer of water on the surface of the ice. As a result, the freezing point of the melted water is lowered, and it can become much colder than melting ice usually is. As the salty ice melts, it uses energy to change from solid ice to liquid water. To do this, it takes in heat from its surroundings. This includes the juice in the middle of the bowl. As the ice melts, the juice loses heat and begins to freeze. However, the juice doesn't freeze solid because it contains sugars and other dissolved substances that give it a lower freezing point than water. When cold enough, the water in the juice forms ice crystals. By stirring the juice every 30 minutes or so, the ice crystals remain dispersed enough to provide a slushie texture, as opposed to a solid block of ice.

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

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INBOX
Speak your mind

CLEANING QUERY

Dear **HIW**,
Why does dust appear so quickly after cleaning? How are there so many dirt particles produced so regularly?
Lenny D-S

Dust is constantly being made, as it's a mixture of human skin, hair, carpet fibres, clothing, soil and other tiny fragments. As fabrics rub against each other in the home, they slowly wear down, with tiny pieces being freed into the air and landing on surrounding surfaces. Carpets release fibres as you walk on them and other materials like paper shed microscopic fragments. Eventually, gravity pulls the larger particles down onto surfaces, which are visible when you wipe them during cleaning. Cleaning can never stop dust production, but it temporarily removes this buildup so it doesn't get out of control.



Household dust contains a tiny fraction of cosmic matter



Incense is used in Vietnam to honour ancestors and purify spaces in temples

COLOURFUL BUNDLES

Dear **HIW**,
I was recently in Vietnam and saw lots of colourful bundles of something lining the street. I was told it was incense, but I'd like to know more. How are these made and why are they so bright?
Ceara Jones

It's very likely that what you saw was the production process of incense sticks. In parts of Vietnam, these are made in huge quantities using ancient techniques. One of the most famous places to see incense production is in Quang Phu Cau, near Hanoi. There, thousands of sticks are spread out at the same time to dry in the sunshine. Sticks of bamboo are split and cut to size before being coated with a mixture that will become the fragrance. This mixture usually consists of sandalwood, cinnamon or star anise. These are mixed with a natural binder and water to make a paste, which is rolled onto the bamboo sticks. The bright colours are due to the sticks being dyed before the paste is added. This can be any colour, from vivid reds to pinks and yellows. Red is most significant in Vietnamese culture, being associated with celebration and good fortune. The sticks are left to dry in bundles that fan out so that sunlight can reach them all. The result is an aesthetically pleasing array of bouquets. Once dry, the incense sticks are sorted and packaged for use in homes and temples. When the sticks are alight, they burn slowly while releasing and vaporising the aromatic plant resins.

LETTER of the MONTH

WIN!

AN AMAZING PRIZE FOR LETTER OF THE MONTH

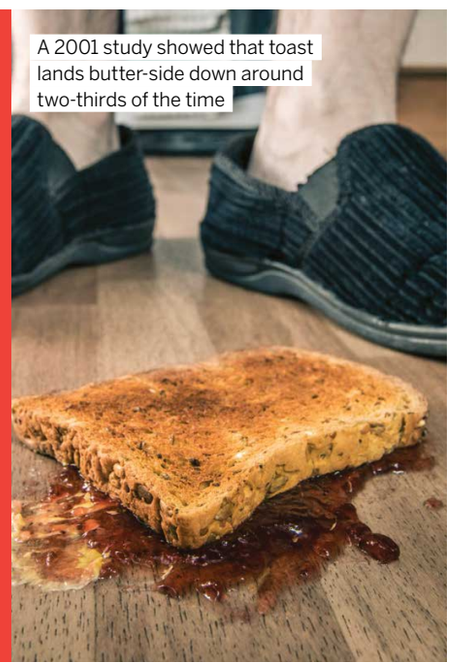
HOW TO UNDERSTAND AND APPLY AI

The clear, simple explanations will help you learn what bias means, spot fake news or hallucinations and understand AI's impact on the planet – good and bad!

BUTTER-SIDE DOWN

Dear **HIW**,
I don't think I've ever dropped toast without it landing butter-side down. Is this just my luck, or is toast more likely to land on the buttered side?
Ben Fisher

It might seem like toast is always programmed to fall buttered-side down. However, much of this is simply due to the rotation and height of a fall. When you drop toast, it usually begins to rotate as it falls, as one side slides off your plate first. If it's dropped from a table, the typical rotation speed, falling speed and distance fallen often mean that toast can only make half a turn before making contact with the floor. The result is that the buttered side lands touching the floor. Butter can also make one side heavier than the other, but studies show that the impact of this is slim compared to the drop height and rotation factors. Additionally, you are more likely to remember the messy toast incidents.

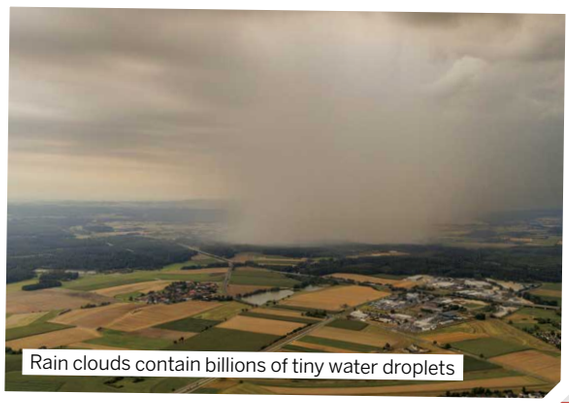


A 2001 study showed that toast lands butter-side down around two-thirds of the time

RAIN COVERAGE

Dear **HIW**,
What's the smallest area it can rain in? For example, the other day it was raining where I live, but a few streets away at my friend's it wasn't raining.
Zoe Clarke

Rain can fall over surprisingly small areas, as a rain cloud can sometimes be just a few miles wide. This leads to incidents like yours, when one part of a neighbourhood is getting wet, while another part a few streets away remains bright and dry. Buildings, hills and wind can affect where clouds develop. There isn't a minimum size, but these varied conditions can make weather forecasts unpredictable.



Rain clouds contain billions of tiny water droplets

IN OUR 20 MAY NEWSLETTER, WE ASKED YOU:

WHICH INVERTEBRATE DESERVES THE 'MOST MISUNDERSTOOD' AWARD?

45% Cockroaches
30% Spiders
20% Wasps
5% Moths

Sign up to the How It Works newsletter for more fun polls like this, as well as fascinating articles, quick quizzes, fast facts and amazing images. It's crafted and curated by the team, it's free and you'll find it in your inbox every Wednesday morning

SCAN HERE

...OR ENTER THIS URL INTO YOUR BROWSER: tinyurl.com/ypzp7spm

WE ASKED YOU

This month on social media, we asked you:

WHAT WELLNESS TRENDS HAVE YOU TRIED?

AMIRAH F
I LIVE BY THE SEA, SO REGULARLY TRY COLD WATER PLUNGING

AMELIA G
I TRIED A SOUND BATH FOR THE FIRST TIME. VERY RELAXING

STEVE F
COLD SHOWERS

FREYA D
YOGA NIDRA!

GRACE S
I'VE BEEN TEMPTED BY A SILENT RETREAT

JEN P-W
I BOUGHT A WEIGHTED BLANKET AS I OFTEN STRUGGLE TO SLEEP

NEXT ISSUE

ISSUE 221 ON SALE 8 OCT 2026

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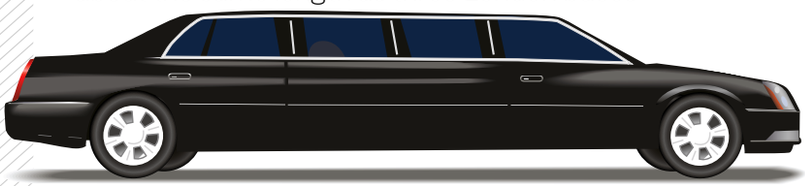
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FAST FACTS

Amazing trivia that will blow your mind

30.5 METRES

Jay Ohrberg's American Dream limousine is about the same length as three London buses



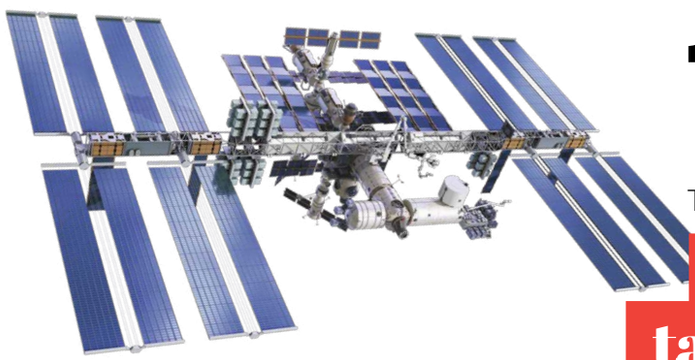
THE SMELL OF RAIN ON DRY GROUND IS CALLED 'PETRICHOR'

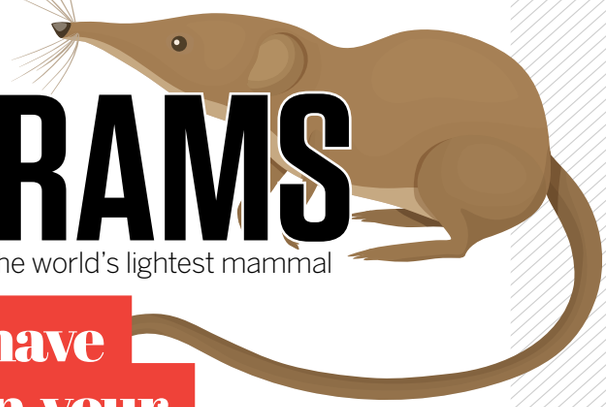
QR CODES WERE ORIGINALLY INVENTED TO TRACK CAR PARTS



24 HOURS

In a single day, the ISS orbits the Earth 16 times



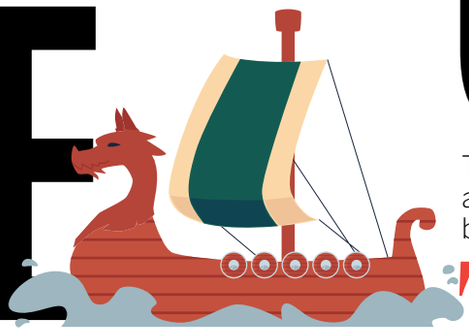


1.8 GRAMS

The Etruscan shrew is the world's lightest mammal

You also have taste buds in your digestive tract

1000 CE



Vikings reached North America over 500 years before Christopher Columbus

@

This symbol was used in accounting for centuries before the internet



859 CE

Al-Qarawiyyin in Morocco is the world's oldest continuously operating university

TEN TONNES

At sea level, the air above you presses down with incredible force

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★★★★★

"Great app. A godsend when renewals are due!"

★★★★★

Storm warning



This is a shopping forecast issued on behalf of customers of Christopher Ward, Bell Street, Maidenhead. General synopsis for September 2026. **Trident Biscay Automatic.** New pressure north, occasionally backing north-west. Anodised aluminium bezel, 250 HV Vickers, moving 0 to 12. Anti-cyclonic, 360 degrees. Visibility clear. Legibility and luminosity excellent to depths of 200 metres. Movement accuracy variable, minus four, veering plus six, constant. Sales storms, force 10, imminent.

Do your research.

Christopher Ward

christopherward.com

9031

9000